The xintexpr and allied packages source code

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1 An introduction and a brief timeline

This is 1.4m of 2022/06/10.

The CHANGES.html contains a detailed history of the evolution of the packages:

Internet: http://mirrors.ctan.org/macros/generic/xint/CHANGES.html

At 1.4m I added hyperlinks to the macro code. Each instance of a macro in the code is linked with target the location of its definition (via \def or \let or variants). This has been done via a heist on doc (v2 version) automated indexing which has been transformed here into automated hyperlinking. The details are commented upon in the next section. Furthermore the codeline where the macro is defined will link to its description in the user manual, if available, inside xint-all.pdf which combines user manual and source code. In sourcexint.pdf the link is more modestly targeting the sectioning heading referencing the macro name, if available. Again in xint-all.pdf the macros documented in the user manual have a link *source* to their source code.

The sad truth however is that my code is poorly documented. On two counts:

- scarcity at times,
- occasional excessive verbosity,
- generally inadequate or irrelevant contents.

The macro comments have had a distinct tendency to record the changes across releases or even those occurring during pre-release development phase, rather than explaining the interface, or perhaps an algorithm. As I am aware of that, I have a mechanism of "private comments" which are removed by the dtx build script. But then I sometimes use it en masse as it would be too much work to clean-up the existing comments, and as a result the code is not commented at all anymore... A typical example is with \xintiiSquareRoot which is amply documented in the private sources but only 10% of it could be of any value to any other reader than myself and it would be simply the description of what #1, #2, ... stand for. As a result I converted at some point (perhaps even originally) everything into private comments. Extracting the useful parts describing the macro parameters and checking they are actually still valid would be very time-consuming. The real problem here is that the actual underlying algorithms are rarely if ever described. But rest assured this is all only school mathematics anyway.

- Release 1.4m of 2022/06/09 is mainly a documentation upgrade, with proud hyperlinked macros in the code, and various documentation enhancements. It is also fixing a longstanding incompatibility with miniltx of which the author was unaware. It also inaugurates usage of the engine string comparison primitive.
- Release 1.4i of 2021/06/11: extension of the «simultaneous assignments» concept (backwards compatible).
- Release 1.4g of 2021/05/25: powers are now parsed in a right associative way. Removal of the single-character operators &, |, and = (deprecated at 1.1). Reformatted expandable error messages.
- Release 1.4e of 2021/05/05: logarithms and exponentials up to 62 digits, trigonometry still mainly done at high level but with guard digits so all digits up to the last one included can be trusted for faithful rounding and high probability of correct rounding.
- Release 1.4 of 2020/01/31: xintexpr overhaul to use \expanded based expansion control. Many new features, in particular support for input and output of nested structures. Breaking changes, main ones being the (provisory) drop of x*[a, b,...], x+[a, b,...] et al.syntax and the requirement of \expanded primitive (currently required only by xintexpr).
- Release 1.3e of 2019/04/05: packages xinttrig, xintlog; \xintdefefunc ``non-protected'' variant of \xintdeffunc (at 1.4 the two got merged and \xintdefefunc became a deprecated alias for \xintdeffunc). Indices removed from sourcexint.pdf.
- Release 1.3d of 2019/01/06: fix of 1.2p bug for division with a zero dividend and a one-digit divisor, \xinteval et al. wrappers, gcd() and lcm() work with fractions.
- Release 1.3c of 2018/06/17: documentation better hyperlinked, indices added to sourcexint.pdf. Colon in := now optional for \xintdefvar and \xintdeffunc.
- Release 1.3b of 2018/05/18: randomness related additions (still WIP).
- Release 1.3a of 2018/03/07: efficiency fix of the mechanism for recursive functions.
- Release 1.3 of 2018/03/01: addition and subtraction use systematically least common multiple of denominators. Extensive under-the-hood refactoring of \xintNewExpr and \xintdeffunc which now allow recursive definitions. Removal of 1.2o deprecated macros.
- Release 1.2q of 2018/02/06: fix of 1.2l subtraction bug in special situation; tacit multiplication extended to cases such as 10!20!30!.
- Release 1.2p of 2017/12/05: maps // and /: to the floored, not truncated, division. Simultaneous assignments possible with \xintdefvar. Efficiency improvements in xinttools.
- Release 1.2o of 2017/08/29: massive deprecations of those macros from xintcore and xint which filtered their arguments via \xintNum.
- Release 1.2n of 2017/08/06: improvements of xintbinhex.
- Release 1.2m of 2017/07/31: rewrite of xintbinhex in the style of the 1.2 techniques.

- Release 1.2l of 2017/07/26: under the hood efficiency improvements in the style of the 1.2 techniques; subtraction refactored. Compatibility of most xintfrac macros with arguments using non-delimited \the\numexpr or \the\mathcode etc...
- Release 1.2i of 2016/12/13: under the hood efficiency improvements in the style of the 1.2 techniques.
- Release 1.2 of 2015/10/10: complete refactoring of the core arithmetic macros and faster \xintexpr parser.
- Release 1.1 of 2014/10/28: extensive changes in xintexpr. Addition and subtraction do not multiply denominators blindly but sometimes produce smaller ones. Also with that release, packages xintkernel and xintcore got extracted from xinttools and xint.
- Release 1.09g of 2013/11/22: the xinttools package is extracted from xint; addition of \xintloop and \xintiloop.
- Release 1.09c of 2013/10/09: \xintFor, \xintNewNumExpr (ancestor of \xintNewExpr/\xintdeffunc mechanism).
- Release 1.09a of 2013/09/24: support for functions by xintexpr.
- Release 1.08 of 2013/06/07: the xintbinhex package.
- Release 1.07 of 2013/05/25: support for floating point numbers added to xintfrac and first release of the xintexpr package (provided \xintexpr and \xintfloatexpr).
- Release 1.04 of 2013/04/25: the xintcfrac package.
- Release 1.03 of 2013/04/14: the xintfrac and xintseries packages.
- Release 1.0 of 2013/03/28: initial release of the xint and xintgcd packages.

2 Custom macrocode environment

I have always used the monospaced newtxtt typeface, more precisely its newtxttz variant with variable interword spacing and allowed hyphenation, both for the user manual and for the code comments. But as the code itself is also rendered with newtxtt, naturally using this time the monospace typeface preventing hyphenation, and with a verbatim rendering obeying spaces and linebreaks, it is somewhat of an issue to help better separate visually the comments from the code. I long used a special color (which was Purple for a long time), not for all code comments but for those which in the source were inside a custom verbatim environment[1] which allows free-flowing of horizontal whitespace and soft-wrapping at linebreaks.[2] Using this verbatim rendering spared me the tedious task of escaping macros or other special characters inside my code comments.

But other paragraphs of code comments[3] were typed-in as normal LaTeX-markup with occasional usage of the | escape for short verbatim and some custom \cs-type macros enhanced for hyperlinks. So I ended up in a situation with some paragraphs of code comments all uniformly colorized (apart from rare hyperlinks allowed by an escape inside) and others in black containing some colored short verbatim and some hyperlinks.

To try to alleviate this I modified my custom verbatim to work with an active backslash character \ in order to gather the control sequence name, check if it corresponds to a labeled reference in the implementation if yes insert the usage of \hyperref to link to it.

[1] I used to employ a Plain TeX mark-up with a macro \lverb (meaning "long \verb"), but I converted this into an environment at the time of adding the hacks described next. [2] Some special mark-up at starts of lines such as %(and %) serves to delimit portions where whitespace is obeyed as in regular verbatim. [3] I do employ the standard dtx mark-up for such code comments, i.e. with these comments on lines with a % as their first character; but the part of xint.dtx giving the user manual is a regular LaTeX document, as this is easier to manage on the long term. Also the present comments are input as if in a regular LaTeX document.

Those familiar with doc.sty will have recognized immediately that it too activates the \ in order to insert suitable indexing commands.[4]

I had actually never really looked into doc.sty code, but I started wondering if one could not indeed divert its indexing facility into an automated generation of hyperlinks: i.e. hyperlinking from macro names to the line where they are first defined.[5]

In this section I will display and comment the hacks I have done to convert the doc.sty macros into achieving automatic hyperlinking inside the code lines, from the places of use of a macro to the place of its definition, and from the place of its definition to the user documentation (if building xint-all.pdf), if available. Using the colored links of hyperref this already provides a kind of minimal syntax highlighting to the code lines, which we will enhance via colorizing the inline comments (i.e. everything following a % in the source code), and also colorizing the tokens not involved in control sequence names.

Horrified readers will see I have completely botchered not only the indexing facilities but also this business of "modules" which is in a part of documentation I haven't read yet. And, now that you are appalled enough let's admit that the sourcexint.pdf documentation never has made any usage of the macro and environment environments from doc.sty, so I have not even tested if they survive the mistreatment here.[6]

```
% \macrocode
% ==========

% 2014/11/04 did some hack with active characters à la upquote for straight
% quotes, but this is now irrelevant as we use suitable font from newtxtt with
% straight quotes.

% doc.sty does \AtBeginDocument{\let\macro@font\MacroFont} and formerly I
% overwrote \macro@font to use a newtxtt font with a slashed 0 in the
% implementation part.

% 2022/05/17 removes this, but I still need to redefine \macro@font to remove some
% stuff I formerly added to \MacroFont and which is only useful for the user manual.
\def\macro@font {\ttfamily }
```

The \makestarlowast makes the * active to be lowered like this ∗. Formerly I hacked \macrocode or used \macro@font (which comes before \dospecials in \macro@code but the * is not a special character) but it seems now cleaner to use the LaTeX environment hooks.

```
% no problem as * is not "special" so the active catcode will not be reset
\AddToHook{env/macrocode/begin}{\makestarlowast}
```

Let's continue benefiting from modern hooks to work around vertical spacing issues
https://github.com/latex3/latex2e/issues/563

```
\AddToHook{env/macrocode/after}{\@nobreakfalse}
\AddToHook{env/macrocode/begin}{\partopsep0pt\relax}
```

As explained above I make the % active in order to colorize comments so here I do need to overwrite the core delimited macro \xmacro@code.

```
\begingroup
\catcode`\|=\z@ \catcode`\[=\@ne \catcode`\]=\tw@
\catcode`\{=12 \catcode`\}=12
```

[4] The sourcexint.pdf documentation included automated indices thanks to by doc, but only during 2018-2019. I felt the indices made the build process quite longer, produced very big PDFs and, in view of the capabilities of the modern PDF viewers had a limited interest in the case at hand. Besides, they were some limitations such as requiring user intervention for macros created via \csname constructs. This limitation can not be overcome easily, especially when furthermore, as in xintexpr, this is done sometimes via loops applying some templates, as it would seem for that one has to emulate TeX itself. This limitation applies naturally also to the hacks described in this section! [5] The recently released V3 of doc is about hyperlinking, I have to check better its documentation but I don't think it creates hyperlinks from code lines to code lines as we will do here. [6] Of course I did use those facilities for some of my LaTeX packages... but for sourceint.pdf I have always used the LaTeX sectioning commands rather. With a hack which will be described at the end of this section to introduce suitable hyperlink targets for those names entered into the comma separated section titles.

```
% Let % be active to use a color for it and gray-out
% comments left in code (there are few)
\catcode`\%=13 \catcode`\ =\active \catcode`\\=\active
|gdef|xmacro@code#1%    \end{macrocode}[#1|end[macrocode]]
|endgroup
```

I will give a document wide definition to the active %, other places where I need an active % like my lverb environment use \let at the appropriate time to give it another meaning. The redefinition makes it change the color, and for this it opens a scope limiting group, which gets closed via the active end of line, suitably locally altered.

```
\begingroup\catcode`\%=\active\catcode`\^^M 13
\gdef%{\begingroup\color{macrocodecommentcolor}\@percentchar\odef
{\expandafter\endgroup
}}\endgroup
```

The \odef in the above code is an xintkernel utility.

```
\texttt{\meaning\odef}
```

macro:#1->\expandafter \def \expandafter #1\expandafter

Let's mention already that there better should not be a \def\foo in a comment as no mechanism has been added here to prevent the macrocode to believe this is an actual definition (whose detection method is described below).

For hyperlinking I turn CodelineNo into a regular LaTeX counter. The next few lines were actually executed right after having loaded doc v2:

```
% First we want to turn CodelineNo into a real LaTeX counter
% This will spare defining an extra counter for the hyperlinks with \hyperref
\begingroup\let\newcount\@gobble\@definecounter{CodelineNo}\endgroup
% Let's now reenact the doc.sty default for \theCodeLineNo
\def\theCodelineNo{\reset@font\scriptsize\arabic{CodelineNo}}
% But as we will reset CodelineNo at each style file we need some unique id
\def\theHCodelineNo{\the\value{section}.\the\value{CodelineNo}}
```

The xint packages use @, :, ?, ^ and _ as letters, and xintexpr also uses ! as letter.

```
\def\xintMakePrivateLetters{\catcode`: 11 \catcode`? 11 \catcode`@ 11
                            \catcode`^ 11 \catcode`_ 11 }
\def\xintexprMakePrivateLetters{\xintMakePrivateLetters \catcode`! 11 }
\let\MakePrivateLetters\xintMakePrivateLetters
```

The whole idea is to colorize things so we executed the following in the preamble after having loaded xcolor in order to have all such settings in one place only.

```
\definecolor{xintnamecolor}{RGB}{228,57,0}
\colorlet{verbcolor}{Maroon}
%
\colorlet{privatecommentcolor}{cyan}
\colorlet{macrocodecommentcolor}{gray}
\colorlet{macrocodenewmacrocolor}{verbcolor}
\colorlet{macrocodelinktouserdoccolor}{xintnamecolor}% and bold face
\colorlet{macrocodelinktosectioncolor}{DarkBlue}% and bold face
\colorlet{macrocodelinktocodelinecolor}{DarkBlue}
\colorlet{macrocodenoncscolor}{Green}
\def\xintdocMacrocodeFallbackColorCmd{\normalcolor}
```

Let's overwrite the macrocode \everypar and use for this \init@crossref as suitable hook. We need this to

- make the % active (after the \macro@code has done \dospecials already), in order to colorize the inline comments,
- reset the color, because we will place an overall \color command in a "before" hook to colorize the non control sequence tokens,

- insert a suitable \refstepcounter. This would not be needed if using an \hypertarget/\hyperlink approach.

In passing we start the destruction of FM's work by not including the \check@module inside the \everypar. I had used it as an entry-point hook before actually deciding to overwrite the \everypar and remove \check@module altogether from it.

```
\odef\init@crossref{\init@crossref%
     \everypar{\refstepcounter{CodelineNo}%
               \llap{{\xintdocMacrocodeFallbackColorCmd\theCodelineNo}\
                      \hskip\@totalleftmargin}%
               }%
     \catcode`\%\active
}%
```

In the environment the backslash is active and is given the meaning of \scan@macro. Let's modify this meaning

- to not insert itself yet,
- and to prepare for collecting not only a name but also spaces (for reasons explained below).

```
\def\scan@macro{%
   % we do not insert it yet
   % \special@escape@char
   \step@checksum
%   \ifscan@allowed
     \let\macro@namepart\@empty
     % we need this for reasons explained below
     \let\macro@spacepart\@empty
     \def\next{\futurelet\next\macro@switch}%
%   \else \let\next\@empty \fi
   \next
}
% unchanged:
% \def\macro@switch{\ifcat\noexpand\next a%
%      \let\next\macro@name
%      \else \let\next\short@macro  \fi
%    \next}
```

We do not bother with "short" control sequences:

```
\def\short@macro#1{\special@escape@char#1}
```

The \macro@name is not modified but \more@macroname gets overwritten:

```
% \def\macro@name#1{\edef\macro@namepart{\macro@namepart#1}%
%      \futurelet\next\more@macroname}
% \def\more@macroname{\ifcat\noexpand\next a%
%      \let\next\macro@name
%      \else \let\next\macro@finish \fi
%      \next}
\def\more@macroname{\ifcat\noexpand\next a%
     \expandafter\macro@name
     % we keep the \next for usage later and start filtering out of the way spaces
     % this is caused by necessity of handling things such as \let<space>\foo\bar
     % but also not be fooled by \let<space>#6\macro
     \else \expandafter\macro@gatherspaces \fi
     }
```

Now a simple \futurelet loop will gather consecutive active spaces which may separate a \def or \let from the control sequence which is getting defined in the source code:

```
\def\macro@gatherspaces{%
```

```
      \ifx\next\@xobeysp
          \expandafter\macro@gatherspaces@i
      \else
          \expandafter\macro@finish
      \fi}%
  \def\macro@gatherspaces@i#1{%
      \odef\macro@spacepart{\macro@spacepart#1}% #1 = active space
      \futurelet\next\macro@gatherspaces}%
```

We need to collect those spaces in order to have a peek at what is coming next. Some code comments, but I am not going to comment my comments...

```
  % We do not want \expandafter\def\csname to consider it defines \csname
  % We de no want \expanded{\edef\expandafter\noexpand\csname...}
  % to consider it defines \noexpand.  We do not want this input
  % expandafter\def\expandafter#1\expandafter{\romannumeral
  % to consider it defines \expandafter or \romannumeral.
  % We do not want \ifdefined\odef\else to be interpreted as definition
  % of \else
```

When we scan a \def or \let or... we toggle a boolean that says that what comes next will either insert a LaTeX \label (and the counter CodelineNo is suitably \refstepcountered in \everypar to create an hypertarget), or an \hyperref. I also use a LaTeX counter simply to be able to boast about the number of defined macros at the end of the PDF.[7]

```
  \newif\iflabelmacro@allowed
  \newcounter{xintMacroCnt}
  \def\xintimplabelprefix{src-}
  \let\xintdoclabelprefix\empty
  \let\xintlabelprefix\xintimplabelprefix
```

Now to the crux of the matter. The core of our hacks is in \macro@finish. We will need the _ to be of catcode letter there.

```
  \catcode`\_ 11 %
  \def\macro@finish{%
    \iflabelmacro@allowed
```

Some control sequence names should never create hyperlinking. I hesitate about what to do with \empty and \space: xintkernel does define them if they do not exist (which seems improbable) but we know what they are anyhow. Let's be careful here with how \in@ works and add suitable delimiters to avoid sub-matches.

```
     \expandafter\in@\expandafter{\expandafter.\macro@namepart,}%
     {.csname,.expandafter,.noexpand,.else,%
      .t,.w,.x,.y,.z,.XINT_x,.XINT_y,%
      .XINT_tmpa,.XINT_tmpb,.XINT_tmpc,.XINT_tmpd,.XINT_tmpe,% _ is letter here
      .XINT_expr_defbin_b,.XINT_expr_defbin_c,.XINT_expr_defbin_d,%
      .empty,.space,}%
```

If the thing is not excluded we check via a custom flag if we created already a \label, if not we create the \label and step the macro counter. In the latter case we will try to link to a target in the user manual (which may be available naturally only if we are creating xint-all.pdf) or to a label from a sectioning title in the implementation part. The latter situation is a bit silly because it will mean a link to a place perhaps only a few lines above the location of the macro definition but well. For some macros I wrote a very long incipit and then the link is useful as it jumps back to its start and allows to read the whole thing again in a never ending cycle.

A link to the user documentation part will be colorized **\likethis** whereas hyperlinking to the nearby section will look **\likethat**. If no such target exists we use \this_color to highlight the

[7] But I needed to make a manual estimate of a correction due to the many macros defined in xintexpr via \csname constructors. On June 6, 2022, I estimated there are at least about 452 of them and I since correct the macro counter with this addition at the end of source file for xintexpr.

new macro (it is currently the same highlighting as for \verb usage in the code comments). It is then not a link but a target only. Finally, things excluded from the mechanism are rendered using a fall-back color, which currently is simply the color from \normalcolor, i.e. the black color.

```
     \ifin@
       {\xintdocMacrocodeFallbackColorCmd\special@escape@char\macro@namepart}%
     \else
       \ifcsname alreadydefined-\macro@namepart\endcsname
```

Contrarily to doc.sty we have not yet typeset the \ so we insert it via \special@escape@char (this makes me realize I have not yet checked if I use a special catcode zero character anywhere in the sources; I surely do in the sources for this documentation, but probably not for the actual packages).

```
         \hyperref[xintmacro-\macro@namepart]{\special@escape@char\macro@namepart}%
       \else
```

We rarely define things twice but it happens sometimes when a macro needs a space token. Unfortunately LaTeX's \label has no mechanism to tell if a label has already been used and if we issue a second \label with same name it will complain at some later stage. We can not use CodelineNo as how are we going then to refer to it? So we set up a flag to signal the \label has been created.

```
         % this will make a rather large number of macro names in the string pool...
         \global\expandafter\let\csname alreadydefined-\macro@namepart\endcsname\@empty
         \label{xintmacro-\macro@namepart}%
```

I considered a \hypertarget/\hyperlink method, but use finally \label and \hyperref. It is actually fun to see a gigantic .aux file allowing to get the information and to have the possibility to count again with grep for example.

```
         \stepcounter{xintMacroCnt}%
         % try to link to a label in user documentation if building xint-all.pdf
         \ifcsname r@\xintdoclabelprefix\macro@namepart\endcsname
            {\hypersetup{linkcolor=macrocodelinktouserdoccolor}%
             \hyperref[\xintdoclabelprefix\macro@namepart]%
                      {\textbf{\special@escape@char\macro@namepart}}}%
         \else
         % try to link to a labeled section in implementation part
         \ifcsname r@\xintimplabelprefix \macro@namepart\endcsname
            {\hypersetup{linkcolor=macrocodelinktosectioncolor}%
             \hyperref[\xintimplabelprefix\macro@namepart]%
                      {\textbf{\special@escape@char\macro@namepart}}}%
         \else
            \textcolor{macrocodenewmacrocolor}{\special@escape@char\macro@namepart}%
         \fi\fi
       \fi
     \fi
```

In all cases we now turn off the toggle for \label creation. Except if we were dealing with \expandafter, then we do keep it on. But only if what is coming next is a control sequence.

```
     \labelmacro@allowedfalse
     \expandafter\in@\expandafter{\expandafter.\macro@namepart,}{.expandafter,}%
     \ifin@
        \ifx\next\scan@macro\labelmacro@allowedtrue\fi
     \fi
    \else % end of \labelmacro@allowedtrue branch
```

Now we return to the original \macro@finish code, with some check of the macro name to detect when it is \def or a cousin, and if it is we turn on the toggle to associate a \label or an \hyperref to the next control sequence. However we do this only if the next token is the catcode zero character. For this to work we have moved away the spaces beforehand.

I hesitated about adding \chardef and \mathchardef but this would have the effect of adding hyperlinks for the \xint_c_i et al. constants, whose names are anyhow pretty much explicit. An end of line separating \def from the actual control sequence will cause the code to not activate the labelling process.

```
      \ifx\next\scan@macro
        \expandafter\in@\expandafter{\expandafter.\macro@namepart,}%
                  {.def,.edef,.let,.gdef,.xdef,.odef,.oodef,.fdef,}%
        \ifin@\labelmacro@allowedtrue\fi
      \fi
```

If the reference exists, use it. The link will use color like in this example: \xint_dothis. In development, I had an alternative method not using \label/\hyperref but \hypertarget/\hyperlink. But here arose the question about how to know if a target existed (possibly located later in the source code). And it seems the answer would have been to use a mechanisme like the commented-out \ifnot@exclude below or the above \in@ direct usages, but with a big list of all words we know will not have been associated with a target in the other branch. I.e. basically the TeX primitives in the code, or also the constants \xint_c_⟨*roman numeral*⟩ which deliberately were not set-up to configure (as we did not handle \chardef or \mathchardef or \newcount to turn the toggle on. And if were to use a double-pass system via the .aux file, then what was the point. In view of this I opted for the \label/\hyperref even though it makes for very large .aux file and a lot of noise in the console output and in the log.

```
      \ifcsname r@xintmacro-\macro@namepart\endcsname
        \hyperref[xintmacro-\macro@namepart]{\special@escape@char\macro@namepart}%
      \else
        {\xintdocMacrocodeFallbackColorCmd\special@escape@char\macro@namepart}%
      \fi
    \fi
```

We do not use any index, but this could be reenacted. The \short@macro which then would needs to be resurrected as well. The xint source code contains no definition of such short (i.e.one non-letter character following the backslash or escape character) macros anyhow.

```
    % \ifnot@excluded
    %    \edef\@tempa{\noexpand\SpecialIndex{\bslash\macro@namepart}}%
    %    \@tempa
    % \fi
```

And to conclude we now produce the fetched spaces. And after the \scan@macro definition we reset the catcode of _ (this code is not part of the xint*.sty style files where the _ anyhow is of catcode letter, but of the user documentation).

```
    \macro@spacepart
  }%
  \catcode`\_ 8
```

There is one last topic. We want to colorize the tokens more in the macrocode. At some point before the hacks into doc.sty I had decided to issue one single top-level \color command at start of the implementation part in order to unify the looks of the two types of comments which were described at start of this section. So I needed to colorize the macrocode environments back to the black normal color. Now I need to colorize it to some color, knowing that control sequences will be rendered with their own individual colors, either the normal color, or the color for a link to a code line, possibly the **color for a link to the user documentation**, or the **color for a link to a sectioning title in the implementation part** (normally immediately a few lines above), or the color for being a target (then it is not a link), and that comments have been configured to be rendered in their own color. So what remains are the non commented out and non-control sequences token.

What is next is done in order to:

1. not induce spacing changes in the output compared to no color commands
2. not cause a color stack overflow from \normalcolor or a \color at top level with dvipdfmx (same

problem in xetex).

I had encountered the color stack overflow with dvipdfmx (and xetex also) already many years ago for the everbatim* environment which is used in the user manual and in this section to display TeX code and execute it. So I only needed to copy the method and find the correct hooks to use for the macrocode, turns out the good choices are env/macrocode/before to set the color and env/macrocode/end to unset it (not after which causes extra vertical spacing).

```
{\sbox0{\color{macrocodenoncscolor}\xdef\foo{\current@color}}}
\ifpdf
   \edef\xintdoc@macrocode@pushcolor
      {\pdfcolorstack\noexpand\@pdfcolorstack push{\foo}\relax}
   \def\xintdoc@macrocode@popcolor{\pdfcolorstack\@pdfcolorstack pop\relax}
\else
\ifxetex
   \edef\xintdoc@macrocode@pushcolor{\special{color push \foo}}
   \def\xintdoc@macrocode@popcolor{\special{color pop}}
\else
\ifnum\Withdvipdfmx=1
     \edef\xintdoc@macrocode@pushcolor{\special{color push \foo}}
     \def\xintdoc@macrocode@popcolor{\special{color pop}}
\fi\fi\fi
\AddToHook{env/macrocode/before}{\xintdoc@macrocode@pushcolor}
\AddToHook{env/macrocode/end}{\xintdoc@macrocode@popcolor}
% let's use some more quiet color for links inside the code
\AddToHook{env/macrocode/begin}{\hypersetup{linkcolor=macrocodelinktocodelinecolor}}
% let code line numbers really be fully in the margin
\MacroIndent\z@
```

This concludes this section devoted to how the documentation is formatted. Now enjoy the nice colors and hyperlinking!

Ah wait I had forgotten one piece. In order to minimize the mark-up I have hacked into sectioning commands to add automatically labels. And an old commented out part seems to indicate I experimented with inserting automatically macro environments too, but I must have encountered problems and dropped the idea.[8]

```
% HACK OF \@sect
% ============
% goal is to add labels but without having to modify currently
% existing mark-up in sources. But KOMA makes an extra step needed.
% 2018/06/11
\let\original@sect\@sect
\def\@sect#1#2#3#4#5#6[#7]#8{\original@sect{#1}{#2}{#3}{#4}{#5}{#6}[{#7}]%
    {\begingroup
       %not possible because of KOMA wrappers
       %\def\csh##1{\csa{##1}\label{\xintdoclabelprefix\detokenize{##1}}}%
       \let\csh\cshintitle
       \let\cshn\cshnintitle
       #8%
     \endgroup}%
}%
\def\cshintitle#1{\csa{#1}%
                  \label{\xintlabelprefix\detokenize{#1}}%
                  %\expandafter\DescribeMacro\csname#1\endcsname
```

[8] It seems to me now that I have read doc documentation that I had initially completely mis-understood what \DescribeMacro was supposed to be used for... or perhaps I intended to do something like the present \@sect hack to serve in the user manual part?

```
                   }
% \csan: no backslash
\def\cshnintitle#1{\csan{#1}\label{\xintlabelprefix\detokenize{#1}}}
```

The \csa is defined this way:

```
\DeclareRobustCommand\csa[1]
    {{\ttzfamily\char92\endlinechar-1
      \makestarlowast \catcode`_ 12 \catcode`^ 12
      \scantokens\expandafter{\detokenize{#1}}}}
```

And the \csh is defined like this:

```
\newcommand\csh[1]
    {\texorpdfstring{\csa{#1}}{\textbackslash\detokenize{#1}}}
```

for use like in this example from xintkernel:

```
% \subsubsection{\csh{XINTrestorecatcodes}, \csh{XINTsetcatcodes},
%                \csh{XINTrestorecatcodesendinput}}
```

Finally before the \endinput of each style file I insert \StoreCodeLineNo{xint...} in order to prepare the last page of sourcexint.pdf.

```
\def\storedlinecounts {}
\def\StoreCodelineNo #1{%
    \edef\storedlinecounts{\storedlinecounts
                           {{#1}{\the\c@CodelineNo}{\the\c@xintMacroCnt}}%
                          }%
    \global\c@CodelineNo   \z@
    \global\c@xintMacroCnt \z@
}
```

3 Package xintkernel implementation

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This package provides the common minimal code base for loading management and catcode control and also a few programming utilities. With 1.2 a few more helper macros and all \chardef's have been moved here. The package is loaded by both xintcore.sty and xinttools.sty hence by all other packages.

Modified at 1.1 (2014/10/28). Separated package.

Modified at 1.2i (2016/12/13). \xintreplicate, \xintgobble, \xintLengthUpTo and \xintLastItem, and faster \xintLength.

Modified at 1.3b (2018/05/18). \xintUniformDeviate.

Modified at 1.4 (2020/01/31). \xintReplicate, \xintGobble, \xintLastOne, \xintFirstOne.

Modified at 1.4l (2022/05/29). Fix the 1.4 added bug that \XINTrestorecatcodes forgot to restore the catcode of ^^A which is set to 3 by \XINTsetcatcodes.

Modified at 1.4m (2022/06/10). Fix incompatibility under ε-TeX with miniltx, if latter was loaded before xintexpr. The fix happens here because it relates to matters of \ProvidesPackage.

3.1 Catcodes, ε-TeX and reload detection

The code for reload detection was initially copied from Heiko Oberdiek's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

1.4l replaces Info level user messages issued in case of problems such as \numexpr not being available with Warning level messages (in the LaTeX terminolgy). Should arguably be Error level in that case.

xintkernel.sty was the only xint package emitting such an Info, now Warning in case of being loaded twice (via \input in non-LaTeX). This was probably a left-over from initial development stage of the loading architecture for debugging. Starting with 1.4l, it will abort input silently in such case.

Also at 1.4l I refactored a bit the loading code in the xint*sty files for no real reason other than losing time.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5     % ^^M
  \endlinechar=13 %
  \catcode123=1    % {
  \catcode125=2    % }
  \catcode44=12    % ,
```

```
\catcode46=12   % .
\catcode58=12   % :
\catcode94=7    % ^
\def\space{ }\newlinechar10
\let\z\relax
\expandafter\ifx\csname numexpr\endcsname\relax
  \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
    \immediate\write128{^^JPackage xintkernel Warning:^^J%
                        \space\space\space\space
                        \numexpr not available, aborting input.^^J}%
  \else
    \PackageWarningNoLine{xintkernel}{\numexpr not available, aborting input}%
  \fi
  \def\z{\endgroup\endinput}%
\else
  \expandafter\ifx\csname XINTsetupcatcodes\endcsname\relax
  \else
     \def\z{\endgroup\endinput}%
  \fi
\fi
\ifx\z\relax\else\expandafter\z\fi%
```

3.1.1 \XINTrestorecatcodes, \XINTsetcatcodes, \XINTrestorecatcodesendinput

Modified at 1.4e (2021/05/05). Renamed \XINT{set,restore}catcodes to be without underscores, to facilitate the reloading process for xintlog.sty and xinttrig.sty in uncontrolled contexts.

Modified at 1.4l (2022/05/29). Fix the 1.4 bug of omission of \catcode1 restore.

Reordered all catcodes assignements for easier maintenance and dropped most disparate indications of which packages make use of which settings.

The \XINTrestorecatcodes is somewhat misnamed as it is more a template to be used in an \edef to help define actual catcode restoring macros.

However \edef needs usually { and } so there is a potential difficulty with telling people to do \edef\myrestore{\XINTrestorecatcodes}, and I almost added at 1.4l some \XINTsettorestore:#1->\edef#1{\XINTrestorecatcodes} but well, this is not public interface anyhow. The reloading method of xintlog.sty and xinttrig.sty does protect itself though against such irreal usage possibility with non standard { or }.

Removed at 1.4l the \XINT_setcatcodes and \XINT_restorecatcodes not used anywhere now. Used by old version of xintsession.tex, but not anymore since a while.

```
\def\PrepareCatcodes
{%
    \endgroup
    \def\XINTrestorecatcodes
    {% prepared for use in \edef
        \catcode0=\the\catcode0      % ^^@
        \catcode1=\the\catcode1      % ^^A
        \catcode13=\the\catcode13    % ^^M
        \catcode32=\the\catcode32    % <space>
        \catcode33=\the\catcode33    % !
        \catcode34=\the\catcode34    % "
        \catcode35=\the\catcode35    % #
        \catcode36=\the\catcode36    % $
        \catcode38=\the\catcode38    % &
```

```
        \catcode39=\the\catcode39   % '
        \catcode40=\the\catcode40   % (
        \catcode41=\the\catcode41   % )
        \catcode42=\the\catcode42   % *
        \catcode43=\the\catcode43   % +
        \catcode44=\the\catcode44   % ,
        \catcode45=\the\catcode45   % -
        \catcode46=\the\catcode46   % .
        \catcode47=\the\catcode47   % /
        \catcode58=\the\catcode58   % :
        \catcode59=\the\catcode59   % ;
        \catcode60=\the\catcode60   % <
        \catcode61=\the\catcode61   % =
        \catcode62=\the\catcode62   % >
        \catcode63=\the\catcode63   % ?
        \catcode64=\the\catcode64   % @
        \catcode91=\the\catcode91   % [
        \catcode93=\the\catcode93   % ]
        \catcode94=\the\catcode94   % ^
        \catcode95=\the\catcode95   % _
        \catcode96=\the\catcode96   % `
        \catcode123=\the\catcode123 % {
        \catcode124=\the\catcode124 % |
        \catcode125=\the\catcode125 % }
        \catcode126=\the\catcode126 % ~
        \endlinechar=\the\endlinechar\relax
    }%
```

The \noexpand here is required. This feels to me a bit surprising, but is a fact, and the source of this must be in the \edef implementation but I have not checked it out at this time.

```
    \edef\XINTrestorecatcodesendinput
    {%
         \XINTrestorecatcodes\noexpand\endinput %
    }%
    \def\XINTsetcatcodes
    {% standard settings with a few xint*sty specific ones
        \catcode0=12     % for \romannumeral`&&@
        \catcode1=3      % for safe separator &&A
        \catcode13=5     % ^^M
        \catcode32=10    % <space>
        \catcode33=12    % ! but used as LETTER inside xintexpr.sty
        \catcode34=12    % "
        \catcode35=6     % #
        \catcode36=3     % $
        \catcode38=7     % & SUPERSCRIPT for && as replacement of ^^
        \catcode39=12    % '
        \catcode40=12    % (
        \catcode41=12    % )
        \catcode42=12    % *
        \catcode43=12    % +
        \catcode44=12    % ,
        \catcode45=12    % -
        \catcode46=12    % .
```

```
            \catcode47=12   % /
            \catcode58=11   % : LETTER
            \catcode59=12   % ;
            \catcode60=12   % <
            \catcode61=12   % =
            \catcode62=12   % >
            \catcode63=11   % ? LETTER
            \catcode64=11   % @ LETTER
            \catcode91=12   % [
            \catcode93=12   % ]
            \catcode94=11   % ^ LETTER
            \catcode95=11   % _ LETTER
            \catcode96=12   % `
            \catcode123=1   % {
            \catcode124=12  % |
            \catcode125=2   % }
            \catcode126=3   % ~ MATH SHIFT
            \endlinechar=13 %
        }%
        \XINTsetcatcodes
    }%
\PrepareCatcodes
```

Other modules could possibly be loaded under a different catcode regime.

```
\def\XINTsetupcatcodes {% for use by other modules
      \edef\XINTrestorecatcodesendinput
      {%
           \XINTrestorecatcodes\noexpand\endinput %
      }%
      \XINTsetcatcodes
}%
```

3.2 Package identification

Inspired from Heiko Oberdiek's packages.

Modified at 1.09b (2013/10/03). Re-usability in the other modules. Also I assume now that if \ProvidesPackage exists it then does define \ver@<pkgname>.sty, code of HO for some reason escaping me (compatibility with LaTeX 2.09 or other things ??) seems to set extra precautions. [nine years later I understood my mistake, see below].

Modified at 1.09c (2013/10/09). Usage of ε-TeX \ifdefined.

Modified at 1.4m (2022/06/10). Nine years too late, I understand that the HO "extra precautions" were there for some respectable reasons including etex+miniltx and surely other things I can not imagine. So let's now make sure \ver@xintkernel.sty and friends get defined on load, even if \ProvidesPackage exists! However I remain careless in using \ifdefined which could be fooled if some previous macro file ended up testing for \ProvidesPackage in a way letting it to \relax. I do not test for that. If I fixed that carelessness here I would have to fix it in other places where I use similarly \ifdefined\RequirePackage or \ifdefined\PackageWarning or whatever.

```
\ifdefined\ProvidesPackage
   \def\XINT_providespackage\ProvidesPackage#1[#2]{%
            \ProvidesPackage{#1}[{#2}]%
            \expandafter\ifx\csname ver@#1.sty\endcsname\relax
                  \expandafter\xdef\csname ver@#1.sty\endcsname{#2}%
```

```
                             \fi
        }%
\else
    \def\XINT_providespackage\ProvidesPackage#1[#2]{%
             \immediate\write-1{Package: #1 #2}%
             \expandafter\xdef\csname ver@#1.sty\endcsname{#2}%
        }%
\fi
\XINT_providespackage
\ProvidesPackage {xintkernel}%
  [2022/06/10 v1.4m Paraphernalia for the xint packages (JFB)]%
```

3.3 Constants

```
\chardef\xint_c_     0
\chardef\xint_c_i    1
\chardef\xint_c_ii   2
\chardef\xint_c_iii  3
\chardef\xint_c_iv   4
\chardef\xint_c_v    5
\chardef\xint_c_vi   6
\chardef\xint_c_vii  7
\chardef\xint_c_viii 8
\chardef\xint_c_ix     9
\chardef\xint_c_x     10
\chardef\xint_c_xii   12
\chardef\xint_c_xiv   14
\chardef\xint_c_xvi   16
\chardef\xint_c_xvii  17
\chardef\xint_c_xviii 18
\chardef\xint_c_xx    20
\chardef\xint_c_xxii  22
\chardef\xint_c_ii^v  32
\chardef\xint_c_ii^vi 64
\chardef\xint_c_ii^vii       128
\mathchardef\xint_c_ii^viii  256
\mathchardef\xint_c_ii^xii  4096
\mathchardef\xint_c_x^iv   10000
```

3.4 (WIP) \xint_texuniformdeviate and needed counts

```
\ifdefined\pdfuniformdeviate  \let\xint_texuniformdeviate\pdfuniformdeviate\fi
\ifdefined\uniformdeviate     \let\xint_texuniformdeviate\uniformdeviate   \fi
\ifx\xint_texuniformdeviate\relax\let\xint_texuniformdeviate\xint_undefined\fi
\ifdefined\xint_texuniformdeviate
  \csname newcount\endcsname\xint_c_ii^xiv
  \xint_c_ii^xiv   16384 % "4000, 2**14
  \csname newcount\endcsname\xint_c_ii^xxi
  \xint_c_ii^xxi 2097152 % "200000, 2**21
\fi
```

3.5 Token management utilities

Added at 1.2 (2015/10/10). Check if \empty and \space have their standard meanings and raise a warning if not.

Modified at 1.3b (2018/05/18). Moved here \xint_gobandstop_... macros because this is handy for \xintRandomDigits.

Modified at 1.4 (2020/01/31). Force \empty and \space to have their standard meanings, rather than simply alerting user in the (theoretical) case they don't that nothing will work. If some LaTeX user has \renewcommanded them they will be long and this will trigger xint redefinitions and warnings.

```
\def\XINT_tmpa { }%
\ifx\XINT_tmpa\space\else
   \immediate\write-1{Package xintkernel Warning:}%
   \immediate\write-1{\string\space\XINT_tmpa macro does not have its normal
     meaning from Plain or LaTeX, but:}%
   \immediate\write-1{\meaning\space}%
   \let\space\XINT_tmpa
   \immediate\write-1{\space\space\space\space
   % an exclam might let Emacs/AUCTeX think it is an error message, afair
                     Forcing \string\space\space to be the usual one.}%
\fi
\def\XINT_tmpa {}%
\ifx\XINT_tmpa\empty\else
   \immediate\write-1{Package xintkernel Warning:}%
   \immediate\write-1{\string\empty\space macro does not have its normal
     meaning from Plain or LaTeX, but:}%
   \immediate\write-1{\meaning\empty}%
   \let\empty\XINT_tmpa
   \immediate\write-1{\space\space\space\space
                     Forcing \string\empty\space to be the usual one.}%
\fi
\let\XINT_tmpa\relax
\let\xint_gobble_\empty
\long\def\xint_gobble_i    #1{}%
\long\def\xint_gobble_ii   #1#2{}%
\long\def\xint_gobble_iii  #1#2#3{}%
\long\def\xint_gobble_iv   #1#2#3#4{}%
\long\def\xint_gobble_v    #1#2#3#4#5{}%
\long\def\xint_gobble_vi   #1#2#3#4#5#6{}%
\long\def\xint_gobble_vii  #1#2#3#4#5#6#7{}%
\long\def\xint_gobble_viii #1#2#3#4#5#6#7#8{}%
\let\xint_gob_andstop_\space
\long\def\xint_gob_andstop_i    #1{ }%
\long\def\xint_gob_andstop_ii   #1#2{ }%
\long\def\xint_gob_andstop_iii  #1#2#3{ }%
\long\def\xint_gob_andstop_iv   #1#2#3#4{ }%
\long\def\xint_gob_andstop_v    #1#2#3#4#5{ }%
\long\def\xint_gob_andstop_vi   #1#2#3#4#5#6{ }%
\long\def\xint_gob_andstop_vii  #1#2#3#4#5#6#7{ }%
\long\def\xint_gob_andstop_viii #1#2#3#4#5#6#7#8{ }%
\long\def\xint_firstofone  #1{#1}%
\long\def\xint_firstoftwo  #1#2{#1}%
```

```
\long\def\xint_secondoftwo #1#2{#2}%
\long\def\xint_thirdofthree#1#2#3{#3}% 1.4d
\let\xint_stop_aftergobble\xint_gob_andstop_i
\long\def\xint_stop_atfirstofone  #1{ #1}%
\long\def\xint_stop_atfirstoftwo  #1#2{ #1}%
\long\def\xint_stop_atsecondoftwo #1#2{ #2}%
\long\def\xint_exchangetwo_keepbraces    #1#2{{#2}{#1}}%
```

3.6 "gob til" macros and UD style fork

```
\long\def\xint_gob_til_R #1\R {}%
\long\def\xint_gob_til_W #1\W {}%
\long\def\xint_gob_til_Z #1\Z {}%
\long\def\xint_gob_til_zero #10{}%
\long\def\xint_gob_til_one  #11{}%
\long\def\xint_gob_til_zeros_iii   #1000{}%
\long\def\xint_gob_til_zeros_iv    #10000{}%
\long\def\xint_gob_til_eightzeroes #100000000{}%
\long\def\xint_gob_til_dot    #1.{}%
\long\def\xint_gob_til_G     #1G{}%
\long\def\xint_gob_til_minus #1-{}%
\long\def\xint_UDzerominusfork #10-#2#3\krof {#2}%
\long\def\xint_UDzerofork       #10#2#3\krof {#2}%
\long\def\xint_UDsignfork       #1-#2#3\krof {#2}%
\long\def\xint_UDwfork         #1\W#2#3\krof {#2}%
\long\def\xint_UDXINTWfork     #1\XINT_W#2#3\krof {#2}%
\long\def\xint_UDzerosfork     #100#2#3\krof {#2}%
\long\def\xint_UDonezerofork   #110#2#3\krof {#2}%
\long\def\xint_UDsignsfork     #1--#2#3\krof {#2}%
\let\xint:\char
\long\def\xint_gob_til_xint:#1\xint:{}%
\long\def\xint_gob_til_^#1^{}%
\def\xint_bracedstopper{\xint:}%
\long\def\xint_gob_til_exclam #1!{}% This ! has catcode 12
\long\def\xint_gob_til_sc #1;{}%
```

3.7 `\xint_afterfi`

```
\long\def\xint_afterfi #1#2\fi {\fi #1}%
```

3.8 `\xint_bye`, `\xint_Bye`

Modified at 1.09 (2013/09/23). \xint_bye

Modified at 1.2i (2016/12/13). \xint_Bye for \xintDSRr and \xintRound. Also \xint_stop_afterbye.

```
\long\def\xint_bye #1\xint_bye {}%
\long\def\xint_Bye #1\xint_bye {}%
\long\def\xint_stop_afterbye #1\xint_bye { }%
```

3.9 `\xintdothis`, `\xintorthat`

Modified at 1.1 (2014/10/28).

Modified at 1.2 (2015/10/10). Names without underscores.

To be used this way:

```
\if..\xint_dothis{..}\fi
\if..\xint_dothis{..}\fi
\if..\xint_dothis{..}\fi
...more such...
\xint_orthat{...}
```

Ancient testing indicated it is more efficient to list first the more improbable clauses.

```
\long\def\xint_dothis #1#2\xint_orthat #3{\fi #1}% 1.1
\let\xint_orthat \xint_firstofone
\long\def\xintdothis #1#2\xintorthat #3{\fi #1}%
\let\xintorthat \xint_firstofone
```

3.10 \xint_zapspaces

Modified at 1.1 (2014/10/28). This little (quite fragile in the normal sense i.e. non robust in the normal sense of programming lingua) utility zaps leading, intermediate, trailing, spaces in completely expanding context (\edef, \csname...\endcsname).

Usage: `\xint_zapspaces foo<space>\xint_gobble_i`

Explanation: if there are leading spaces, then the first #1 will be empty, and the first #2 being undelimited will be stripped from all the remaining leading spaces, if there was more than one to start with. Of course brace-stripping may occur. And this iterates: each time a #2 is removed, either we then have spaces and next #1 will be empty, or we have no spaces and #1 will end at the first space. Ultimately #2 will be \xint_gobble_i.

The \zap@spaces of LaTeX2e handles unexpectedly things such as

`\zap@spaces 1 {22} 3 4 \@empty`

(spaces are not all removed). This does not happen with \xint_zapspaces.

But for example \foo{aa} {bb} {cc} where \foo is a macro with three non-delimited arguments breaks expansion, as expansion of \foo will happen with \xint_zapspaces still around, and even if it wasn't it would have stripped the braces around {bb}, certainly breaking other things.

Despite such obvious shortcomings it is enough for our purposes. It is currently used by xint-expr at various locations e.g. cleaning up optional argument of \xintiexpr and \xintfloatexpr; maybe in future internal usage will drop this in favour of a more robust utility.

Modified at 1.2e (2015/11/22). \xint_zapspaces_o.

Modified at 1.2i (2016/12/13). Made \long.

ATTENTION THAT xinttools HAS AN \xintzapspaces WHICH SHOULD NOT GET CONFUSED WITH THIS ONE.

```
\long\def\xint_zapspaces #1 #2{#1#2\xint_zapspaces }% 1.1
\long\def\xint_zapspaces_o #1{\expandafter\xint_zapspaces#1 \xint_gobble_i}%
```

3.11 \odef, \oodef, \fdef

May be prefixed with \global. No parameter text.

```
\def\xintodef #1{\expandafter\def\expandafter#1\expandafter }%
\def\xintoodef #1{\expandafter\expandafter\expandafter\def
                  \expandafter\expandafter\expandafter#1%
                  \expandafter\expandafter\expandafter }%
\def\xintfdef #1#2%
    {\expandafter\def\expandafter#1\expandafter{\romannumeral`&&@#2}}%
\ifdefined\odef\else\let\odef\xintodef\fi
\ifdefined\oodef\else\let\oodef\xintoodef\fi
\ifdefined\fdef\else\let\fdef\xintfdef\fi
```

3.12 \xintReverseOrder

Modified at 1.0 (2013/03/28). Does not expand its argument. The whole of xint codebase now contains only two calls to \XINT_rord_main (in xintgcd).
Attention: removes brace pairs (and swallows spaces).
For digit tokens a faster reverse macro is provided by (1.2) \xintReverseDigits in xint.
For comma separated items, 1.2g has \xintCSVReverse in xinttools.

```
\def\xintReverseOrder {\romannumeral0\xintreverseorder }%
\long\def\xintreverseorder #1%
{%
    \XINT_rord_main {}#1%
      \xint:
        \xint_bye\xint_bye\xint_bye\xint_bye
        \xint_bye\xint_bye\xint_bye\xint_bye
      \xint:
}%
\long\def\XINT_rord_main #1#2#3#4#5#6#7#8#9%
{%
    \xint_bye #9\XINT_rord_cleanup\xint_bye
    \XINT_rord_main {#9#8#7#6#5#4#3#2#1}%
}%
\def\XINT_rord_cleanup #1{%
\long\def\XINT_rord_cleanup\xint_bye\XINT_rord_main ##1##2\xint:
{%
    \expandafter#1\xint_gob_til_xint: ##1%
}}\XINT_rord_cleanup { }%
```

3.13 \xintLength

Modified at 1.0 (2013/03/28). Does not expand its argument. See \xintNthElt{0} from xinttools which f-expands its argument.

Modified at 1.2g (2016/03/19). Added \xintCSVLength to xinttools.

Modified at 1.2i (2016/12/13). Rewrote this venerable macro. New code about 40% faster across all lengths. Syntax with \romannumeral0 adds some slight (negligible) overhead; it is done to fit some general principles of structure of the xint package macros but maybe at some point I should drop it. And in fact it is often called directly via the \numexpr access point. (bad coding...)

```
\def\xintLength {\romannumeral0\xintlength }%
\def\xintlength #1{%
\long\def\xintlength ##1%
{%
    \expandafter#1\the\numexpr\XINT_length_loop
    ##1\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
       \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
       \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    \relax
}}\xintlength{ }%
\long\def\XINT_length_loop #1#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_xint: #9\XINT_length_finish_a\xint:
    \xint_c_ix+\XINT_length_loop
}%
\def\XINT_length_finish_a\xint:\xint_c_ix+\XINT_length_loop
```

```
    #1#2#3#4#5#6#7#8#9%
{%
    #9\xint_bye
}%
```

3.14 \xintLastItem

Modified at 1.2i (2016/12/13). One level of braces removed in output. Output empty if input empty. Attention! This means that an empty input or an input ending with a empty brace pair both give same output.

The \xint: token must not be among items. \xintFirstItem added at 1.4 for usage in xintexpr. It must contain neither \xint: nor \xint_bye in its first item.

```
\def\xintLastItem {\romannumeral0\xintlastitem }%
\long\def\xintlastitem #1%
{%
    \XINT_last_loop {}.#1%
    {\xint:\XINT_last_loop_enda}{\xint:\XINT_last_loop_endb}%
    {\xint:\XINT_last_loop_endc}{\xint:\XINT_last_loop_endd}%
    {\xint:\XINT_last_loop_ende}{\xint:\XINT_last_loop_endf}%
    {\xint:\XINT_last_loop_endg}{\xint:\XINT_last_loop_endh}\xint_bye
}%
\long\def\XINT_last_loop #1.#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_xint: #9%
        {#8}{#7}{#6}{#5}{#4}{#3}{#2}{#1}\xint:
    \XINT_last_loop {#9}.%
}%
\long\def\XINT_last_loop_enda #1#2\xint_bye{ #1}%
\long\def\XINT_last_loop_endb #1#2#3\xint_bye{ #2}%
\long\def\XINT_last_loop_endc #1#2#3#4\xint_bye{ #3}%
\long\def\XINT_last_loop_endd #1#2#3#4#5\xint_bye{ #4}%
\long\def\XINT_last_loop_ende #1#2#3#4#5#6\xint_bye{ #5}%
\long\def\XINT_last_loop_endf #1#2#3#4#5#6#7\xint_bye{ #6}%
\long\def\XINT_last_loop_endg #1#2#3#4#5#6#7#8\xint_bye{ #7}%
\long\def\XINT_last_loop_endh #1#2#3#4#5#6#7#8#9\xint_bye{ #8}%
```

3.15 \xintFirstItem

1.4. There must be neither \xint: nor \xint_bye in its first item.

```
\def\xintFirstItem         {\romannumeral0\xintfirstitem }%
\long\def\xintfirstitem   #1{\XINT_firstitem #1{\xint:\XINT_firstitem_end}\xint_bye}%
\long\def\XINT_firstitem #1#2\xint_bye{\xint_gob_til_xint: #1\xint:\space #1}%
\def\XINT_firstitem_end\xint:{ }%
```

3.16 \xintLastOne

As xintexpr 1.4 uses {c1}{c2}....{cN} storage when gathering comma separated values we need to not handle identically an empty list and a list with an empty item (as the above allows hierarchical structures). But \xintLastItem removed one level of brace pair so it is anadequate for the last() function.

By the way it is logical to interpret «item» as meaning {cj} inclusive of the braces; but legacy xint user manual was not written in this spirit. And thus \xintLastItem did brace stripping, thus we need another name for maintaining backwards compatibility (although the cardinality of users is small).

The \xint: token must not be found (visible) among the item contents.

```
\def\xintLastOne {\romannumeral0\xintlastone }%
\long\def\xintlastone #1%
{%
    \XINT_lastone_loop {}.#1%
    {\xint:\XINT_lastone_loop_enda}{\xint:\XINT_lastone_loop_endb}%
    {\xint:\XINT_lastone_loop_endc}{\xint:\XINT_lastone_loop_endd}%
    {\xint:\XINT_lastone_loop_ende}{\xint:\XINT_lastone_loop_endf}%
    {\xint:\XINT_lastone_loop_endg}{\xint:\XINT_lastone_loop_endh}\xint_bye
}%
\long\def\XINT_lastone_loop #1.#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_xint: #9%
        {#8}{#7}{#6}{#5}{#4}{#3}{#2}{#1}\xint:
    \XINT_lastone_loop {{#9}}.%
}%
\long\def\XINT_lastone_loop_enda #1#2\xint_bye{{#1}}%
\long\def\XINT_lastone_loop_endb #1#2#3\xint_bye{{#2}}%
\long\def\XINT_lastone_loop_endc #1#2#3#4\xint_bye{{#3}}%
\long\def\XINT_lastone_loop_endd #1#2#3#4#5\xint_bye{{#4}}%
\long\def\XINT_lastone_loop_ende #1#2#3#4#5#6\xint_bye{{#5}}%
\long\def\XINT_lastone_loop_endf #1#2#3#4#5#6#7\xint_bye{{#6}}%
\long\def\XINT_lastone_loop_endg #1#2#3#4#5#6#7#8\xint_bye{{#7}}%
\long\def\XINT_lastone_loop_endh #1#2#3#4#5#6#7#8#9\xint_bye{ #8}%
```

3.17 \xintFirstOne

For xintexpr 1.4 too. Jan 3, 2020.

This is an experimental macro, don't use it. If input is nil (empty set) it expands to nil, if not it fetches first item and braces it. Fetching will have stripped one brace pair if item was braced to start with, which is the case in non-symbolic xintexpr data objects.

I have not given much thought to this (make it shorter, allow all tokens, (we could first test if empty via combination with \detokenize), etc...) as I need to get xint 1.4 out soon. So in particular attention that the macro assumes the \xint: token is absent from first item of input.

```
\def\xintFirstOne  {\romannumeral0\xintfirstone }%
\long\def\xintfirstone  #1{\XINT_firstone #1{\xint:\XINT_firstone_empty}\xint:}%
\long\def\XINT_firstone #1#2\xint:{\xint_gob_til_xint: #1\xint:{#1}}%
\def\XINT_firstone_empty\xint:#1{ }%
```

3.18 \xintLengthUpTo

Modified at 1.2i (2016/12/13). For use by \xintKeep and \xintTrim (xinttools). The argument N **must be non-negative**.

\xintLengthUpTo{N}{List} produces -0 if length(List)>N, else it returns N-length(List). Hence subtracting it from N always computes min(N,length(List)).

Modified at 1.2j (2016/12/22). Changed ending and interface to core loop.

```
\def\xintLengthUpTo {\romannumeral0\xintlengthupto}%
\long\def\xintlengthupto #1#2%
{%
```

```
    \expandafter\XINT_lengthupto_loop
    \the\numexpr#1.#2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
         \xint_c_vii\xint_c_vi\xint_c_v\xint_c_iv
         \xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye.%
}%
\def\XINT_lengthupto_loop_a #1%
{%
    \xint_UDsignfork
      #1\XINT_lengthupto_gt
      -\XINT_lengthupto_loop
    \krof #1%
}%
\long\def\XINT_lengthupto_gt #1\xint_bye.{-0}%
\long\def\XINT_lengthupto_loop #1.#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_xint: #9\XINT_lengthupto_finish_a\xint:%
    \expandafter\XINT_lengthupto_loop_a\the\numexpr #1-\xint_c_viii.%
}%
\def\XINT_lengthupto_finish_a\xint:\expandafter\XINT_lengthupto_loop_a
    \the\numexpr #1-\xint_c_viii.#2#3#4#5#6#7#8#9%
{%
    \expandafter\XINT_lengthupto_finish_b\the\numexpr #1-#9\xint_bye
}%
\def\XINT_lengthupto_finish_b #1#2.%
{%
    \xint_UDsignfork
       #1{-0}%
        -{ #1#2}%
    \krof
}%
```

3.19 \xintreplicate, \xintReplicate

Modified at 1.2i (2016/12/13). This is cloned from LaTeX3's \prg_replicate:nn, see Joseph's post at

http://tex.stackexchange.com/questions/16189/repeat-command-n-times

I posted there an alternative not using the chained \csname's but it is a bit less efficient (except perhaps for thousands of repetitions). The code in Joseph's post does abs(#1) replications when input #1 is negative and then activates an error triggering macro; here we simply do nothing when #1 is negative.

Usage: \romannumeral\xintreplicate{N}{stuff}

When N is already explicit digits (even N=0, but non-negative) one can call the macro as

\romannumeral\XINT_rep N\endcsname {foo}

to skip the \numexpr.

Modified at 1.4 (2020/01/31). Added \xintReplicate ! The reason I did not before is that the prevailing habits in xint source code was to trigger with \romannumeral0 not \romannumeral which is the lowercased named macros. Thus adding the camelcase one creates a couple \xintReplicate/\xintreplicate not obeying the general mold.

```
\def\xintReplicate{\romannumeral\xintreplicate}%
\def\xintreplicate#1%
   {\expandafter\XINT_replicate\the\numexpr#1\endcsname}%
\def\XINT_replicate #1{\xint_UDsignfork
```

```
                          #1\XINT_rep_neg
                           -\XINT_rep
                        \krof #1}%
\long\def\XINT_rep_neg #1\endcsname #2{\xint_c_}%
\def\XINT_rep    #1{\csname XINT_rep_f#1\XINT_rep_a}%
\def\XINT_rep_a #1{\csname XINT_rep_#1\XINT_rep_a}%
\def\XINT_rep_\XINT_rep_a{\endcsname}%
\long\expandafter\def\csname XINT_rep_0\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}}%
\long\expandafter\def\csname XINT_rep_1\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1}%
\long\expandafter\def\csname XINT_rep_2\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1#1}%
\long\expandafter\def\csname XINT_rep_3\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1#1#1}%
\long\expandafter\def\csname XINT_rep_4\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_5\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_6\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_7\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_8\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_9\endcsname #1%
    {\endcsname{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_f0\endcsname #1%
    {\xint_c_}%
\long\expandafter\def\csname XINT_rep_f1\endcsname #1%
    {\xint_c_ #1}%
\long\expandafter\def\csname XINT_rep_f2\endcsname #1%
    {\xint_c_ #1#1}%
\long\expandafter\def\csname XINT_rep_f3\endcsname #1%
    {\xint_c_ #1#1#1}%
\long\expandafter\def\csname XINT_rep_f4\endcsname #1%
    {\xint_c_ #1#1#1#1}%
\long\expandafter\def\csname XINT_rep_f5\endcsname #1%
    {\xint_c_ #1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_f6\endcsname #1%
    {\xint_c_ #1#1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_f7\endcsname #1%
    {\xint_c_ #1#1#1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_f8\endcsname #1%
    {\xint_c_ #1#1#1#1#1#1#1#1}%
\long\expandafter\def\csname XINT_rep_f9\endcsname #1%
    {\xint_c_ #1#1#1#1#1#1#1#1#1}%
```

3.20 \xintgobble, \xintGobble

Modified at 1.2i (2016/12/13). I hesitated about allowing as many as 9^6-1=531440 tokens to gobble, but 9^5-1=59058 is too low for playing with long decimal expansions.

Usage: `\romannumeral\xintgobble{N}...`

Modified at 1.4 (2020/01/31). Added `\xintGobble`.

```
\def\xintGobble{\romannumeral\xintgobble}%
\def\xintgobble #1%
   {\csname xint_c_\expandafter\XINT_gobble_a\the\numexpr#1.0}%
\def\XINT_gobble #1.{\csname xint_c_\XINT_gobble_a #1.0}%
\def\XINT_gobble_a #1{\xint_gob_til_zero#1\XINT_gobble_d0\XINT_gobble_b#1}%
\def\XINT_gobble_b #1.#2%
  {\expandafter\XINT_gobble_c
      \the\numexpr (#1+\xint_c_v)/\xint_c_ix-\xint_c_i\expandafter.%
      \the\numexpr #2+\xint_c_i.#1.}%
\def\XINT_gobble_c #1.#2.#3.%
  {\csname XINT_g#2\the\numexpr#3-\xint_c_ix*#1\relax\XINT_gobble_a #1.#2}%
\def\XINT_gobble_d0\XINT_gobble_b0.#1{\endcsname}%
\expandafter\let\csname XINT_g10\endcsname\endcsname
\long\expandafter\def\csname XINT_g11\endcsname#1{\endcsname}%
\long\expandafter\def\csname XINT_g12\endcsname#1#2{\endcsname}%
\long\expandafter\def\csname XINT_g13\endcsname#1#2#3{\endcsname}%
\long\expandafter\def\csname XINT_g14\endcsname#1#2#3#4{\endcsname}%
\long\expandafter\def\csname XINT_g15\endcsname#1#2#3#4#5{\endcsname}%
\long\expandafter\def\csname XINT_g16\endcsname#1#2#3#4#5#6{\endcsname}%
\long\expandafter\def\csname XINT_g17\endcsname#1#2#3#4#5#6#7{\endcsname}%
\long\expandafter\def\csname XINT_g18\endcsname#1#2#3#4#5#6#7#8{\endcsname}%
\expandafter\let\csname XINT_g20\endcsname\endcsname
\long\expandafter\def\csname XINT_g21\endcsname #1#2#3#4#5#6#7#8#9%
 {\endcsname}%
\long\expandafter\edef\csname XINT_g22\endcsname #1#2#3#4#5#6#7#8#9%
 {\expandafter\noexpand\csname XINT_g21\endcsname}%
\long\expandafter\edef\csname XINT_g23\endcsname #1#2#3#4#5#6#7#8#9%
 {\expandafter\noexpand\csname XINT_g22\endcsname}%
\long\expandafter\edef\csname XINT_g24\endcsname #1#2#3#4#5#6#7#8#9%
 {\expandafter\noexpand\csname XINT_g23\endcsname}%
\long\expandafter\edef\csname XINT_g25\endcsname #1#2#3#4#5#6#7#8#9%
 {\expandafter\noexpand\csname XINT_g24\endcsname}%
\long\expandafter\edef\csname XINT_g26\endcsname #1#2#3#4#5#6#7#8#9%
 {\expandafter\noexpand\csname XINT_g25\endcsname}%
\long\expandafter\edef\csname XINT_g27\endcsname #1#2#3#4#5#6#7#8#9%
 {\expandafter\noexpand\csname XINT_g26\endcsname}%
\long\expandafter\edef\csname XINT_g28\endcsname #1#2#3#4#5#6#7#8#9%
 {\expandafter\noexpand\csname XINT_g27\endcsname}%
\expandafter\let\csname XINT_g30\endcsname\endcsname
\long\expandafter\edef\csname XINT_g31\endcsname #1#2#3#4#5#6#7#8#9%
 {\expandafter\noexpand\csname XINT_g28\endcsname}%
\long\expandafter\edef\csname XINT_g32\endcsname #1#2#3#4#5#6#7#8#9%
 {\noexpand\csname XINT_g31\expandafter\noexpand\csname XINT_g28\endcsname}%
\long\expandafter\edef\csname XINT_g33\endcsname #1#2#3#4#5#6#7#8#9%
 {\noexpand\csname XINT_g32\expandafter\noexpand\csname XINT_g28\endcsname}%
\long\expandafter\edef\csname XINT_g34\endcsname #1#2#3#4#5#6#7#8#9%
 {\noexpand\csname XINT_g33\expandafter\noexpand\csname XINT_g28\endcsname}%
\long\expandafter\edef\csname XINT_g35\endcsname #1#2#3#4#5#6#7#8#9%
 {\noexpand\csname XINT_g34\expandafter\noexpand\csname XINT_g28\endcsname}%
\long\expandafter\edef\csname XINT_g36\endcsname #1#2#3#4#5#6#7#8#9%
```

```
 {\noexpand\csname XINT_g35\expandafter\noexpand\csname XINT_g28\endcsname}%
\long\expandafter\edef\csname XINT_g37\endcsname #1#2#3#4#5#6#7#8#9%
 {\noexpand\csname XINT_g36\expandafter\noexpand\csname XINT_g28\endcsname}%
\long\expandafter\edef\csname XINT_g38\endcsname #1#2#3#4#5#6#7#8#9%
 {\noexpand\csname XINT_g37\expandafter\noexpand\csname XINT_g28\endcsname}%
\expandafter\let\csname XINT_g40\endcsname\endcsname
\expandafter\edef\csname XINT_g41\endcsname
 {\noexpand\csname XINT_g38\expandafter\noexpand\csname XINT_g31\endcsname}%
\expandafter\edef\csname XINT_g42\endcsname
 {\noexpand\csname XINT_g41\expandafter\noexpand\csname XINT_g41\endcsname}%
\expandafter\edef\csname XINT_g43\endcsname
 {\noexpand\csname XINT_g42\expandafter\noexpand\csname XINT_g41\endcsname}%
\expandafter\edef\csname XINT_g44\endcsname
 {\noexpand\csname XINT_g43\expandafter\noexpand\csname XINT_g41\endcsname}%
\expandafter\edef\csname XINT_g45\endcsname
 {\noexpand\csname XINT_g44\expandafter\noexpand\csname XINT_g41\endcsname}%
\expandafter\edef\csname XINT_g46\endcsname
 {\noexpand\csname XINT_g45\expandafter\noexpand\csname XINT_g41\endcsname}%
\expandafter\edef\csname XINT_g47\endcsname
 {\noexpand\csname XINT_g46\expandafter\noexpand\csname XINT_g41\endcsname}%
\expandafter\edef\csname XINT_g48\endcsname
 {\noexpand\csname XINT_g47\expandafter\noexpand\csname XINT_g41\endcsname}%
\expandafter\let\csname XINT_g50\endcsname\endcsname
\expandafter\edef\csname XINT_g51\endcsname
 {\noexpand\csname XINT_g48\expandafter\noexpand\csname XINT_g41\endcsname}%
\expandafter\edef\csname XINT_g52\endcsname
 {\noexpand\csname XINT_g51\expandafter\noexpand\csname XINT_g51\endcsname}%
\expandafter\edef\csname XINT_g53\endcsname
 {\noexpand\csname XINT_g52\expandafter\noexpand\csname XINT_g51\endcsname}%
\expandafter\edef\csname XINT_g54\endcsname
 {\noexpand\csname XINT_g53\expandafter\noexpand\csname XINT_g51\endcsname}%
\expandafter\edef\csname XINT_g55\endcsname
 {\noexpand\csname XINT_g54\expandafter\noexpand\csname XINT_g51\endcsname}%
\expandafter\edef\csname XINT_g56\endcsname
 {\noexpand\csname XINT_g55\expandafter\noexpand\csname XINT_g51\endcsname}%
\expandafter\edef\csname XINT_g57\endcsname
 {\noexpand\csname XINT_g56\expandafter\noexpand\csname XINT_g51\endcsname}%
\expandafter\edef\csname XINT_g58\endcsname
 {\noexpand\csname XINT_g57\expandafter\noexpand\csname XINT_g51\endcsname}%
\expandafter\let\csname XINT_g60\endcsname\endcsname
\expandafter\edef\csname XINT_g61\endcsname
 {\noexpand\csname XINT_g58\expandafter\noexpand\csname XINT_g51\endcsname}%
\expandafter\edef\csname XINT_g62\endcsname
 {\noexpand\csname XINT_g61\expandafter\noexpand\csname XINT_g61\endcsname}%
\expandafter\edef\csname XINT_g63\endcsname
 {\noexpand\csname XINT_g62\expandafter\noexpand\csname XINT_g61\endcsname}%
\expandafter\edef\csname XINT_g64\endcsname
 {\noexpand\csname XINT_g63\expandafter\noexpand\csname XINT_g61\endcsname}%
\expandafter\edef\csname XINT_g65\endcsname
 {\noexpand\csname XINT_g64\expandafter\noexpand\csname XINT_g61\endcsname}%
\expandafter\edef\csname XINT_g66\endcsname
 {\noexpand\csname XINT_g65\expandafter\noexpand\csname XINT_g61\endcsname}%
```

```
\expandafter\edef\csname XINT_g67\endcsname
 {\noexpand\csname XINT_g66\expandafter\noexpand\csname XINT_g61\endcsname}%
\expandafter\edef\csname XINT_g68\endcsname
 {\noexpand\csname XINT_g67\expandafter\noexpand\csname XINT_g61\endcsname}%
```

3.21 (WIP) \xintUniformDeviate

Modified at 1.3b (2018/05/18). See user manual for related information.

```
\ifdefined\xint_texuniformdeviate
    \expandafter\xint_firstoftwo
\else\expandafter\xint_secondoftwo
\fi
{%
  \def\xintUniformDeviate#1%
     {\the\numexpr\expandafter\XINT_uniformdeviate_sgnfork\the\numexpr#1\xint:}%
  \def\XINT_uniformdeviate_sgnfork#1%
  {%
     \if-#1\XINT_uniformdeviate_neg\fi \XINT_uniformdeviate{}#1%
  }%
  \def\XINT_uniformdeviate_neg\fi\XINT_uniformdeviate#1-%
  {%
      \fi-\numexpr\XINT_uniformdeviate\relax
  }%
  \def\XINT_uniformdeviate#1#2\xint:
  {%(
      \expandafter\XINT_uniformdeviate_a\the\numexpr%
                   -\xint_texuniformdeviate\xint_c_ii^vii%
                   -\xint_c_ii^vii*\xint_texuniformdeviate\xint_c_ii^vii%
                   -\xint_c_ii^xiv*\xint_texuniformdeviate\xint_c_ii^vii%
                   -\xint_c_ii^xxi*\xint_texuniformdeviate\xint_c_ii^vii%
                   +\xint_texuniformdeviate#2\xint:/#2)*#2\xint:+#2\fi\relax#1%
  }%
  \def\XINT_uniformdeviate_a #1\xint:
  {%
      \expandafter\XINT_uniformdeviate_b\the\numexpr#1-(#1%
  }%
  \def\XINT_uniformdeviate_b#1#2\xint:{#1#2\if-#1}%
}%
{%
  \def\xintUniformDeviate#1%
  {%
      \the\numexpr
      \XINT_expandableerror{(xintkernel) No uniformdeviate primitive!}%
      0\relax
  }%
}%
```

3.22 \xintMessage, \ifxintverbose

Modified at 1.2c (2015/11/16). For use by \xintdefvar and \xintdeffunc of xintexpr.

Modified at 1.2e (2015/11/22). Uses \write128 rather than \write16 for compatibility with future extended range of output streams, in LuaTeX in particular.

Modified at 1.3e (2019/04/05). Set the \newlinechar.

```
\def\xintMessage #1#2#3{%
    \edef\XINT_newlinechar{\the\newlinechar}%
    \newlinechar10
    \immediate\write128{Package #1 #2: (on line \the\inputlineno)}%
    \immediate\write128{\space\space\space\space#3}%
    \newlinechar\XINT_newlinechar\space
}%
\newif\ifxintverbose
```

3.23 \ifxintglobaldefs, \XINT_global

Modified at 1.3c (2018/06/17).

```
\newif\ifxintglobaldefs
\def\XINT_global{\ifxintglobaldefs\global\fi}%
```

3.24 (WIP) Expandable error message

Modified at 1.2l (2017/07/26). But really belongs to next major release beyond 1.3. Basically copied over from l3kernel code. Using \ ! / control sequence, which must be left undefined. \xintError: would be 6 letters more.

Modified at 1.4 (2020/01/31). Finally rather than \ ! / I use \xint/.

Modified at 1.4g (2021/05/25). Rewrote to use not an undefined control sequence but trigger "Use of \xint/ doesn't match its definition." message.

Modified at 1.4g (2021/05/25). Things evolve fast and I switch to a third method which will exploit "Paragraph ended before \foo was complete" style error. See

https://github.com/latex3/latex3/issues/931#issuecomment-845367201

However I can not fully exploit this because xint may be used with Plain etex which does not set \newlinechar. I can only use a poorman version with no usage of ^^J. Also xintsession could use the ^^J, maybe I will integrate it there.

I. Explanations on 2021/05/19 and 2021/05/20 before final change

First I tried out things with undefined control sequence such as

```
\        an error was reported by xint ...
```

whose output produces a nice symmetrical display with no \, and with ... both on left and right but this reduces drastically the available space for the actual error context. No go. But see 2021/05/20 update below!

Having replaced \xint/ by "\xint ", I next opted provisorily for "\Hit RET at ?" control sequence, despite it being quite longer. And then I thought about using "\ xint error", possibly with an included ^^J in the name, or in the context.

I experimented with ^^J in the context. But the context size is much constrained, and when \errorcontextlines is at its default value of 5 for etex, not -1 as done by LaTeX, having the info shifted to the right makes it actually more visible. (however I have now updated xintsession to 0.2b which sets \errorcontextlines to 0)

So I was finally back here to square one, apart from having replaced "\xint/" by the more longish "\ xint error", hesitating with "\xinterrupt"...

Then I had the idea to replace the undefined control sequence method by a method with a macro \foo defined as \def\foo.{} but used as \foo<space> for example. This gives something like this (the first line will be otherwise if engine is run with -file-line-error):

```
! Use of \xint/ doesn't match its definition.
<argument> \xint/
                  Ooops, looks like we are missing a ] (hit RET)
```

\xint/<space> (where the space is the unexpected token, the definition expecting rather a full stop) makes for 7 characters to compare to \ xint error which had 12, so I gained back 5.
Back to ^^J: I had overlooked that TeX in the first part of the error message will display \macro fully, so inserting ^^J in its name allows arbitrarily long expandable error messages... as pointed out by BLF in latex3/issues#931 as I read on the morning of 2021/05/20. This is very nice but requires to predefine control sequences for each message, and also the actual arguments #1, #2, ... values can appear only in the context.

And the situation with ^^J is somewhat complicated:

xintsession sets the \newlinechar to 10, but this is not the case with bare usage of xintexpr with etex. And this matters. To discuss ^^J we have to separate two locations:

- it appears in the control sequence name,
- or in the context (which itself has two parts)

1) When in the context, what happens with ^^J is independent of the setting of \newlinechar, and with TeXLive pdflatex the ^^J will induce a linebreak, but with xelatex it must be used with option -8bit.
2) When in the control sequence name the behaviour in log/terminal of ^^J is influenced by the setting of \newlinechar. Although with pdflatex it will always induce a linebreak, the actual count of characters where TeX will forcefully break is influenced by whether ^^J is or not \newlinechar. And with xelatex if it is \newlinechar, it does not depend then if -8bit or not, but if not \newlinechar then it does and TeX forceful breaks also change as for pdflatex.

So, the control sequence name trick can be used to obtain arbitrarily long messages, but the \newlinechar must be set.

And in the context, we can try to insert some ^^J but this would need with xetex the -8bit option, and anyhow the context size is limited, and there is apparently no trick to get it larger.

So, in view of all the above I decided not to use ^^J (rather &&J here) at all, whether here in the control sequence or the context or inserted in \XINT_signalcondition in the context!

I also have a problem with usage from bnumexpr or polexpr for example, they would need their own to avoid perhaps displaying \xint/ or analogous.

II. Finally I modified again the method (completely, and no more need for funny catcode 7 space as delimiter) as this allows a longer context message, starting at start of line, and which obeys ^^J if \newlinechar is set to it. It also allows to incorporate non-limited generic explanations as a postfix, with linebreaks if \newlinechar is known.

But as xintexpr can be used with Plain+etex which does not set the \newlinechar, I can't use ^^J out of thee box. I can in xintsession. What I decided finally is to make a conditional definition here.

In both cases I include the "hit RET" (how rather "hit <return>") in the control sequence name serving to both provide extra information and trigger the error from being defined short and finding a \par.

The maximal size was increased from 48 characters (method with \xint/ being badly delimited), to now 55 characters (using "! xint error:<^^J or space>" as prefix to the message). Longer messages are truncated at 56 characters with an appended "\ETC.".

As it is late on this 2021/05/20, and in order to not have to change all usages, I keep \XINT_signalcondition (in xintcore) as a one argument macro for time being, so will not include a more specific module name.

The \par token has a special role here, and can't be (I)nserted without damage, but who would want to insert it in an expandable computation anyhow... and I don't need it in my custom error messages for sure.

On 2021/05/21 I add a test about \newlinechar at time of package loading, and make two distinct definitions: one using ^^J in the control sequence, the other not using it.

The -file-line-error toggle makes it impossible to control if the line-break on first line will match next lines. In the ^^J branch I insert "| " (no, finally " " with two spaces) at start of continuation lines. Also I preferred to ensure a good-looking first line break for the case it starts with a "! Paragraph ended ..." because a priori error messages will be read if -file-line-error was emitted only a fortiori (this toggle suggests some IDE launched TeX and probably -interaction=nonstopmode).

I will perhaps make another definition in xintsession (it currently loads xintexpr prior to having set the \newlinechar, so the no ^^J definition will be used, if nothing else is modified there).

With some hesitation I do not insert a ^^J after "! xint error:", as Emacs/AucTeX will display only the first line prominently and then the rest (which is in file:line:error mode) in one block under "--- TeX said ---". I use the ^^J only in the generic helper message embedded in the control sequence. The cases with or without \newlinechar being 10 diverge a bit, as in the latter case I had to ensure acceptable linebreaks at 79 chars, and I did that first and then had spent enough time on the matter not to add more to backport the latest ^^J style message.

Modified at 1.4m (2022/06/10). Shorten the error message. I am always too verbose initially.

```
\ifnum\newlinechar=10
\expandafter\def\csname
xint<...> is done, but will resume:&&J \space
hit <return> at the ? prompt to try fixing the error above&&J \space
which has been encountered before expansion\endcsname
#1\xint:{}%
\def\XINT_expandableerror#1{%
\def\XINT_expandableerror##1{%
  \expandafter
  \XINT_expandableerrorcontinue
  #1! xint error: ##1\par
}}\expandafter\XINT_expandableerror\csname
xint<...> is done, but will resume:&&J \space
hit <return> at the ? prompt to try fixing the error above&&J \space
which has been encountered before expansion\endcsname
\else
\expandafter\def\csname
xint<...> is done, but will resume: hit <return>
at \space the ? prompt to try fixing the error
encountered before expansion\endcsname
#1\xint:{}%
\def\XINT_expandableerror#1{%
\def\XINT_expandableerror##1{%
  \expandafter
  \XINT_expandableerrorcontinue
  #1! xint error: ##1\par
}}\expandafter\XINT_expandableerror\csname
xint<...> is done, but will resume: hit <return>
at \space the ? prompt to try fixing the error
encountered before expansion\endcsname
\fi
\def\XINT_expandableerrorcontinue#1\par{#1}%
```

3.25 The \xintstrcmp as alias of the engine primitive

Added at 1.4m (2022/06/10) [on 2022/06/05]. For the LuaTeX engine the code is copied over from l3names.dtx. I also looked at Heiko Oberdiek's pdftexcmds.sty and pdftexcmds.lua, but I removed \luaescapestring and used token.scan_string() as seen in l3names.dtx (and I did try to inform myself about this in the LuaTeX manual, but only briefly). I am not sure about my syntax with the local's. And should I use \directlua0? Testing was minimal Thus, we proceed at the user own risk.

```
\ifdefined\strcmp\let\xintstrcmp\strcmp
\else\ifdefined\pdfstrcmp\let\xintstrcmp\pdfstrcmp
\else\ifdefined\directlua\directlua{%
xintkernel = xintkernel or {}
local minus_tok = token.new(string.byte'-', 12)
local zero_tok = token.new(string.byte'0', 12)
local one_tok = token.new(string.byte'1', 12)
function xintkernel.strcmp()
  local A = token.scan_string()
  local B = token.scan_string()
  if A < B then
    tex.write(minus_tok, one_tok)
  else
    tex.write(A == B and zero_tok or one_tok)
  end
end
}\def\xintstrcmp{%
  \directlua{xintkernel.strcmp()}%
}%
\else
\xintMessage{xintkernel}{Error}{Could not set-up \string\xintstrcmp.}%
\errhelp{What kind of format are you using? Perhaps write the author? Bye now}%
\errmessage{Sorry, could not find or define string comparison primitive}\fi\fi\fi
\XINTrestorecatcodesendinput%
```

4 Package xinttools implementation

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Added at 1.09g (2013/11/22). Splits off xinttools from xint.

Modified at 1.1 (2014/10/28). xinttools ceases being loaded automatically by xint.

4.1 Catcodes, ε-TEX and reload detection

The code for reload detection was initially copied from Heiko Oberdiek's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5    % ^^M
  \endlinechar=13 %
  \catcode123=1   % {
  \catcode125=2   % }
  \catcode64=11   % @
  \catcode44=12   % ,
  \catcode46=12   % .
  \catcode58=12   % :
  \catcode94=7    % ^
  \def\empty{}\def\space{ }\newlinechar10
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xinttools.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xintkernel.sty\endcsname
```

```
  \expandafter\ifx\csname numexpr\endcsname\relax
    \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
      \immediate\write128{^^JPackage xinttools Warning:^^J%
                        \space\space\space\space
                        \numexpr not available, aborting input.^^J}%
    \else
      \PackageWarningNoLine{xinttools}{\numexpr not available, aborting input}%
    \fi
    \def\z{\endgroup\endinput}%
  \else
    \ifx\x\relax   % plain-TeX, first loading of xinttools.sty
      \ifx\w\relax % but xintkernel.sty not yet loaded.
         \def\z{\endgroup\input xintkernel.sty\relax}%
      \fi
    \else
      \ifx\x\empty % LaTeX, first loading,
      % variable is initialized, but \ProvidesPackage not yet seen
          \ifx\w\relax % xintkernel.sty not yet loaded.
            \def\z{\endgroup\RequirePackage{xintkernel}}%
          \fi
      \else
        \def\z{\endgroup\endinput}% xinttools already loaded.
      \fi
    \fi
  \fi
\z%
\XINTsetupcatcodes% defined in xintkernel.sty
```

4.2 Package identification

```
\XINT_providespackage
\ProvidesPackage{xinttools}%
  [2022/06/10 v1.4m Expandable and non-expandable utilities (JFB)]%
```

\XINT_toks is used in macros such as \xintFor. It is not used elsewhere in the xint bundle.

```
\newtoks\XINT_toks
\xint_firstofone{\let\XINT_sptoken= } %<- space here!
```

4.3 \xintgodef, \xintgoodef, \xintgfdef

Added at 1.09i (2013/12/18). For use in \xintAssign.

```
\def\xintgodef  {\global\xintodef }%
\def\xintgoodef {\global\xintoodef }%
\def\xintgfdef  {\global\xintfdef }%
```

4.4 \xintRevWithBraces

Added at 1.06 (2013/05/07). Makes the expansion of its argument and then reverses the resulting tokens or braced tokens, adding a pair of braces to each (thus, maintaining it when it was already there.) The reason for \xint:, here and in other locations, is in case #1 expands to nothing, the \romannumeral-`0 must be stopped.

```
\def\xintRevWithBraces         {\romannumeral0\xintrevwithbraces }%
```

```
\def\xintRevWithBracesNoExpand {\romannumeral0\xintrevwithbracesnoexpand }%
\long\def\xintrevwithbraces #1%
{%
    \expandafter\XINT_revwbr_loop\expandafter{\expandafter}%
    \romannumeral`&&@#1\xint:\xint:\xint:\xint:%
                      \xint:\xint:\xint:\xint:\xint_bye
}%
\long\def\xintrevwithbracesnoexpand #1%
{%
    \XINT_revwbr_loop {}%
    #1\xint:\xint:\xint:\xint:%
      \xint:\xint:\xint:\xint:\xint_bye
}%
\long\def\XINT_revwbr_loop #1#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_xint: #9\XINT_revwbr_finish_a\xint:%
    \XINT_revwbr_loop {{#9}{#8}{#7}{#6}{#5}{#4}{#3}{#2}#1}%
}%
\long\def\XINT_revwbr_finish_a\xint:\XINT_revwbr_loop #1#2\xint_bye
{%
    \XINT_revwbr_finish_b #2\R\R\R\R\R\R\R\Z #1%
}%
\def\XINT_revwbr_finish_b #1#2#3#4#5#6#7#8\Z
{%
    \xint_gob_til_R
            #1\XINT_revwbr_finish_c \xint_gobble_viii
            #2\XINT_revwbr_finish_c \xint_gobble_vii
            #3\XINT_revwbr_finish_c \xint_gobble_vi
            #4\XINT_revwbr_finish_c \xint_gobble_v
            #5\XINT_revwbr_finish_c \xint_gobble_iv
            #6\XINT_revwbr_finish_c \xint_gobble_iii
            #7\XINT_revwbr_finish_c \xint_gobble_ii
            \R\XINT_revwbr_finish_c \xint_gobble_i\Z
}%
```

1.1c revisited this old code and improved upon the earlier endings.

```
\def\XINT_revwbr_finish_c#1{%
\def\XINT_revwbr_finish_c##1##2\Z{\expandafter#1##1}%
}\XINT_revwbr_finish_c{ }%
```

4.5 \xintZapFirstSpaces

Added at 1.09f (2013/11/04) [on 2013/11/01].

Modified at 1.1 (2014/10/28). To correct the bug in case of an empty argument, or argument containing only spaces, which had been forgotten in first version. New version is simpler than the initial one. This macro does NOT expand its argument.

```
\def\xintZapFirstSpaces {\romannumeral0\xintzapfirstspaces }%
\def\xintzapfirstspaces#1{\long
\def\xintzapfirstspaces ##1{\XINT_zapbsp_a #1##1\xint:#1#1\xint:}%
}\xintzapfirstspaces{ }%
```

If the original #1 started with a space, the grabbed #1 is empty. Thus _again? will see #1=\xint_bye, and hand over control to _again which will loop back into \XINT_zapbsp_a, with one initial space less. If the original #1 did not start with a space, or was empty, then the #1 below will be a <sptoken>, then an extract of the original #1, not empty and not starting with a space, which contains what was up to the first <sp><sp> present in original #1, or, if none preexisted, <sptoken> and all of #1 (possibly empty) plus an ending \xint:. The added initial space will stop later the \romannumeral0. No brace stripping is possible. Control is handed over to \XINT_zapbsp_b which strips out the ending \xint:<sp><sp>\xint:

```
\def\XINT_zapbsp_a#1{\long\def\XINT_zapbsp_a ##1#1#1{%
  \XINT_zapbsp_again?##1\xint_bye\XINT_zapbsp_b ##1#1#1}%
}\XINT_zapbsp_a{ }%
\long\def\XINT_zapbsp_again? #1{\xint_bye #1\XINT_zapbsp_again }%
\xint_firstofone{\def\XINT_zapbsp_again\XINT_zapbsp_b} {\XINT_zapbsp_a }%
\long\def\XINT_zapbsp_b #1\xint:#2\xint:{#1}%
```

4.6 \xintZapLastSpaces

Added at 1.09f (2013/11/04) [on 2013/11/01].

```
\def\xintZapLastSpaces {\romannumeral0\xintzaplastspaces }%
\def\xintzaplastspaces#1{\long
\def\xintzaplastspaces ##1{\XINT_zapesp_a {}\empty##1#1#1\xint_bye\xint:}%
}\xintzaplastspaces{ }%
```

The \empty from \xintzaplastspaces is to prevent brace removal in the #2 below. The \expandafter chain removes it.

```
\xint_firstofone {\long\def\XINT_zapesp_a #1#2 } %<- second space here
    {\expandafter\XINT_zapesp_b\expandafter{#2}{#1}}%
```

Notice again an \empty added here. This is in preparation for possibly looping back to \XINT_zapesp_a. If the initial #1 had no <sp><sp>, the stuff however will not loop, because #3 will already be <some spaces>\xint_bye. Notice that this macro fetches all way to the ending \xint:. This looks not very efficient, but how often do we have to strip ending spaces from something which also has inner stretches of _multiple_ space tokens ?;-).

```
\long\def\XINT_zapesp_b #1#2#3\xint:%
    {\XINT_zapesp_end? #3\XINT_zapesp_e {#2#1}\empty #3\xint:}%
```

When we have been over all possible <sp><sp> things, we reach the ending space tokens, and #3 will be a bunch of spaces (possibly none) followed by \xint_bye. So the #1 in _end? will be \xint_bye. In all other cases #1 can not be \xint_bye (assuming naturally this token does nor arise in original input), hence control falls back to \XINT_zapesp_e which will loop back to \XINT_zapesp_a.

```
\long\def\XINT_zapesp_end? #1{\xint_bye #1\XINT_zapesp_end }%
```

We are done. The #1 here has accumulated all the previous material, and is stripped of its ending spaces, if any.

```
\long\def\XINT_zapesp_end\XINT_zapesp_e #1#2\xint:{ #1}%
```

We haven't yet reached the end, so we need to re-inject two space tokens after what we have gotten so far. Then we loop.

```
\def\XINT_zapesp_e#1{%
\long\def\XINT_zapesp_e ##1{\XINT_zapesp_a {##1#1#1}}%
}\XINT_zapesp_e{ }%
```

4.7 \xintZapSpaces

Added at 1.09f (2013/11/04) [on 2013/11/01].

Modified at 1.1 (2014/10/28). It had the same bug as \xintZapFirstSpaces. We in effect do first \xintZapFirstSpaces, then \xintZapLastSpaces.

```
\def\xintZapSpaces {\romannumeral0\xintzapspaces }%
\def\xintzapspaces#1{%
\long\def\xintzapspaces ##1% like \xintZapFirstSpaces.
        {\XINT_zapsp_a #1##1\xint:#1#1\xint:}%
}\xintzapspaces{ }%
\def\XINT_zapsp_a#1{%
\long\def\XINT_zapsp_a ##1#1#1%
        {\XINT_zapsp_again?##1\xint_bye\XINT_zapsp_b##1#1#1}%
}\XINT_zapsp_a{ }%
\long\def\XINT_zapsp_again? #1{\xint_bye #1\XINT_zapsp_again }%
\xint_firstofone{\def\XINT_zapsp_again\XINT_zapsp_b} {\XINT_zapsp_a }%
\xint_firstofone{\def\XINT_zapsp_b} {\XINT_zapsp_c }%
\def\XINT_zapsp_c#1{%
\long\def\XINT_zapsp_c ##1\xint:##2\xint:%
        {\XINT_zapesp_a{}\empty ##1#1#1\xint_bye\xint:}%
}\XINT_zapsp_c{ }%
```

4.8 \xintZapSpacesB

Added at 1.09f (2013/11/04) [on 2013/11/01]. Strips up to one pair of braces (but then does not strip spaces inside).

```
\def\xintZapSpacesB {\romannumeral0\xintzapspacesb }%
\long\def\xintzapspacesb #1{\XINT_zapspb_one? #1\xint:\xint:%
                          \xint_bye\xintzapspaces {#1}}%
\long\def\XINT_zapspb_one? #1#2%
    {\xint_gob_til_xint: #1\XINT_zapspb_onlyspaces\xint:%
     \xint_gob_til_xint: #2\XINT_zapspb_bracedorone\xint:%
     \xint_bye {#1}}%
\def\XINT_zapspb_onlyspaces\xint:%
     \xint_gob_til_xint:\xint:\XINT_zapspb_bracedorone\xint:%
     \xint_bye #1\xint_bye\xintzapspaces #2{ }%
\long\def\XINT_zapspb_bracedorone\xint:%
     \xint_bye #1\xint:\xint_bye\xintzapspaces #2{ #1}%
```

4.9 \xintCSVtoList, \xintCSVtoListNonStripped

Added at 1.06 (2013/05/07). \xintCSVtoList transforms a,b,..,z into {a}{b}...{z}. The comma separated list may be a macro which is first f-expanded. Here, use of \Z (and \R) perfectly safe.

Modified at 1.09f (2013/11/04). Automatically filters items with \xintZapSpacesB to strip away all spaces around commas, and spaces at the start and end of the list. The original is kept as \xintCSVtoListNonStripped, and is faster. But ... it doesn't strip spaces.
ATTENTION: if the input is empty the output contains one item (empty, of course). This means an \xintFor loop always executes at least once the iteration, contrarily to \xintFor*.

```
\def\xintCSVtoList {\romannumeral0\xintcsvtolist }%
\long\def\xintcsvtolist #1{\expandafter\xintApply
           \expandafter\xintzapspacesb
           \expandafter{\romannumeral0\xintcsvtolistnonstripped{#1}}}%
\def\xintCSVtoListNoExpand {\romannumeral0\xintcsvtolistnoexpand }%
\long\def\xintcsvtolistnoexpand #1{\expandafter\xintApply
```

```
           \expandafter\xintzapspacesb
           \expandafter{\romannumeral0\xintcsvtolistnonstrippednoexpand{#1}}}%
\def\xintCSVtoListNonStripped {\romannumeral0\xintcsvtolistnonstripped }%
\def\xintCSVtoListNonStrippedNoExpand
         {\romannumeral0\xintcsvtolistnonstrippednoexpand }%
\long\def\xintcsvtolistnonstripped #1%
{%
    \expandafter\XINT_csvtol_loop_a\expandafter
    {\expandafter}\romannumeral`&&@#1%
        ,\xint_bye,\xint_bye,\xint_bye,\xint_bye
        ,\xint_bye,\xint_bye,\xint_bye,\xint_bye,\Z
}%
\long\def\xintcsvtolistnonstrippednoexpand #1%
{%
    \XINT_csvtol_loop_a
    {}#1,\xint_bye,\xint_bye,\xint_bye,\xint_bye
        ,\xint_bye,\xint_bye,\xint_bye,\xint_bye,\Z
}%
\long\def\XINT_csvtol_loop_a #1#2,#3,#4,#5,#6,#7,#8,#9,%
{%
    \xint_bye #9\XINT_csvtol_finish_a\xint_bye
    \XINT_csvtol_loop_b {#1}{{#2}{#3}{#4}{#5}{#6}{#7}{#8}{#9}}%
}%
\long\def\XINT_csvtol_loop_b #1#2{\XINT_csvtol_loop_a {#1#2}}%
\long\def\XINT_csvtol_finish_a\xint_bye\XINT_csvtol_loop_b #1#2#3\Z
{%
    \XINT_csvtol_finish_b #3\R,\R,\R,\R,\R,\R,\R,\Z #2{#1}%
}%
```

1.1c revisits this old code and improves upon the earlier endings. But as the _d.. macros have already nine parameters, I needed the \expandafter and \xint_gob_til_Z in finish_b (compare \XINT_keep_endb, or also \XINT_RQ_end_b).

```
\def\XINT_csvtol_finish_b #1,#2,#3,#4,#5,#6,#7,#8\Z
{%
    \xint_gob_til_R
            #1\expandafter\XINT_csvtol_finish_dviii\xint_gob_til_Z
            #2\expandafter\XINT_csvtol_finish_dvii \xint_gob_til_Z
            #3\expandafter\XINT_csvtol_finish_dvi  \xint_gob_til_Z
            #4\expandafter\XINT_csvtol_finish_dv   \xint_gob_til_Z
            #5\expandafter\XINT_csvtol_finish_div  \xint_gob_til_Z
            #6\expandafter\XINT_csvtol_finish_diii \xint_gob_til_Z
            #7\expandafter\XINT_csvtol_finish_dii  \xint_gob_til_Z
            \R\XINT_csvtol_finish_di \Z
}%
\long\def\XINT_csvtol_finish_dviii #1#2#3#4#5#6#7#8#9{ #9}%
\long\def\XINT_csvtol_finish_dvii  #1#2#3#4#5#6#7#8#9{ #9{#1}}%
\long\def\XINT_csvtol_finish_dvi   #1#2#3#4#5#6#7#8#9{ #9{#1}{#2}}%
\long\def\XINT_csvtol_finish_dv    #1#2#3#4#5#6#7#8#9{ #9{#1}{#2}{#3}}%
\long\def\XINT_csvtol_finish_div   #1#2#3#4#5#6#7#8#9{ #9{#1}{#2}{#3}{#4}}%
\long\def\XINT_csvtol_finish_diii  #1#2#3#4#5#6#7#8#9{ #9{#1}{#2}{#3}{#4}{#5}}%
\long\def\XINT_csvtol_finish_dii   #1#2#3#4#5#6#7#8#9%
                                         { #9{#1}{#2}{#3}{#4}{#5}{#6}}%
\long\def\XINT_csvtol_finish_di\Z  #1#2#3#4#5#6#7#8#9%
```

```
                                           { #9{#1}{#2}{#3}{#4}{#5}{#6}{#7}}%
```

4.10 \xintListWithSep

Added at 1.04 (2013/04/25). \xintListWithSep {\sep}{{a}{b}...{z}} returns a \sep b \sep ....\sep z. It f-expands its second argument. The 'sep' may be \par's: the macro \xintlistwithsep etc... are all declared long. 'sep' does not have to be a single token. It is not expanded. The "list" argument may be empty.

\xintListWithSepNoExpand does not f-expand its second argument.

Modified at 1.2p (2017/12/05). This venerable macro from 1.04 remained unchanged for a long time and was finally refactored at 1.2p for increased speed. Tests done with a list of identical {\x} items and a sep of \z demonstrated a speed increase of about:

- 3x for 30 items,
- 4.5x for 100 items,
- 7.5x--8x for 1000 items.

```
\def\xintListWithSep        {\romannumeral0\xintlistwithsep }%
\def\xintListWithSepNoExpand {\romannumeral0\xintlistwithsepnoexpand }%
\long\def\xintlistwithsep #1#2%
    {\expandafter\XINT_lws\expandafter {\romannumeral`&&@#2}{#1}}%
\long\def\xintlistwithsepnoexpand #1#2%
{%
    \XINT_lws_loop_a {#1}#2{\xint_bye\XINT_lws_e_vi}%
       {\xint_bye\XINT_lws_e_v}{\xint_bye\XINT_lws_e_iv}%
       {\xint_bye\XINT_lws_e_iii}{\xint_bye\XINT_lws_e_ii}%
       {\xint_bye\XINT_lws_e_i}{\xint_bye\XINT_lws_e}%
       {\xint_bye\expandafter\space}\xint_bye
}%
\long\def\XINT_lws #1#2%
{%
    \XINT_lws_loop_a {#2}#1{\xint_bye\XINT_lws_e_vi}%
       {\xint_bye\XINT_lws_e_v}{\xint_bye\XINT_lws_e_iv}%
       {\xint_bye\XINT_lws_e_iii}{\xint_bye\XINT_lws_e_ii}%
       {\xint_bye\XINT_lws_e_i}{\xint_bye\XINT_lws_e}%
       {\xint_bye\expandafter\space}\xint_bye
}%
\long\def\XINT_lws_loop_a #1#2#3#4#5#6#7#8#9%
{%
    \xint_bye #9\xint_bye
    \XINT_lws_loop_b {#1}{#2}{#3}{#4}{#5}{#6}{#7}{#8}{#9}%
}%
\long\def\XINT_lws_loop_b #1#2#3#4#5#6#7#8#9%
{%
    \XINT_lws_loop_a {#1}{#2#1#3#1#4#1#5#1#6#1#7#1#8#1#9}%
}%
\long\def\XINT_lws_e_vi\xint_bye\XINT_lws_loop_b #1#2#3#4#5#6#7#8#9\xint_bye
    { #2#1#3#1#4#1#5#1#6#1#7#1#8}%
\long\def\XINT_lws_e_v\xint_bye\XINT_lws_loop_b #1#2#3#4#5#6#7#8\xint_bye
    { #2#1#3#1#4#1#5#1#6#1#7}%
\long\def\XINT_lws_e_iv\xint_bye\XINT_lws_loop_b #1#2#3#4#5#6#7\xint_bye
    { #2#1#3#1#4#1#5#1#6}%
\long\def\XINT_lws_e_iii\xint_bye\XINT_lws_loop_b #1#2#3#4#5#6\xint_bye
    { #2#1#3#1#4#1#5}%
```

```
\long\def\XINT_lws_e_ii\xint_bye\XINT_lws_loop_b #1#2#3#4#5\xint_bye
    { #2#1#3#1#4}%
\long\def\XINT_lws_e_i\xint_bye\XINT_lws_loop_b #1#2#3#4\xint_bye
    { #2#1#3}%
\long\def\XINT_lws_e\xint_bye\XINT_lws_loop_b #1#2#3\xint_bye
    { #2}%
```

4.11 \xintNthElt

Added at 1.06 (2013/05/07).

Modified at 1.2j (2016/12/22). Last refactored in 1.2j.

\xintNthElt {i}{List} returns the i th item from List (one pair of braces removed). The list is first f-expanded. The \xintNthEltNoExpand does no expansion of its second argument. Both variants expand i inside \numexpr.

With i = 0, the number of items is returned using \xintLength but with the List argument f-expanded first.

Negative values return the |i|th element from the end.

When i is out of range, an empty value is returned.

```
\def\xintNthElt         {\romannumeral0\xintnthelt }%
\def\xintNthEltNoExpand {\romannumeral0\xintntheltnoexpand }%
\long\def\xintnthelt #1#2{\expandafter\XINT_nthelt_a\the\numexpr #1\expandafter.%
                        \expandafter{\romannumeral`&&@#2}}%
\def\xintntheltnoexpand #1{\expandafter\XINT_nthelt_a\the\numexpr #1.}%
\def\XINT_nthelt_a #1%
{%
    \xint_UDzerominusfork
        #1-\XINT_nthelt_zero
        0#1\XINT_nthelt_neg
         0-{\XINT_nthelt_pos #1}%
    \krof
}%
\def\XINT_nthelt_zero #1.{\xintlength }%
\long\def\XINT_nthelt_neg #1.#2%
{%
    \expandafter\XINT_nthelt_neg_a\the\numexpr\xint_c_i+\XINT_length_loop
    #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    -#1.#2\xint_bye
}%
\def\XINT_nthelt_neg_a #1%
{%
    \xint_UDzerominusfork
        #1-\xint_stop_afterbye
        0#1\xint_stop_afterbye
         0-{}%
    \krof
    \expandafter\XINT_nthelt_neg_b
    \romannumeral\expandafter\XINT_gobble\the\numexpr-\xint_c_i+#1%
}%
\long\def\XINT_nthelt_neg_b #1#2\xint_bye{ #1}%
\long\def\XINT_nthelt_pos #1.#2%
```

```
{%
    \expandafter\XINT_nthelt_pos_done
    \romannumeral0\expandafter\XINT_trim_loop\the\numexpr#1-\xint_c_x.%
     #2\xint:\xint:\xint:\xint:\xint:%
       \xint:\xint:\xint:\xint:\xint:%
    \xint_bye
}%
\def\XINT_nthelt_pos_done #1{%
\long\def\XINT_nthelt_pos_done ##1##2\xint_bye{%
  \xint_gob_til_xint:##1\expandafter#1\xint_gobble_ii\xint:#1##1}%
}\XINT_nthelt_pos_done{ }%
```

4.12 \xintNthOnePy

Added at 1.4 (2020/01/31). See relevant code comments in xintexpr.

```
\def\xintNthOnePy         {\romannumeral0\xintnthonepy }%
\def\xintNthOnePyNoExpand {\romannumeral0\xintnthonepynoexpand }%
\long\def\xintnthonepy #1#2{\expandafter\XINT_nthonepy_a\the\numexpr #1\expandafter.%
                        \expandafter{\romannumeral`&&@#2}}%
\def\xintnthonepynoexpand #1{\expandafter\XINT_nthonepy_a\the\numexpr #1.}%
\def\XINT_nthonepy_a #1%
{%
    \xint_UDsignfork
        #1\XINT_nthonepy_neg
         -{\XINT_nthonepy_nonneg #1}%
    \krof
}%
\long\def\XINT_nthonepy_neg #1.#2%
{%
    \expandafter\XINT_nthonepy_neg_a\the\numexpr\xint_c_i+\XINT_length_loop
    #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    -#1.#2\xint_bye
}%
\def\XINT_nthonepy_neg_a #1%
{%
    \xint_UDzerominusfork
        #1-\xint_stop_afterbye
        0#1\xint_stop_afterbye
         0-{}%
    \krof
    \expandafter\XINT_nthonepy_neg_b
    \romannumeral\expandafter\XINT_gobble\the\numexpr-\xint_c_i+#1%
}%
\long\def\XINT_nthonepy_neg_b #1#2\xint_bye{{#1}}%
\long\def\XINT_nthonepy_nonneg #1.#2%
{%
    \expandafter\XINT_nthonepy_nonneg_done
    \romannumeral0\expandafter\XINT_trim_loop\the\numexpr#1-\xint_c_ix.%
     #2\xint:\xint:\xint:\xint:\xint:%
       \xint:\xint:\xint:\xint:\xint:%
```

```
    \xint_bye
}%
\def\XINT_nthonepy_nonneg_done #1{%
\long\def\XINT_nthonepy_nonneg_done ##1##2\xint_bye{%
  \xint_gob_til_xint:##1\expandafter#1\xint_gobble_ii\xint:{##1}}%
}\XINT_nthonepy_nonneg_done{ }%
```

4.13 \xintKeep

Added at 1.09m (2014/02/26). \xintKeep{i}{L} f-expands its second argument L. It then grabs the first i items from L and discards the rest.

ATTENTION: **each such kept item is returned inside a brace pair** Use \xintKeepUnbraced to avoid that.

For i equal or larger to the number N of items in (expanded) L, the full L is returned (with braced items). For i=0, the macro returns an empty output. For i<0, the macro discards the first N-|i| items. No brace pairs added to the remaining items. For i is less or equal to -N, the full L is returned (with no braces added.)

\xintKeepNoExpand does not expand the L argument.

Modified at 1.2i (2016/12/13). Prior to 1.2i the code proceeded along a loop with no pre-computation of the length of L, for the i>0 case. The faster 1.2i version takes advantage of novel \xintLengthUpTo from xintkernel.sty.

```
\def\xintKeep         {\romannumeral0\xintkeep }%
\def\xintKeepNoExpand {\romannumeral0\xintkeepnoexpand }%
\long\def\xintkeep #1#2{\expandafter\XINT_keep_a\the\numexpr #1\expandafter.%
                        \expandafter{\romannumeral`&&@#2}}%
\def\xintkeepnoexpand #1{\expandafter\XINT_keep_a\the\numexpr #1.}%
\def\XINT_keep_a #1%
{%
    \xint_UDzerominusfork
        #1-\XINT_keep_keepnone
        0#1\XINT_keep_neg
         0-{\XINT_keep_pos #1}%
    \krof
}%
\long\def\XINT_keep_keepnone .#1{ }%
\long\def\XINT_keep_neg #1.#2%
{%
    \expandafter\XINT_keep_neg_a\the\numexpr
    #1-\numexpr\XINT_length_loop
    #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye.#2%
}%
\def\XINT_keep_neg_a #1%
{%
    \xint_UDsignfork
        #1{\expandafter\space\romannumeral\XINT_gobble}%
         -\XINT_keep_keepall
    \krof
}%
\def\XINT_keep_keepall #1.{ }%
\long\def\XINT_keep_pos #1.#2%
```

```
{%
    \expandafter\XINT_keep_loop
    \the\numexpr#1-\XINT_lengthupto_loop
    #1.#2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
         \xint_c_vii\xint_c_vi\xint_c_v\xint_c_iv
         \xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye.%
    -\xint_c_viii.{}#2\xint_bye%
}%
\def\XINT_keep_loop #1#2.%
{%
    \xint_gob_til_minus#1\XINT_keep_loop_end-%
    \expandafter\XINT_keep_loop
    \the\numexpr#1#2-\xint_c_viii\expandafter.\XINT_keep_loop_pickeight
}%
\long\def\XINT_keep_loop_pickeight
     #1#2#3#4#5#6#7#8#9{{#1{#2}{#3}{#4}{#5}{#6}{#7}{#8}{#9}}}%
\def\XINT_keep_loop_end-\expandafter\XINT_keep_loop
    \the\numexpr-#1-\xint_c_viii\expandafter.\XINT_keep_loop_pickeight
    {\csname XINT_keep_end#1\endcsname}%
\long\expandafter\def\csname XINT_keep_end1\endcsname
   #1#2#3#4#5#6#7#8#9\xint_bye { #1{#2}{#3}{#4}{#5}{#6}{#7}{#8}}%
\long\expandafter\def\csname XINT_keep_end2\endcsname
   #1#2#3#4#5#6#7#8\xint_bye { #1{#2}{#3}{#4}{#5}{#6}{#7}}%
\long\expandafter\def\csname XINT_keep_end3\endcsname
   #1#2#3#4#5#6#7\xint_bye { #1{#2}{#3}{#4}{#5}{#6}}%
\long\expandafter\def\csname XINT_keep_end4\endcsname
   #1#2#3#4#5#6\xint_bye { #1{#2}{#3}{#4}{#5}}%
\long\expandafter\def\csname XINT_keep_end5\endcsname
   #1#2#3#4#5\xint_bye { #1{#2}{#3}{#4}}%
\long\expandafter\def\csname XINT_keep_end6\endcsname
   #1#2#3#4\xint_bye { #1{#2}{#3}}%
\long\expandafter\def\csname XINT_keep_end7\endcsname
   #1#2#3\xint_bye { #1{#2}}%
\long\expandafter\def\csname XINT_keep_end8\endcsname
   #1#2\xint_bye { #1}%
```

4.14 \xintKeepUnbraced

Added at 1.2a (2015/10/19). Same as \xintKeep but will *not* add (or maintain) brace pairs around the kept items when length(L)>i>0.

The name may cause a mis-understanding: for i<0, (i.e. keeping only trailing items), there is no brace removal at all happening.

Modified at 1.2i (2016/12/13). As \xintKeep.

```
\def\xintKeepUnbraced         {\romannumeral0\xintkeepunbraced }%
\def\xintKeepUnbracedNoExpand {\romannumeral0\xintkeepunbracednoexpand }%
\long\def\xintkeepunbraced #1#2%
    {\expandafter\XINT_keepunbr_a\the\numexpr #1\expandafter.%
                        \expandafter{\romannumeral`&&@#2}}%
\def\xintkeepunbracednoexpand #1%
   {\expandafter\XINT_keepunbr_a\the\numexpr #1.}%
\def\XINT_keepunbr_a #1%
{%
```

```
    \xint_UDzerominusfork
        #1-\XINT_keep_keepnone
        0#1\XINT_keep_neg
         0-{\XINT_keepunbr_pos #1}%
    \krof
}%
\long\def\XINT_keepunbr_pos #1.#2%
{%
    \expandafter\XINT_keepunbr_loop
    \the\numexpr#1-\XINT_lengthupto_loop
    #1.#2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
         \xint_c_vii\xint_c_vi\xint_c_v\xint_c_iv
         \xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye.%
    -\xint_c_viii.{}#2\xint_bye%
}%
\def\XINT_keepunbr_loop #1#2.%
{%
    \xint_gob_til_minus#1\XINT_keepunbr_loop_end-%
    \expandafter\XINT_keepunbr_loop
    \the\numexpr#1#2-\xint_c_viii\expandafter.\XINT_keepunbr_loop_pickeight
}%
\long\def\XINT_keepunbr_loop_pickeight
     #1#2#3#4#5#6#7#8#9{{#1#2#3#4#5#6#7#8#9}}%
\def\XINT_keepunbr_loop_end-\expandafter\XINT_keepunbr_loop
    \the\numexpr-#1-\xint_c_viii\expandafter.\XINT_keepunbr_loop_pickeight
    {\csname XINT_keepunbr_end#1\endcsname}%
\long\expandafter\def\csname XINT_keepunbr_end1\endcsname
   #1#2#3#4#5#6#7#8#9\xint_bye { #1#2#3#4#5#6#7#8}%
\long\expandafter\def\csname XINT_keepunbr_end2\endcsname
   #1#2#3#4#5#6#7#8\xint_bye { #1#2#3#4#5#6#7}%
\long\expandafter\def\csname XINT_keepunbr_end3\endcsname
   #1#2#3#4#5#6#7\xint_bye { #1#2#3#4#5#6}%
\long\expandafter\def\csname XINT_keepunbr_end4\endcsname
   #1#2#3#4#5#6\xint_bye { #1#2#3#4#5}%
\long\expandafter\def\csname XINT_keepunbr_end5\endcsname
   #1#2#3#4#5\xint_bye { #1#2#3#4}%
\long\expandafter\def\csname XINT_keepunbr_end6\endcsname
   #1#2#3#4\xint_bye { #1#2#3}%
\long\expandafter\def\csname XINT_keepunbr_end7\endcsname
   #1#2#3\xint_bye { #1#2}%
\long\expandafter\def\csname XINT_keepunbr_end8\endcsname
   #1#2\xint_bye { #1}%
```

4.15 \xintTrim

Added at 1.09m (2014/02/26). \xintTrim{i}{L} f-expands its second argument L. It then removes the first i items from L and keeps the rest. For i equal or larger to the number N of items in (expanded) L, the macro returns an empty output. For i=0, the original (expanded) L is returned. For i<0, the macro proceeds from the tail. It thus removes the last |i| items, i.e. it keeps the first N-|i| items. For |i|>= N, the empty list is returned.
\xintTrimNoExpand does not expand the L argument.

Modified at 1.2i (2016/12/13). Speed improvements for i<0 branch (which hands over to \xintKeep).

Speed improvements with 1.2j for i>0 branch which gobbles items nine by nine despite not knowing in advance if it will go too far.

```
\def\xintTrim         {\romannumeral0\xinttrim }%
\def\xintTrimNoExpand {\romannumeral0\xinttrimnoexpand }%
\long\def\xinttrim #1#2{\expandafter\XINT_trim_a\the\numexpr #1\expandafter.%
                        \expandafter{\romannumeral`&&@#2}}%
\def\xinttrimnoexpand #1{\expandafter\XINT_trim_a\the\numexpr #1.}%
\def\XINT_trim_a #1%
{%
    \xint_UDzerominusfork
        #1-\XINT_trim_trimnone
        0#1\XINT_trim_neg
         0-{\XINT_trim_pos #1}%
    \krof
}%
\long\def\XINT_trim_trimnone .#1{ #1}%
\long\def\XINT_trim_neg #1.#2%
{%
    \expandafter\XINT_trim_neg_a\the\numexpr
    #1-\numexpr\XINT_length_loop
    #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    .{}#2\xint_bye
}%
\def\XINT_trim_neg_a #1%
{%
    \xint_UDsignfork
        #1{\expandafter\XINT_keep_loop\the\numexpr-\xint_c_viii+}%
         -\XINT_trim_trimall
    \krof
}%
\def\XINT_trim_trimall#1{%
\def\XINT_trim_trimall {\expandafter#1\xint_bye}%
}\XINT_trim_trimall{ }%
```

This branch doesn't pre-evaluate the length of the list argument. Redone again for 1.2j, manages to trim nine by nine. Some non optimal looking aspect of the code is for allowing sharing with \xintNthElt.

```
\long\def\XINT_trim_pos #1.#2%
{%
    \expandafter\XINT_trim_pos_done\expandafter\space
    \romannumeral0\expandafter\XINT_trim_loop\the\numexpr#1-\xint_c_ix.%
     #2\xint:\xint:\xint:\xint:\xint:%
       \xint:\xint:\xint:\xint:\xint:%
    \xint_bye
}%
\def\XINT_trim_loop #1#2.%
{%
    \xint_gob_til_minus#1\XINT_trim_finish-%
    \expandafter\XINT_trim_loop\the\numexpr#1#2\XINT_trim_loop_trimnine
}%
\long\def\XINT_trim_loop_trimnine #1#2#3#4#5#6#7#8#9%
```

```
{%
    \xint_gob_til_xint: #9\XINT_trim_toofew\xint:-\xint_c_ix.%
}%
\def\XINT_trim_toofew\xint:{*\xint_c_}%
\def\XINT_trim_finish#1{%
\def\XINT_trim_finish-%
    \expandafter\XINT_trim_loop\the\numexpr-##1\XINT_trim_loop_trimnine
{%
    \expandafter\expandafter\expandafter#1%
    \csname xint_gobble_\romannumeral\numexpr\xint_c_ix-##1\endcsname
}}\XINT_trim_finish{ }%
\long\def\XINT_trim_pos_done #1\xint:#2\xint_bye {#1}%
```

4.16 \xintTrimUnbraced

Added at 1.2a (2015/10/19).

Modified at 1.2i (2016/12/13). As \xintTrim.

```
\def\xintTrimUnbraced         {\romannumeral0\xinttrimunbraced }%
\def\xintTrimUnbracedNoExpand {\romannumeral0\xinttrimunbracednoexpand }%
\long\def\xinttrimunbraced #1#2%
    {\expandafter\XINT_trimunbr_a\the\numexpr #1\expandafter.%
                        \expandafter{\romannumeral`&&@#2}}%
\def\xinttrimunbracednoexpand #1%
    {\expandafter\XINT_trimunbr_a\the\numexpr #1.}%
\def\XINT_trimunbr_a #1%
{%
    \xint_UDzerominusfork
        #1-\XINT_trim_trimnone
        0#1\XINT_trimunbr_neg
         0-{\XINT_trim_pos #1}%
    \krof
}%
\long\def\XINT_trimunbr_neg #1.#2%
{%
    \expandafter\XINT_trimunbr_neg_a\the\numexpr
    #1-\numexpr\XINT_length_loop
    #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    .{}#2\xint_bye
}%
\def\XINT_trimunbr_neg_a #1%
{%
    \xint_UDsignfork
        #1{\expandafter\XINT_keepunbr_loop\the\numexpr-\xint_c_viii+}%
         -\XINT_trim_trimall
    \krof
}%
```

4.17 \xintApply

Added at 1.04 (2013/04/25). \xintApply {\macro}{{a}{b}...{z}} returns {\macro{a}}...{\macro{b}} where each instance of \macro is f-expanded. The list itself is first f-expanded and may thus be a macro.

```
\def\xintApply          {\romannumeral0\xintapply }%
\def\xintApplyNoExpand {\romannumeral0\xintapplynoexpand }%
\long\def\xintapply #1#2%
{%
    \expandafter\XINT_apply\expandafter {\romannumeral`&&@#2}%
    {#1}%
}%
\long\def\XINT_apply #1#2{\XINT_apply_loop_a {}{#2}#1\xint_bye }%
\long\def\xintapplynoexpand #1#2{\XINT_apply_loop_a {}{#1}#2\xint_bye }%
\long\def\XINT_apply_loop_a #1#2#3%
{%
    \xint_bye #3\XINT_apply_end\xint_bye
    \expandafter
    \XINT_apply_loop_b
    \expandafter {\romannumeral`&&@#2{#3}}{#1}{#2}%
}%
\long\def\XINT_apply_loop_b #1#2{\XINT_apply_loop_a {#2{#1}}}%
\long\def\XINT_apply_end\xint_bye\expandafter\XINT_apply_loop_b
    \expandafter #1#2#3{ #2}%
```

4.18 \xintApply:x (WIP, commented-out)

Added at 1.4 (2020/01/31) [on 2020/01/27]. For usage in the NumPy-like slicing routines. Well, actually, in the end I sticked with old-fashioned (quadratic cost) \xintApply for 1.4 2020/01/31 release. See comments there.

(Comments mainly from 2020/01/27, but on 2020/02/24 I comment out the code and add an alternative)

To expand in \expanded context, and does not need to do any expansion of its second argument.

This uses techniques I had developed for 1.2i/1.2j Keep, Trim, Length, LastItem like macros, and I should revamp venerable \xintApply probably too. But the latter f-expandability (if it does not have \expanded at disposal) complicates significantly matters as it has to store material and release at very end.

Here it is simpler and I am doing it quickly as I really want to release 1.4. The \xint: token should not be located in looped over items. I could use something more exotic like the null char with catcode 3...

```
\long\def\xintApply:x #1#2%
{%
    \XINT_apply:x_loop {#1}#2%
    {\xint:\XINT_apply:x_loop_enda}{\xint:\XINT_apply:x_loop_endb}%
    {\xint:\XINT_apply:x_loop_endc}{\xint:\XINT_apply:x_loop_endd}%
    {\xint:\XINT_apply:x_loop_ende}{\xint:\XINT_apply:x_loop_endf}%
    {\xint:\XINT_apply:x_loop_endg}{\xint:\XINT_apply:x_loop_endh}\xint_bye
}%
\long\def\XINT_apply:x_loop #1#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_xint: #9\xint:
    {#1{#2}}{#1{#3}}{#1{#4}}{#1{#5}}{#1{#6}}{#1{#7}}{#1{#8}}{#1{#9}}%
```

```
        \XINT_apply:x_loop {#1}%
    }%
    \long\def\XINT_apply:x_loop_endh\xint: #1\xint_bye{}%
    \long\def\XINT_apply:x_loop_endg\xint: #1#2\xint_bye{{#1}}%
    \long\def\XINT_apply:x_loop_endf\xint: #1#2#3\xint_bye{{#1}{#2}}%
    \long\def\XINT_apply:x_loop_ende\xint: #1#2#3#4\xint_bye{{#1}{#2}{#3}}%
    \long\def\XINT_apply:x_loop_endd\xint: #1#2#3#4#5\xint_bye{{#1}{#2}{#3}{#4}}%
    \long\def\XINT_apply:x_loop_endc\xint: #1#2#3#4#5#6\xint_bye{{#1}{#2}{#3}{#4}{#5}}%
    \long\def\XINT_apply:x_loop_endb\xint: #1#2#3#4#5#6#7\xint_bye{{#1}{#2}{#3}{#4}{#5}{#6}}%
    \long\def\XINT_apply:x_loop_enda\xint: #1#2#3#4#5#6#7#8\xint_bye{{#1}{#2}{#3}{#4}{#5}{#6}{#7}}%
```

For small number of items gain with respect to \xintApply is little if any (might even be a loss).

Picking one by one is possibly better for small number of items. Like this for example, the natural simple minded thing:

```
  \long\def\xintApply:x #1#2%
    {%
        \XINT_apply:x_loop {#1}#2\xint_bye\xint_bye
    }%
    \long\def\XINT_apply:x_loop #1#2%
    {%
        \xint_bye #2\xint_bye {#1{#2}}%
        \XINT_apply:x_loop {#1}%
    }%
```

Some variant on 2020/02/24

```
    \long\def\xint_Bbye#1\xint_Bye{}%
    \long\def\xintApply:x #1#2%
    {%
        \XINT_apply:x_loop {#1}#2%
        {\xint_bye}{\xint_bye}{\xint_bye}{\xint_bye}%
        {\xint_bye}{\xint_bye}{\xint_bye}{\xint_bye}\xint_bye
    }%
    \long\def\XINT_apply:x_loop #1#2#3#4#5#6#7#8#9%
    {%
        \xint_Bye #2\xint_bye {#1{#2}}%
        \xint_Bye #3\xint_bye {#1{#3}}%
        \xint_Bye #4\xint_bye {#1{#4}}%
        \xint_Bye #5\xint_bye {#1{#5}}%
        \xint_Bye #6\xint_bye {#1{#6}}%
        \xint_Bye #7\xint_bye {#1{#7}}%
        \xint_Bye #8\xint_bye {#1{#8}}%
        \xint_Bye #9\xint_bye {#1{#9}}%
        \XINT_apply:x_loop {#1}%
    }%
```

4.19 \xintApplyUnbraced

Added at 1.06b (2013/05/14). \xintApplyUnbraced {\macro}{{a}{b}...{z}} returns \macro{a}...\macro{z} where each instance of \macro is f-expanded using \romannumeral-`0. The second argument may be a macro as it is itself also f-expanded. No braces are added: this allows for example a non-expandable \def in \macro, without having to do \gdef.

```
\def\xintApplyUnbraced {\romannumeral0\xintapplyunbraced }%
\def\xintApplyUnbracedNoExpand {\romannumeral0\xintapplyunbracednoexpand }%
\long\def\xintapplyunbraced #1#2%
```

```
{%
    \expandafter\XINT_applyunbr\expandafter {\romannumeral`&&@#2}%
    {#1}%
}%
\long\def\XINT_applyunbr #1#2{\XINT_applyunbr_loop_a {}{#2}#1\xint_bye }%
\long\def\xintapplyunbracednoexpand #1#2%
   {\XINT_applyunbr_loop_a {}{#1}#2\xint_bye }%
\long\def\XINT_applyunbr_loop_a #1#2#3%
{%
    \xint_bye #3\XINT_applyunbr_end\xint_bye
    \expandafter\XINT_applyunbr_loop_b
    \expandafter {\romannumeral`&&@#2{#3}}{#1}{#2}%
}%
\long\def\XINT_applyunbr_loop_b #1#2{\XINT_applyunbr_loop_a {#2#1}}%
\long\def\XINT_applyunbr_end\xint_bye\expandafter\XINT_applyunbr_loop_b
    \expandafter #1#2#3{ #2}%
```

4.20 `\xintApplyUnbraced:x` (WIP, commented-out)

Added at 1.4 (2020/01/31) [on 2020/01/27]. For usage in the NumPy-like slicing routines.

The items should not contain `\xint:` and the applied macro should not contain `\empty`.

Finally, xintexpr.sty 1.4 code did not use this macro but the f-expandable one `\xintApplyUnbraced`.

Modified at 1.4b (2020/02/25). For 1.4b I prefer to keep the `\xintApplyUnbraced:x` code commented out, and classify it as WIP.

```
\long\def\xintApplyUnbraced:x #1#2%
{%
    \XINT_applyunbraced:x_loop {#1}#2%
    {\xint:\XINT_applyunbraced:x_loop_enda}{\xint:\XINT_applyunbraced:x_loop_endb}%
    {\xint:\XINT_applyunbraced:x_loop_endc}{\xint:\XINT_applyunbraced:x_loop_endd}%
    {\xint:\XINT_applyunbraced:x_loop_ende}{\xint:\XINT_applyunbraced:x_loop_endf}%
    {\xint:\XINT_applyunbraced:x_loop_endg}{\xint:\XINT_applyunbraced:x_loop_endh}\xint_bye
}%
\long\def\XINT_applyunbraced:x_loop #1#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_xint: #9\xint:
            #1{#2}%
      \empty#1{#3}%
      \empty#1{#4}%
      \empty#1{#5}%
      \empty#1{#6}%
      \empty#1{#7}%
      \empty#1{#8}%
      \empty#1{#9}%
    \XINT_applyunbraced:x_loop {#1}%
}%
\long\def\XINT_applyunbraced:x_loop_endh\xint: #1\xint_bye{}%
\long\def\XINT_applyunbraced:x_loop_endg\xint: #1\empty#2\xint_bye{#1}%
\long\def\XINT_applyunbraced:x_loop_endf\xint: #1\empty
                                                #2\empty#3\xint_bye{#1#2}%
\long\def\XINT_applyunbraced:x_loop_ende\xint: #1\empty
                                                #2\empty
                                                #3\empty#4\xint_bye{#1#2#3}%
```

```
\long\def\XINT_applyunbraced:x_loop_endd\xint: #1\empty
                                               #2\empty
                                               #3\empty
                                               #4\empty#5\xint_bye{#1#2#3#4}%
\long\def\XINT_applyunbraced:x_loop_endc\xint: #1\empty
                                               #2\empty
                                               #3\empty
                                               #4\empty
                                               #5\empty#6\xint_bye{#1#2#3#4#5}%
\long\def\XINT_applyunbraced:x_loop_endb\xint: #1\empty
                                               #2\empty
                                               #3\empty
                                               #4\empty
                                               #5\empty
                                               #6\empty#7\xint_bye{#1#2#3#4#5#6}%
\long\def\XINT_applyunbraced:x_loop_enda\xint: #1\empty
                                               #2\empty
                                               #3\empty
                                               #4\empty
                                               #5\empty
                                               #6\empty
                                               #7\empty#8\xint_bye{#1#2#3#4#5#6#7}%
```

4.21 `\xintZip` (WIP, not public)

Added at 1.4b (2020/02/25) [on 2020/02/25]. Support for zip(). Requires \expanded.

The implementation here thus considers the argument is already completely expanded and is a sequence of nut-ples. I will come back at later date for more generic macros.

Consider even the name of the function zip() as WIP.

As per what this does, it imitates the zip() function. See xint-manual.pdf.

I use lame terminators. Will think again later on this. I have to be careful with the used terminators, in particular with the NE context in mind.

Generally speaking I will think another day about efficiency else I will never start this.

OK, done. More compact than I initially thought. Various things should be commented upon here. Well, actually not so compact in the end as I basically had to double the whole thing simply to avoid the overhead of having to grab the final result delimited by some \xint_bye\xint_bye\xint_bye\xint_bye\empty terminator. Now actually rather \xint_bye\xint_bye\xint_bye\xint_bye\xint:

```
\def\xintZip #1{\expanded\XINT_zip_A#1\xint_bye\xint_bye}%
\def\XINT_zip_A#1%
{%
    \xint_bye#1{\expandafter}\xint_bye
    \expanded{\unexpanded{\XINT_ziptwo_A
        #1\xint_bye\xint_bye\xint_bye\xint_bye\xint:}\expandafter}%
    \expanded\XINT_zip_a
}%
\def\XINT_zip_a#1%
{%
    \xint_bye#1\XINT_zip_terminator\xint_bye
    \expanded{\unexpanded{\XINT_ziptwo_a
        #1\xint_bye\xint_bye\xint_bye\xint_bye\xint:}\expandafter}%
    \expanded\XINT_zip_a
}%
```

```
\def\XINT_zip_terminator\xint_bye#1\xint_bye{{}\empty\empty\empty\empty\xint:}%
\def\XINT_ziptwo_a #1#2#3#4#5\xint:#6#7#8#9%
{%
    \bgroup
    \xint_bye #1\XINT_ziptwo_e \xint_bye
    \xint_bye #6\XINT_ziptwo_e \xint_bye {{#1}#6}%
    \xint_bye #2\XINT_ziptwo_e \xint_bye
    \xint_bye #7\XINT_ziptwo_e \xint_bye {{#2}#7}%
    \xint_bye #3\XINT_ziptwo_e \xint_bye
    \xint_bye #8\XINT_ziptwo_e \xint_bye {{#3}#8}%
    \xint_bye #4\XINT_ziptwo_e \xint_bye
    \xint_bye #9\XINT_ziptwo_e \xint_bye {{#4}#9}%
```

Attention here that #6 can very well deliver no tokens at all. But the \ifx will then do the expected thing. Only mentioning!

By the way, the \xint_bye method means TeX needs to look into tokens but skipping braced groups. A conditional based method lets TeX look only at the start but then it has to find \else or \fi so here also it must looks at tokens, and actually goes into braced groups. But (written 2020/02/26) I never did serious testing comparing the two, and in xint I have usually preferred \xint_bye/\xint_gob_til_foo types of methods (they proved superior than \ifnum to check for 0000 in numerical core context for example, at the early days when xint used blocks of 4 digits, not 8), or usage of \if/\ifx only on single tokens, combined with some \xint_dothis/\xint_orthat syntax.

```
    \ifx \empty#6\expandafter\XINT_zipone_a\fi
    \XINT_ziptwo_b #5\xint:
}%
\def\XINT_zipone_a\XINT_ziptwo_b{\XINT_zipone_b}%
\def\XINT_ziptwo_b #1#2#3#4#5\xint:#6#7#8#9%
{%
    \xint_bye #1\XINT_ziptwo_e \xint_bye
    \xint_bye #6\XINT_ziptwo_e \xint_bye {{#1}#6}%
    \xint_bye #2\XINT_ziptwo_e \xint_bye
    \xint_bye #7\XINT_ziptwo_e \xint_bye {{#2}#7}%
    \xint_bye #3\XINT_ziptwo_e \xint_bye
    \xint_bye #8\XINT_ziptwo_e \xint_bye {{#3}#8}%
    \xint_bye #4\XINT_ziptwo_e \xint_bye
    \xint_bye #9\XINT_ziptwo_e \xint_bye {{#4}#9}%
    \XINT_ziptwo_b #5\xint:
}%
\def\XINT_ziptwo_e #1\XINT_ziptwo_b #2\xint:#3\xint:
    {\iffalse{\fi}\xint_bye\xint_bye\xint_bye\xint_bye\xint:}%
\def\XINT_zipone_b #1#2#3#4%
{%
    \xint_bye #1\XINT_zipone_e \xint_bye {{#1}}%
    \xint_bye #2\XINT_zipone_e \xint_bye {{#2}}%
    \xint_bye #3\XINT_zipone_e \xint_bye {{#3}}%
    \xint_bye #4\XINT_zipone_e \xint_bye {{#4}}%
    \XINT_zipone_b
}%
\def\XINT_zipone_e #1\XINT_zipone_b #2\xint:
    {\iffalse{\fi}\xint_bye\xint_bye\xint_bye\xint_bye\empty}%
\def\XINT_ziptwo_A #1#2#3#4#5\xint:#6#7#8#9%
{%
    \bgroup
```

```
    \xint_bye #1\XINT_ziptwo_end \xint_bye
    \xint_bye #6\XINT_ziptwo_end \xint_bye {{#1}#6}%
    \xint_bye #2\XINT_ziptwo_end \xint_bye
    \xint_bye #7\XINT_ziptwo_end \xint_bye {{#2}#7}%
    \xint_bye #3\XINT_ziptwo_end \xint_bye
    \xint_bye #8\XINT_ziptwo_end \xint_bye {{#3}#8}%
    \xint_bye #4\XINT_ziptwo_end \xint_bye
    \xint_bye #9\XINT_ziptwo_end \xint_bye {{#4}#9}%
    \ifx \empty#6\expandafter\XINT_zipone_A\fi
    \XINT_ziptwo_B #5\xint:
}%
\def\XINT_zipone_A\XINT_ziptwo_B{\XINT_zipone_B}%
\def\XINT_ziptwo_B #1#2#3#4#5\xint:#6#7#8#9%
{%
    \xint_bye #1\XINT_ziptwo_end \xint_bye
    \xint_bye #6\XINT_ziptwo_end \xint_bye {{#1}#6}%
    \xint_bye #2\XINT_ziptwo_end \xint_bye
    \xint_bye #7\XINT_ziptwo_end \xint_bye {{#2}#7}%
    \xint_bye #3\XINT_ziptwo_end \xint_bye
    \xint_bye #8\XINT_ziptwo_end \xint_bye {{#3}#8}%
    \xint_bye #4\XINT_ziptwo_end \xint_bye
    \xint_bye #9\XINT_ziptwo_end \xint_bye {{#4}#9}%
    \XINT_ziptwo_B #5\xint:
}%
\def\XINT_ziptwo_end #1\XINT_ziptwo_B #2\xint:#3\xint:{\iffalse{\fi}}%
\def\XINT_zipone_B #1#2#3#4%
{%
    \xint_bye #1\XINT_zipone_end \xint_bye {{#1}}%
    \xint_bye #2\XINT_zipone_end \xint_bye {{#2}}%
    \xint_bye #3\XINT_zipone_end \xint_bye {{#3}}%
    \xint_bye #4\XINT_zipone_end \xint_bye {{#4}}%
    \XINT_zipone_B
}%
\def\XINT_zipone_end #1\XINT_zipone_B #2\xint:#3\xint:{\iffalse{\fi}}%
```

4.22 \xintSeq

Added at 1.09c (2013/10/09). Without the optional argument puts stress on the input stack, should not be used to generated thousands of terms then.

Modified at 1.4j (2021/07/13). This venerable macro had a brace removal bug in case it produced a single number: \xintSeq{10}{10} expanded to 10 not {10}. When I looked at the code the bug looked almost deliberate to me, but reading the documentation (which I have not modified), the behaviour is really unexpected. And the variant with step parameter \xintSeq[1]{10}{10} did produce {10}, so yes, definitely it was a bug!

I take this occasion to do some style (and perhaps efficiency) refactoring in the coding. I feel there is room for improvement, no time this time. And I don't touch the variant with step parameter.

Memo: xintexpr has some variants, a priori on ultra quick look they do not look like having similar bug as this one had.

```
\def\xintSeq {\romannumeral0\xintseq }%
\def\xintseq #1{\XINT_seq_chkopt  #1\xint_bye }%
\def\XINT_seq_chkopt #1%
{%
```

```
    \ifx [#1\expandafter\XINT_seq_opt
       \else\expandafter\XINT_seq_noopt
    \fi  #1%
}%
\def\XINT_seq_noopt #1\xint_bye #2%
{%
    \expandafter\XINT_seq
    \the\numexpr#1\expandafter.\the\numexpr #2.%
}%
\def\XINT_seq #1.#2.%
{%
   \ifnum #1=#2 \xint_dothis\XINT_seq_e\fi
   \ifnum #2>#1 \xint_dothis\XINT_seq_pa\fi
                \xint_orthat\XINT_seq_na
   #2.{#1}{#2}%
}%
\def\XINT_seq_e#1.#2{}%
\def\XINT_seq_pa {\expandafter\XINT_seq_p\the\numexpr-\xint_c_i+}%
\def\XINT_seq_na {\expandafter\XINT_seq_n\the\numexpr\xint_c_i+}%
\def\XINT_seq_p #1.#2%
{%
    \ifnum #1>#2
      \expandafter\XINT_seq_p\the
    \else
      \expandafter\XINT_seq_e
    \fi
    \numexpr #1-\xint_c_i.{#2}{#1}%
}%
\def\XINT_seq_n #1.#2%
{%
    \ifnum #1<#2
      \expandafter\XINT_seq_n\the
    \else
      \expandafter\XINT_seq_e
    \fi
    \numexpr #1+\xint_c_i.{#2}{#1}%
}%
```

Note at time of the 1.4j bug fix : I definitely should improve this branch and diminish the number of expandafter's but no time this time.

```
\def\XINT_seq_opt [\xint_bye #1]#2#3%
{%
    \expandafter\XINT_seqo\expandafter
    {\the\numexpr #2\expandafter}\expandafter
    {\the\numexpr #3\expandafter}\expandafter
    {\the\numexpr #1}%
}%
\def\XINT_seqo #1#2%
{%
   \ifcase\ifnum #1=#2 0\else\ifnum #2>#1 1\else -1\fi\fi\space
      \expandafter\XINT_seqo_a
   \or
      \expandafter\XINT_seqo_pa
```

```
   \else
      \expandafter\XINT_seqo_na
   \fi
   {#1}{#2}%
}%
\def\XINT_seqo_a #1#2#3{ {#1}}%
\def\XINT_seqo_o #1#2#3#4{ #4}%
\def\XINT_seqo_pa #1#2#3%
{%
    \ifcase\ifnum #3=\xint_c_ 0\else\ifnum #3>\xint_c_ 1\else -1\fi\fi\space
           \expandafter\XINT_seqo_o
    \or
           \expandafter\XINT_seqo_pb
    \else
           \xint_afterfi{\expandafter\space\xint_gobble_iv}%
    \fi
    {#1}{#2}{#3}{{#1}}%
}%
\def\XINT_seqo_pb #1#2#3%
{%
    \expandafter\XINT_seqo_pc\expandafter{\the\numexpr #1+#3}{#2}{#3}%
}%
\def\XINT_seqo_pc #1#2%
{%
    \ifnum #1>#2
        \expandafter\XINT_seqo_o
    \else
        \expandafter\XINT_seqo_pd
    \fi
    {#1}{#2}%
}%
\def\XINT_seqo_pd #1#2#3#4{\XINT_seqo_pb {#1}{#2}{#3}{#4{#1}}}%
\def\XINT_seqo_na #1#2#3%
{%
    \ifcase\ifnum #3=\xint_c_ 0\else\ifnum #3>\xint_c_ 1\else -1\fi\fi\space
        \expandafter\XINT_seqo_o
    \or
        \xint_afterfi{\expandafter\space\xint_gobble_iv}%
    \else
        \expandafter\XINT_seqo_nb
    \fi
    {#1}{#2}{#3}{{#1}}%
}%
\def\XINT_seqo_nb #1#2#3%
{%
    \expandafter\XINT_seqo_nc\expandafter{\the\numexpr #1+#3}{#2}{#3}%
}%
\def\XINT_seqo_nc #1#2%
{%
    \ifnum #1<#2
        \expandafter\XINT_seqo_o
    \else
```

```
        \expandafter\XINT_seqo_nd
    \fi
    {#1}{#2}%
}%
\def\XINT_seqo_nd #1#2#3#4{\XINT_seqo_nb {#1}{#2}{#3}{#4{#1}}}%
```

4.23 \xintloop, \xintbreakloop, \xintbreakloopanddo, \xintloopskiptonext

Added at 1.09g (2013/11/22) [on 2013/11/22].

Modified at 1.09h (2013/11/28). Made \long.

```
\long\def\xintloop #1#2\repeat {#1#2\xintloop_again\fi\xint_gobble_i {#1#2}}%
\long\def\xintloop_again\fi\xint_gobble_i #1{\fi
                             #1\xintloop_again\fi\xint_gobble_i {#1}}%
\long\def\xintbreakloop #1\xintloop_again\fi\xint_gobble_i #2{}%
\long\def\xintbreakloopanddo #1#2\xintloop_again\fi\xint_gobble_i #3{#1}%
\long\def\xintloopskiptonext #1\xintloop_again\fi\xint_gobble_i #2{%
                        #2\xintloop_again\fi\xint_gobble_i {#2}}%
```

4.24 \xintiloop, \xintiloopindex, \xintbracediloopindex, \xintouteriloopindex, \xintbracedouteriloopindex, \xintbreakiloop, \xintbreakiloopanddo, \xintiloopskiptonext, \xintiloopskipandredo

Added at 1.09g (2013/11/22) [on 2013/11/22].

Modified at 1.09h (2013/11/28). Made \long.

Added at 1.3b (2018/05/18) [on 2018/04/24]. "braced" variants.

```
\def\xintiloop [#1+#2]{%
    \expandafter\xintiloop_a\the\numexpr #1\expandafter.\the\numexpr #2.}%
\long\def\xintiloop_a #1.#2.#3#4\repeat{%
    #3#4\xintiloop_again\fi\xint_gobble_iii {#1}{#2}{#3#4}}%
\def\xintiloop_again\fi\xint_gobble_iii #1#2{%
    \fi\expandafter\xintiloop_again_b\the\numexpr#1+#2.#2.}%
\long\def\xintiloop_again_b #1.#2.#3{%
    #3\xintiloop_again\fi\xint_gobble_iii {#1}{#2}{#3}}%
\long\def\xintbreakiloop #1\xintiloop_again\fi\xint_gobble_iii #2#3#4{}%
\long\def\xintbreakiloopanddo
     #1.#2\xintiloop_again\fi\xint_gobble_iii #3#4#5{#1}%
\long\def\xintiloopindex #1\xintiloop_again\fi\xint_gobble_iii #2%
                {#2#1\xintiloop_again\fi\xint_gobble_iii {#2}}%
\long\def\xintbracediloopindex #1\xintiloop_again\fi\xint_gobble_iii #2%
     {{#2}#1\xintiloop_again\fi\xint_gobble_iii {#2}}%
\long\def\xintouteriloopindex #1\xintiloop_again
                         #2\xintiloop_again\fi\xint_gobble_iii #3%
   {#3#1\xintiloop_again #2\xintiloop_again\fi\xint_gobble_iii {#3}}%
\long\def\xintbracedouteriloopindex #1\xintiloop_again
                         #2\xintiloop_again\fi\xint_gobble_iii #3%
   {{#3}#1\xintiloop_again #2\xintiloop_again\fi\xint_gobble_iii {#3}}%
\long\def\xintiloopskiptonext #1\xintiloop_again\fi\xint_gobble_iii #2#3{%
    \expandafter\xintiloop_again_b \the\numexpr#2+#3.#3.}%
\long\def\xintiloopskipandredo #1\xintiloop_again\fi\xint_gobble_iii #2#3#4{%
    #4\xintiloop_again\fi\xint_gobble_iii {#2}{#3}{#4}}%
```

4.25 \XINT_xflet

Added at 1.09e (2013/10/29) [on 2013/10/29]. We f-expand unbraced tokens and swallow arising space tokens until the dust settles.

```
\def\XINT_xflet #1%
{%
    \def\XINT_xflet_macro {#1}\XINT_xflet_zapsp
}%
\def\XINT_xflet_zapsp
{%
    \expandafter\futurelet\expandafter\XINT_token
    \expandafter\XINT_xflet_sp?\romannumeral`&&@%
}%
\def\XINT_xflet_sp?
{%
    \ifx\XINT_token\XINT_sptoken
         \expandafter\XINT_xflet_zapsp
    \else\expandafter\XINT_xflet_zapspB
    \fi
}%
\def\XINT_xflet_zapspB
{%
    \expandafter\futurelet\expandafter\XINT_tokenB
    \expandafter\XINT_xflet_spB?\romannumeral`&&@%
}%
\def\XINT_xflet_spB?
{%
    \ifx\XINT_tokenB\XINT_sptoken
         \expandafter\XINT_xflet_zapspB
    \else\expandafter\XINT_xflet_eq?
    \fi
}%
\def\XINT_xflet_eq?
{%
    \ifx\XINT_token\XINT_tokenB
         \expandafter\XINT_xflet_macro
    \else\expandafter\XINT_xflet_zapsp
    \fi
}%
```

4.26 \xintApplyInline

Added at 1.09a (2013/09/24). \xintApplyInline\macro{{a}{b}...{z}} has the same effect as executing \macro{a} and then applying again \xintApplyInline to the shortened list {{b}...{z}} until nothing is left. This is a non-expandable command which will result in quicker code than using \xintApplyUnbraced. It f-expands its second (list) argument first, which may thus be encapsulated in a macro.

Modified at 1.09c (2013/10/09). Rewritten. Nota bene: uses catcode 3 Z as privated list terminator.

```
\catcode`Z 3
\long\def\xintApplyInline #1#2%
{%
```

```
  \long\expandafter\def\expandafter\XINT_inline_macro
  \expandafter ##\expandafter 1\expandafter {#1{##1}}%
  \XINT_xflet\XINT_inline_b #2Z% this Z has catcode 3
}%
\def\XINT_inline_b
{%
    \ifx\XINT_token Z\expandafter\xint_gobble_i
    \else\expandafter\XINT_inline_d\fi
}%
\long\def\XINT_inline_d #1%
{%
  \long\def\XINT_item{{#1}}\XINT_xflet\XINT_inline_e
}%
\def\XINT_inline_e
{%
    \ifx\XINT_token Z\expandafter\XINT_inline_w
    \else\expandafter\XINT_inline_f\fi
}%
\def\XINT_inline_f
{%
  \expandafter\XINT_inline_g\expandafter{\XINT_inline_macro {##1}}%
}%
\long\def\XINT_inline_g #1%
{%
   \expandafter\XINT_inline_macro\XINT_item
   \long\def\XINT_inline_macro ##1{#1}\XINT_inline_d
}%
\def\XINT_inline_w #1%
{%
   \expandafter\XINT_inline_macro\XINT_item
}%
```

4.27 \xintFor, \xintFor*, \xintBreakFor, \xintBreakForAndDo

Added at 1.09c (2013/10/09) [on 2013/10/09]. A new kind of loop which uses macro parameters #1, #2, #3, #4 rather than macros; while not expandable it survives executing code closing groups, like what happens in an alignment with the & character. When inserted in a macro for later use, the # character must be doubled.

The non-star variant works on a csv list, which it expands once, the star variant works on a token list, which it (repeatedly) f-expands.

Modified at 1.09e (2013/10/29). Adds \XINT_forever with \xintintegers, \xintdimensions, \xintrationals and \xintBreakFor, \xintBreakForAndDo, \xintifForFirst, \xintifForLast. On this occasion \xint_firstoftwo and \xint_secondoftwo are made long.

Modified at 1.09f (2013/11/04). Rewrites large parts of \xintFor code in order to filter the comma separated list via \xintCSVtoList which gets rid of spaces. The #1 in \XINT_for_forever? has an initial space token which serves two purposes: preventing brace stripping, and stopping the expansion made by \xintcsvtolist. If the \XINT_forever branch is taken, the added space will not be a problem there.

Now allows all macro parameters from #1 to #9 in \xintFor, \xintFor*, and \XINT_forever.

Modified at 1.2i (2016/12/13). Slightly more robust \xintifForFirst/Last in case of nesting.

```
\def\XINT_tmpa #1#2{\ifnum #2<#1 \xint_afterfi {{#########2}}\fi}%
\def\XINT_tmpb #1#2{\ifnum #1<#2 \xint_afterfi {{#########2}}\fi}%
```

```
\def\XINT_tmpc #1%
{%
    \expandafter\edef \csname XINT_for_left#1\endcsname
               {\xintApplyUnbraced {\XINT_tmpa #1}{123456789}}%
    \expandafter\edef \csname XINT_for_right#1\endcsname
               {\xintApplyUnbraced {\XINT_tmpb #1}{123456789}}%
}%
\xintApplyInline \XINT_tmpc {123456789}%
\long\def\xintBreakFor      #1Z{}%
\long\def\xintBreakForAndDo #1#2Z{#1}%
\def\xintFor {\let\xintifForFirst\xint_firstoftwo
              \let\xintifForLast\xint_secondoftwo
              \futurelet\XINT_token\XINT_for_ifstar }%
\def\XINT_for_ifstar {\ifx\XINT_token*\expandafter\XINT_forx
                                \else\expandafter\XINT_for \fi }%
\catcode`U 3 % with numexpr
\catcode`V 3 % with xintfrac.sty (xint.sty not enough)
\catcode`D 3 % with dimexpr
\def\XINT_flet_zapsp
{%
    \futurelet\XINT_token\XINT_flet_sp?
}%
\def\XINT_flet_sp?
{%
    \ifx\XINT_token\XINT_sptoken
         \xint_afterfi{\expandafter\XINT_flet_zapsp\romannumeral0}%
    \else\expandafter\XINT_flet_macro
    \fi
}%
\long\def\XINT_for #1#2in#3#4#5%
{%
    \expandafter\XINT_toks\expandafter
        {\expandafter\XINT_for_d\the\numexpr #2\relax {#5}}%
    \def\XINT_flet_macro {\expandafter\XINT_for_forever?\space}%
    \expandafter\XINT_flet_zapsp #3Z%
}%
\def\XINT_for_forever? #1Z%
{%
    \ifx\XINT_token U\XINT_to_forever\fi
    \ifx\XINT_token V\XINT_to_forever\fi
    \ifx\XINT_token D\XINT_to_forever\fi
    \expandafter\the\expandafter\XINT_toks\romannumeral0\xintcsvtolist {#1}Z%
}%
\def\XINT_to_forever\fi #1\xintcsvtolist #2{\fi \XINT_forever #2}%
\long\def\XINT_forx *#1#2in#3#4#5%
{%
    \expandafter\XINT_toks\expandafter
       {\expandafter\XINT_forx_d\the\numexpr #2\relax {#5}}%
    \XINT_xflet\XINT_forx_forever? #3Z%
}%
\def\XINT_forx_forever?
{%
```

```
    \ifx\XINT_token U\XINT_to_forxever\fi
    \ifx\XINT_token V\XINT_to_forxever\fi
    \ifx\XINT_token D\XINT_to_forxever\fi
    \XINT_forx_empty?
}%
\def\XINT_to_forxever\fi #1\XINT_forx_empty? {\fi \XINT_forever }%
\catcode`U 11
\catcode`D 11
\catcode`V 11
\def\XINT_forx_empty?
{%
    \ifx\XINT_token Z\expandafter\xintBreakFor\fi
    \the\XINT_toks
}%
\long\def\XINT_for_d #1#2#3%
{%
  \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
  \XINT_toks {{#3}}%
  \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
                   \the\XINT_toks   \csname XINT_for_right#1\endcsname }%
  \XINT_toks {\XINT_x\let\xintifForFirst\xint_secondoftwo
                   \let\xintifForLast\xint_secondoftwo\XINT_for_d #1{#2}}%
  \futurelet\XINT_token\XINT_for_last?
}%
\long\def\XINT_forx_d #1#2#3%
{%
  \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
  \XINT_toks {{#3}}%
  \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
                   \the\XINT_toks   \csname XINT_for_right#1\endcsname }%
  \XINT_toks {\XINT_x\let\xintifForFirst\xint_secondoftwo
                   \let\xintifForLast\xint_secondoftwo\XINT_forx_d #1{#2}}%
  \XINT_xflet\XINT_for_last?
}%
\def\XINT_for_last?
{%
  \ifx\XINT_token Z\expandafter\XINT_for_last?yes\fi
  \the\XINT_toks
}%
\def\XINT_for_last?yes
{%
 \let\xintifForLast\xint_firstoftwo
 \xintBreakForAndDo{\XINT_x\xint_gobble_i Z}%
}%
```

4.28 \XINT_forever, \xintintegers, \xintdimensions, \xintrationals

Added at 1.09e (2013/10/29). But this used inadvertently \xintiadd/\xintimul which have the unnecessary \xintnum overhead.

Modified at 1.09f (2013/11/04). Use \xintiiadd/\xintiimul which do not have this overhead. Also 1.09f uses \xintZapSpacesB for the \xintrationals case to get rid of leading and ending spaces in the #4 and #5 delimited parameters of \XINT_forever_opt_a (for \xintintegers and

\xintdimensions this is not necessary, due to the use of \numexpr resp. \dimexpr in \XINT_?expr_Ua, resp.\XINT_?expr_Da).

```
\catcode`U 3
\catcode`D 3
\catcode`V 3
\let\xintegers      U%
\let\xintintegers   U%
\let\xintdimensions D%
\let\xintrationals  V%
\def\XINT_forever #1%
{%
  \expandafter\XINT_forever_a
  \csname XINT_?expr_\ifx#1UU\else\ifx#1DD\else V\fi\fi a\expandafter\endcsname
  \csname XINT_?expr_\ifx#1UU\else\ifx#1DD\else V\fi\fi i\expandafter\endcsname
  \csname XINT_?expr_\ifx#1UU\else\ifx#1DD\else V\fi\fi \endcsname
}%
\catcode`U 11
\catcode`D 11
\catcode`V 11
\def\XINT_?expr_Ua #1#2%
   {\expandafter{\expandafter\numexpr\the\numexpr #1\expandafter\relax
                                \expandafter\relax\expandafter}%
    \expandafter{\the\numexpr #2}}%
\def\XINT_?expr_Da #1#2%
   {\expandafter{\expandafter\dimexpr\number\dimexpr #1\expandafter\relax
                  \expandafter s\expandafter p\expandafter\relax\expandafter}%
    \expandafter{\number\dimexpr #2}}%
\catcode`Z 11
\def\XINT_?expr_Va #1#2%
{%
    \expandafter\XINT_?expr_Vb\expandafter
          {\romannumeral`&&@\xintrawwithzeros{\xintZapSpacesB{#2}}}%
          {\romannumeral`&&@\xintrawwithzeros{\xintZapSpacesB{#1}}}%
}%
\catcode`Z 3
\def\XINT_?expr_Vb #1#2{\expandafter\XINT_?expr_Vc #2.#1.}%
\def\XINT_?expr_Vc #1/#2.#3/#4.%
{%
     \xintifEq {#2}{#4}%
       {\XINT_?expr_Vf {#3}{#1}{#2}}%
       {\expandafter\XINT_?expr_Vd\expandafter
        {\romannumeral0\xintiimul {#2}{#4}}%
        {\romannumeral0\xintiimul {#1}{#4}}%
        {\romannumeral0\xintiimul {#2}{#3}}%
       }%
}%
\def\XINT_?expr_Vd #1#2#3{\expandafter\XINT_?expr_Ve\expandafter {#2}{#3}{#1}}%
\def\XINT_?expr_Ve #1#2{\expandafter\XINT_?expr_Vf\expandafter {#2}{#1}}%
\def\XINT_?expr_Vf #1#2#3{{#2/#3}{{0}{#1}{#2}{#3}}}%
\def\XINT_?expr_Ui {{\numexpr 1\relax}{1}}%
\def\XINT_?expr_Di {{\dimexpr 0pt\relax}{65536}}%
\def\XINT_?expr_Vi {{1/1}{0111}}%
```

```
\def\XINT_?expr_U #1#2%
   {\expandafter{\expandafter\numexpr\the\numexpr #1+#2\relax\relax}{#2}}%
\def\XINT_?expr_D #1#2%
   {\expandafter{\expandafter\dimexpr\the\numexpr #1+#2\relax sp\relax}{#2}}%
\def\XINT_?expr_V #1#2{\XINT_?expr_Vx #2}%
\def\XINT_?expr_Vx #1#2%
{%
     \expandafter\XINT_?expr_Vy\expandafter
        {\romannumeral0\xintiiadd {#1}{#2}}{#2}%
}%
\def\XINT_?expr_Vy #1#2#3#4%
{%
     \expandafter{\romannumeral0\xintiiadd {#3}{#1}/#4}{{#1}{#2}{#3}{#4}}%
}%
\def\XINT_forever_a #1#2#3#4%
{%
    \ifx #4[\expandafter\XINT_forever_opt_a
       \else\expandafter\XINT_forever_b
    \fi #1#2#3#4%
}%
\def\XINT_forever_b #1#2#3Z{\expandafter\XINT_forever_c\the\XINT_toks #2#3}%
\long\def\XINT_forever_c #1#2#3#4#5%
    {\expandafter\XINT_forever_d\expandafter #2#4#5{#3}Z}%
\def\XINT_forever_opt_a #1#2#3[#4+#5]#6Z%
{%
    \expandafter\expandafter\expandafter
    \XINT_forever_opt_c\expandafter\the\expandafter\XINT_toks
    \romannumeral`&&@#1{#4}{#5}#3%
}%
\long\def\XINT_forever_opt_c #1#2#3#4#5#6{\XINT_forever_d #2{#4}{#5}#6{#3}Z}%
\long\def\XINT_forever_d #1#2#3#4#5%
{%
  \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#5}%
  \XINT_toks {{#2}}%
  \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
                     \the\XINT_toks   \csname XINT_for_right#1\endcsname }%
  \XINT_x
  \let\xintifForFirst\xint_secondoftwo
  \let\xintifForLast\xint_secondoftwo
  \expandafter\XINT_forever_d\expandafter #1\romannumeral`&&@#4{#2}{#3}#4{#5}%
}%
```

4.29 \xintForpair, \xintForthree, \xintForfour

Added at 1.09c (2013/10/09).

Modified at 1.09f (2013/11/04). \xintForpair delegate to \xintCSVtoList and its \xintZapSpacesB the handling of spaces. Does not share code with \xintFor anymore.

\xintForpair extended to accept #1#2, #2#3 etc... up to #8#9, \xintForthree, #1#2#3 up to #7#8#9, \xintForfour id.

Modified at 1.2i (2016/12/13). Slightly more robust \xintifForFirst/Last in case of nesting.

```
\catcode`j 3
\long\def\xintForpair #1#2#3in#4#5#6%
```

```
{%
    \let\xintifForFirst\xint_firstoftwo
    \let\xintifForLast\xint_secondoftwo
    \XINT_toks  {\XINT_forpair_d #2{#6}}%
    \expandafter\the\expandafter\XINT_toks #4jZ%
}%
\long\def\XINT_forpair_d #1#2#3(#4)#5%
{%
  \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
  \XINT_toks \expandafter{\romannumeral0\xintcsvtolist{ #4}}%
  \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
      \the\XINT_toks \csname XINT_for_right\the\numexpr#1+\xint_c_i\endcsname}%
  \ifx #5j\expandafter\XINT_for_last?yes\fi
  \XINT_x
  \let\xintifForFirst\xint_secondoftwo
  \let\xintifForLast\xint_secondoftwo
  \XINT_forpair_d #1{#2}%
}%
\long\def\xintForthree #1#2#3in#4#5#6%
{%
    \let\xintifForFirst\xint_firstoftwo
    \let\xintifForLast\xint_secondoftwo
    \XINT_toks  {\XINT_forthree_d #2{#6}}%
    \expandafter\the\expandafter\XINT_toks #4jZ%
}%
\long\def\XINT_forthree_d #1#2#3(#4)#5%
{%
  \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
  \XINT_toks \expandafter{\romannumeral0\xintcsvtolist{ #4}}%
  \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
      \the\XINT_toks \csname XINT_for_right\the\numexpr#1+\xint_c_ii\endcsname}%
  \ifx #5j\expandafter\XINT_for_last?yes\fi
  \XINT_x
  \let\xintifForFirst\xint_secondoftwo
  \let\xintifForLast\xint_secondoftwo
  \XINT_forthree_d #1{#2}%
}%
\long\def\xintForfour #1#2#3in#4#5#6%
{%
    \let\xintifForFirst\xint_firstoftwo
    \let\xintifForLast\xint_secondoftwo
    \XINT_toks  {\XINT_forfour_d #2{#6}}%
    \expandafter\the\expandafter\XINT_toks #4jZ%
}%
\long\def\XINT_forfour_d #1#2#3(#4)#5%
{%
  \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
  \XINT_toks \expandafter{\romannumeral0\xintcsvtolist{ #4}}%
  \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
     \the\XINT_toks \csname XINT_for_right\the\numexpr#1+\xint_c_iii\endcsname}%
  \ifx #5j\expandafter\XINT_for_last?yes\fi
  \XINT_x
```

```
  \let\xintifForFirst\xint_secondoftwo
  \let\xintifForLast\xint_secondoftwo
  \XINT_forfour_d #1{#2}%
}%
\catcode`Z 11
\catcode`j 11
```

4.30 \xintAssign, \xintAssignArray, \xintDigitsOf

\xintAssign {a}{b}..{z}\to\A\B...\Z resp. \xintAssignArray {a}{b}..{z}\to\U.
\xintDigitsOf=\xintAssignArray.

Modified at 1.1c (2015/09/12). Belatedly corrects some "features" of \xintAssign which didn't like the case of a space right before the "\to", or the case with the first token not an opening brace and the subsequent material containing brace groups. The new code handles gracefully these situations.

```
\def\xintAssign{\def\XINT_flet_macro {\XINT_assign_fork}\XINT_flet_zapsp }%
\def\XINT_assign_fork
{%
    \let\XINT_assign_def\def
    \ifx\XINT_token[\expandafter\XINT_assign_opt
               \else\expandafter\XINT_assign_a
    \fi
}%
\def\XINT_assign_opt [#1]%
{%
    \ifcsname #1def\endcsname
      \expandafter\let\expandafter\XINT_assign_def \csname #1def\endcsname
    \else
      \expandafter\let\expandafter\XINT_assign_def \csname xint#1def\endcsname
    \fi
    \XINT_assign_a
}%
\long\def\XINT_assign_a #1\to
{%
    \def\XINT_flet_macro{\XINT_assign_b}%
    \expandafter\XINT_flet_zapsp\romannumeral`&&@#1\xint:\to
}%
\long\def\XINT_assign_b
{%
    \ifx\XINT_token\bgroup
         \expandafter\XINT_assign_c
    \else\expandafter\XINT_assign_f
    \fi
}%
\long\def\XINT_assign_f #1\xint:\to #2%
{%
    \XINT_assign_def #2{#1}%
}%
\long\def\XINT_assign_c #1%
{%
    \def\XINT_assign_tmp {#1}%
    \ifx\XINT_assign_tmp\xint_bracedstopper
```

```
        \expandafter\XINT_assign_e
    \else
        \expandafter\XINT_assign_d
    \fi
}%
\long\def\XINT_assign_d #1\to #2%
{%
    \expandafter\XINT_assign_def\expandafter #2\expandafter{\XINT_assign_tmp}%
    \XINT_assign_c #1\to
}%
\def\XINT_assign_e #1\to {}%
\def\xintRelaxArray #1%
{%
    \edef\XINT_restoreescapechar {\escapechar\the\escapechar\relax}%
    \escapechar -1
    \expandafter\def\expandafter\xint_arrayname\expandafter {\string #1}%
    \XINT_restoreescapechar
    \xintiloop [\csname\xint_arrayname 0\endcsname+-1]
      \global
      \expandafter\let\csname\xint_arrayname\xintiloopindex\endcsname\relax
      \ifnum \xintiloopindex > \xint_c_
    \repeat
    \global\expandafter\let\csname\xint_arrayname 00\endcsname\relax
    \global\let #1\relax
}%
\def\xintAssignArray{\def\XINT_flet_macro {\XINT_assignarray_fork}%
                     \XINT_flet_zapsp }%
\def\XINT_assignarray_fork
{%
    \let\XINT_assignarray_def\def
    \ifx\XINT_token[\expandafter\XINT_assignarray_opt
               \else\expandafter\XINT_assignarray
    \fi
}%
\def\XINT_assignarray_opt [#1]%
{%
    \ifcsname #1def\endcsname
      \expandafter\let\expandafter\XINT_assignarray_def \csname #1def\endcsname
    \else
      \expandafter\let\expandafter\XINT_assignarray_def
                                  \csname xint#1def\endcsname
    \fi
    \XINT_assignarray
}%
\long\def\XINT_assignarray #1\to #2%
{%
    \edef\XINT_restoreescapechar {\escapechar\the\escapechar\relax }%
    \escapechar -1
    \expandafter\def\expandafter\xint_arrayname\expandafter {\string #2}%
    \XINT_restoreescapechar
    \def\xint_itemcount {0}%
    \expandafter\XINT_assignarray_loop \romannumeral`&&@#1\xint:
```

```
    \csname\xint_arrayname 00\expandafter\endcsname
    \csname\xint_arrayname 0\expandafter\endcsname
    \expandafter {\xint_arrayname}#2%
}%
\long\def\XINT_assignarray_loop #1%
{%
    \def\XINT_assign_tmp {#1}%
    \ifx\XINT_assign_tmp\xint_bracedstopper
       \expandafter\def\csname\xint_arrayname 0\expandafter\endcsname
                   \expandafter{\the\numexpr\xint_itemcount}%
       \expandafter\expandafter\expandafter\XINT_assignarray_end
    \else
       \expandafter\def\expandafter\xint_itemcount\expandafter
                   {\the\numexpr\xint_itemcount+\xint_c_i}%
       \expandafter\XINT_assignarray_def
          \csname\xint_arrayname\xint_itemcount\expandafter\endcsname
             \expandafter{\XINT_assign_tmp }%
       \expandafter\XINT_assignarray_loop
    \fi
}%
\def\XINT_assignarray_end #1#2#3#4%
{%
    \def #4##1%
    {%
        \romannumeral0\expandafter #1\expandafter{\the\numexpr ##1}%
    }%
    \def #1##1%
    {%
        \ifnum ##1<\xint_c_
            \xint_afterfi{\XINT_expandableerror{Array index is negative: ##1.} }%
        \else
        \xint_afterfi {%
              \ifnum ##1>#2
                  \xint_afterfi
                  {\XINT_expandableerror{Array index is beyond range: ##1 > #2.} }%
              \else\xint_afterfi
       {\expandafter\expandafter\expandafter\space\csname #3##1\endcsname}%
              \fi}%
        \fi
     }%
}%
\let\xintDigitsOf\xintAssignArray
```

4.31 CSV (non user documented) variants of Length, Keep, Trim, NthElt, Reverse

Modified at 1.2j (2016/12/22). These routines are for use by \xintListSel:x:csv and \xintListSel:f:csv from xintexpr, and also for the reversed and len functions. Refactored for 1.2j release, following 1.2i updates to \xintKeep, \xintTrim, ...

These macros will remain undocumented in the user manual:

-- they exist primarily for internal use by the xintexpr parsers, hence don't have to be general purpose; for example, they a priori need to handle only catcode 12 tokens (not true in

\xintNewExpr, though) hence they are not really worried about controlling brace stripping (nevertheless 1.2j has paid some secondary attention to it, see below.) They are not worried about normalizing leading spaces either, because none will be encountered when the macros are used as auxiliaries to the expression parsers.

-- crucial design elements may change in future:

1. whether the handled lists must have or not have a final comma. Currently, the model is the one of comma separated lists with **no** final comma. But this means that there can not be a distinction of principle between a truly empty list and a list which contains one item which turns out to be empty. More importantly it makes the coding more complicated as it is needed to distinguish the empty list from the single-item list, both lacking commas.

For the internal use of xintexpr, it would be ok to require all list items to be terminated by a comma, and this would bring quite some simplications here, but as initially I started with non-terminated lists, I have left it this way in the 1.2j refactoring.

2. the way to represent the empty list. I was tempted for matter of optimization and synchronization with xintexpr context to require the empty list to be always represented by a space token and to not let the macros admit a completely empty input. But there were complications so for the time being 1.2j does accept truly empty output (it is not distinguished from an input equal to a space token) and produces empty output for empty list. This means that the status of the «nil» object for the xintexpr parsers is not completely clarified (currently it is represented by a space token).

The original Python slicing code in xintexpr 1.1 used \xintCSVtoList and \xintListWithSep{, } to convert back and forth to token lists and apply \xintKeep/\xintTrim. Release 1.2g switched to devoted f-expandable macros added to xinttools. Release 1.2j refactored all these macros as a follow-up to 1.2i improvements to \xintKeep/\xintTrim. They were made \long on this occasion and auxiliary \xintLengthUpTo:f:csv was added.

Leading spaces in items are currently maintained as is by the 1.2j macros, even by \xintNthEltPy:f:csv, with the exception of the first item, as the list is f-expanded. Perhaps \xintNthEltPy:f:csv should remove a leading space if present in the picked item; anyway, there are no spaces for the lists handled internally by the Python slicer of xintexpr, except the «nil» object currently represented by exactly one space.

Kept items (with no leading spaces; but first item special as it will have lost a leading space due to f-expansion) will lose a brace pair under \xintKeep:f:csv if the first argument was positive and strictly less than the length of the list. This differs of course from \xintKeep (which always braces items it outputs when used with positive first argument) and also from \xintKeepUnbraced in the case when the whole list is kept. Actually the case of singleton list is special, and brace removal will happen then.

This behaviour was otherwise for releases earlier than 1.2j and may change again.

Directly usable names are provided, but these macros (and the behaviour as described above) are to be considered *unstable* for the time being.

4.31.1 \xintLength:f:csv

Added at 1.2g (2016/03/19).

Modified at 1.2j (2016/12/22). Contrarily to \xintLength from xintkernel this one expands its argument.

```
\def\xintLength:f:csv {\romannumeral0\xintlength:f:csv}%
\def\xintlength:f:csv #1%
{\long\def\xintlength:f:csv ##1{%
    \expandafter#1\the\numexpr\expandafter\XINT_length:f:csv_a
    \romannumeral`&&@##1\xint:,\xint:,\xint:,\xint:,%
      \xint:,\xint:,\xint:,\xint:,\xint:,%
      \xint_c_ix,\xint_c_viii,\xint_c_vii,\xint_c_vi,%
```

```
      \xint_c_v,\xint_c_iv,\xint_c_iii,\xint_c_ii,\xint_c_i,\xint_bye
    \relax
}}\xintlength:f:csv { }%
```

Must first check if empty list.

```
\long\def\XINT_length:f:csv_a #1%
{%
    \xint_gob_til_xint: #1\xint_c_\xint_bye\xint:%
    \XINT_length:f:csv_loop #1%
}%
\long\def\XINT_length:f:csv_loop #1,#2,#3,#4,#5,#6,#7,#8,#9,%
{%
    \xint_gob_til_xint: #9\XINT_length:f:csv_finish\xint:%
    \xint_c_ix+\XINT_length:f:csv_loop
}%
\def\XINT_length:f:csv_finish\xint:\xint_c_ix+\XINT_length:f:csv_loop
    #1,#2,#3,#4,#5,#6,#7,#8,#9,{#9\xint_bye}%
```

4.31.2 \xintLengthUpTo:f:csv

Added at 1.2j (2016/12/22). \added{1.2j}\xintLengthUpTo:f:csv{N}{comma-list}. No ending comma.
Returns -0 if length>N, else returns difference N-length. **N must be non-negative!!**
Attention to the dot after \xint_bye for the loop interface.

```
\def\xintLengthUpTo:f:csv {\romannumeral0\xintlengthupto:f:csv}%
\long\def\xintlengthupto:f:csv #1#2%
{%
    \expandafter\XINT_lengthupto:f:csv_a
    \the\numexpr#1\expandafter.%
    \romannumeral`&&@#2\xint:,\xint:,\xint:,\xint:,%
         \xint:,\xint:,\xint:,\xint:,%
         \xint_c_viii,\xint_c_vii,\xint_c_vi,\xint_c_v,%
         \xint_c_iv,\xint_c_iii,\xint_c_ii,\xint_c_i,\xint_bye.%
}%
```

Must first recognize if empty list. If this is the case, return N.

```
\long\def\XINT_lengthupto:f:csv_a #1.#2%
{%
    \xint_gob_til_xint: #2\XINT_lengthupto:f:csv_empty\xint:%
    \XINT_lengthupto:f:csv_loop_b #1.#2%
}%
\def\XINT_lengthupto:f:csv_empty\xint:%
    \XINT_lengthupto:f:csv_loop_b #1.#2\xint_bye.{ #1}%
\def\XINT_lengthupto:f:csv_loop_a #1%
{%
    \xint_UDsignfork
      #1\XINT_lengthupto:f:csv_gt
       -\XINT_lengthupto:f:csv_loop_b
    \krof #1%
}%
\long\def\XINT_lengthupto:f:csv_gt #1\xint_bye.{-0}%
\long\def\XINT_lengthupto:f:csv_loop_b #1.#2,#3,#4,#5,#6,#7,#8,#9,%
{%
    \xint_gob_til_xint: #9\XINT_lengthupto:f:csv_finish_a\xint:%
    \expandafter\XINT_lengthupto:f:csv_loop_a\the\numexpr #1-\xint_c_viii.%
```

```
}%
\def\XINT_lengthupto:f:csv_finish_a\xint:
    \expandafter\XINT_lengthupto:f:csv_loop_a
    \the\numexpr #1-\xint_c_viii.#2,#3,#4,#5,#6,#7,#8,#9,%
{%
    \expandafter\XINT_lengthupto:f:csv_finish_b\the\numexpr #1-#9\xint_bye
}%
\def\XINT_lengthupto:f:csv_finish_b #1#2.%
{%
    \xint_UDsignfork
       #1{-0}%
        -{ #1#2}%
    \krof
}%
```

4.31.3 \xintKeep:f:csv

Added at 1.2g (2016/03/19) [on 2016/03/17].

Modified at 1.2j (2016/12/22). Redone with use of \xintLengthUpTo:f:csv. Same code skeleton as \xintKeep but handling comma separated but non terminated lists has complications. The \xintKeep in case of a negative #1 uses \xintgobble, we don't have that for comma delimited items, hence we do a special loop here (this style of loop is surely competitive with xintgobble for a few dozens items and even more). The loop knows before starting that it will not go too far.

```
\def\xintKeep:f:csv {\romannumeral0\xintkeep:f:csv }%
\long\def\xintkeep:f:csv #1#2%
{%
    \expandafter\xint_stop_aftergobble
    \romannumeral0\expandafter\XINT_keep:f:csv_a
    \the\numexpr #1\expandafter.\expandafter{\romannumeral`&&@#2}%
}%
\def\XINT_keep:f:csv_a #1%
{%
    \xint_UDzerominusfork
        #1-\XINT_keep:f:csv_keepnone
        0#1\XINT_keep:f:csv_neg
         0-{\XINT_keep:f:csv_pos #1}%
    \krof
}%
\long\def\XINT_keep:f:csv_keepnone .#1{,}%
\long\def\XINT_keep:f:csv_neg #1.#2%
{%
    \expandafter\XINT_keep:f:csv_neg_done\expandafter,%
    \romannumeral0%
    \expandafter\XINT_keep:f:csv_neg_a\the\numexpr
    #1-\numexpr\XINT_length:f:csv_a
    #2\xint:,\xint:,\xint:,\xint:,%
      \xint:,\xint:,\xint:,\xint:,\xint:,%
      \xint_c_ix,\xint_c_viii,\xint_c_vii,\xint_c_vi,%
      \xint_c_v,\xint_c_iv,\xint_c_iii,\xint_c_ii,\xint_c_i,\xint_bye
    .#2\xint_bye
}%
```

```
\def\XINT_keep:f:csv_neg_a #1%
{%
    \xint_UDsignfork
        #1{\expandafter\XINT_keep:f:csv_trimloop\the\numexpr-\xint_c_ix+}%
         -\XINT_keep:f:csv_keepall
    \krof
}%
\def\XINT_keep:f:csv_keepall #1.{ }%
\long\def\XINT_keep:f:csv_neg_done #1\xint_bye{#1}%
\def\XINT_keep:f:csv_trimloop #1#2.%
{%
    \xint_gob_til_minus#1\XINT_keep:f:csv_trimloop_finish-%
    \expandafter\XINT_keep:f:csv_trimloop
    \the\numexpr#1#2-\xint_c_ix\expandafter.\XINT_keep:f:csv_trimloop_trimnine
}%
\long\def\XINT_keep:f:csv_trimloop_trimnine #1,#2,#3,#4,#5,#6,#7,#8,#9,{}%
\def\XINT_keep:f:csv_trimloop_finish-%
    \expandafter\XINT_keep:f:csv_trimloop
    \the\numexpr-#1-\xint_c_ix\expandafter.\XINT_keep:f:csv_trimloop_trimnine
    {\csname XINT_trim:f:csv_finish#1\endcsname}%
\long\def\XINT_keep:f:csv_pos #1.#2%
{%
    \expandafter\XINT_keep:f:csv_pos_fork
    \romannumeral0\XINT_lengthupto:f:csv_a
    #1.#2\xint:,\xint:,\xint:,\xint:,%
         \xint:,\xint:,\xint:,\xint:,%
         \xint_c_viii,\xint_c_vii,\xint_c_vi,\xint_c_v,%
         \xint_c_iv,\xint_c_iii,\xint_c_ii,\xint_c_i,\xint_bye.%
    .#1.{}#2\xint_bye%
}%
\def\XINT_keep:f:csv_pos_fork #1#2.%
{%
    \xint_UDsignfork
      #1{\expandafter\XINT_keep:f:csv_loop\the\numexpr-\xint_c_viii+}%
       -\XINT_keep:f:csv_pos_keepall
    \krof
}%
\long\def\XINT_keep:f:csv_pos_keepall #1.#2#3\xint_bye{,#3}%
\def\XINT_keep:f:csv_loop #1#2.%
{%
    \xint_gob_til_minus#1\XINT_keep:f:csv_loop_end-%
    \expandafter\XINT_keep:f:csv_loop
    \the\numexpr#1#2-\xint_c_viii\expandafter.\XINT_keep:f:csv_loop_pickeight
}%
\long\def\XINT_keep:f:csv_loop_pickeight
     #1#2,#3,#4,#5,#6,#7,#8,#9,{{#1,#2,#3,#4,#5,#6,#7,#8,#9}}%
\def\XINT_keep:f:csv_loop_end-\expandafter\XINT_keep:f:csv_loop
    \the\numexpr-#1-\xint_c_viii\expandafter.\XINT_keep:f:csv_loop_pickeight
    {\csname XINT_keep:f:csv_end#1\endcsname}%
\long\expandafter\def\csname XINT_keep:f:csv_end1\endcsname
   #1#2,#3,#4,#5,#6,#7,#8,#9\xint_bye {#1,#2,#3,#4,#5,#6,#7,#8}%
\long\expandafter\def\csname XINT_keep:f:csv_end2\endcsname
```

```
    #1#2,#3,#4,#5,#6,#7,#8\xint_bye {#1,#2,#3,#4,#5,#6,#7}%
\long\expandafter\def\csname XINT_keep:f:csv_end3\endcsname
    #1#2,#3,#4,#5,#6,#7\xint_bye {#1,#2,#3,#4,#5,#6}%
\long\expandafter\def\csname XINT_keep:f:csv_end4\endcsname
    #1#2,#3,#4,#5,#6\xint_bye {#1,#2,#3,#4,#5}%
\long\expandafter\def\csname XINT_keep:f:csv_end5\endcsname
    #1#2,#3,#4,#5\xint_bye {#1,#2,#3,#4}%
\long\expandafter\def\csname XINT_keep:f:csv_end6\endcsname
    #1#2,#3,#4\xint_bye {#1,#2,#3}%
\long\expandafter\def\csname XINT_keep:f:csv_end7\endcsname
    #1#2,#3\xint_bye {#1,#2}%
\long\expandafter\def\csname XINT_keep:f:csv_end8\endcsname
    #1#2\xint_bye {#1}%
```

4.31.4 `\xintTrim:f:csv`

Added at 1.2g (2016/03/19) [on 2016/03/17].

Modified at 1.2j (2016/12/22). Redone on the basis of new `\xintTrim`.

```
\def\xintTrim:f:csv {\romannumeral0\xinttrim:f:csv }%
\long\def\xinttrim:f:csv #1#2%
{%
    \expandafter\xint_stop_aftergobble
    \romannumeral0\expandafter\XINT_trim:f:csv_a
    \the\numexpr #1\expandafter.\expandafter{\romannumeral`&&@#2}%
}%
\def\XINT_trim:f:csv_a #1%
{%
    \xint_UDzerominusfork
        #1-\XINT_trim:f:csv_trimnone
        0#1\XINT_trim:f:csv_neg
         0-{\XINT_trim:f:csv_pos #1}%
    \krof
}%
\long\def\XINT_trim:f:csv_trimnone .#1{,#1}%
\long\def\XINT_trim:f:csv_neg #1.#2%
{%
    \expandafter\XINT_trim:f:csv_neg_a\the\numexpr
    #1-\numexpr\XINT_length:f:csv_a
    #2\xint:,\xint:,\xint:,\xint:,%
      \xint:,\xint:,\xint:,\xint:,\xint:,%
      \xint_c_ix,\xint_c_viii,\xint_c_vii,\xint_c_vi,%
      \xint_c_v,\xint_c_iv,\xint_c_iii,\xint_c_ii,\xint_c_i,\xint_bye
    .{}#2\xint_bye
}%
\def\XINT_trim:f:csv_neg_a #1%
{%
    \xint_UDsignfork
        #1{\expandafter\XINT_keep:f:csv_loop\the\numexpr-\xint_c_viii+}%
         -\XINT_trim:f:csv_trimall
    \krof
}%
\def\XINT_trim:f:csv_trimall {\expandafter,\xint_bye}%
```

```
\long\def\XINT_trim:f:csv_pos #1.#2%
{%
    \expandafter\XINT_trim:f:csv_pos_done\expandafter,%
    \romannumeral0%
    \expandafter\XINT_trim:f:csv_loop\the\numexpr#1-\xint_c_ix.%
     #2\xint:,\xint:,\xint:,\xint:,\xint:,%
       \xint:,\xint:,\xint:,\xint:,\xint:\xint_bye
}%
\def\XINT_trim:f:csv_loop #1#2.%
{%
    \xint_gob_til_minus#1\XINT_trim:f:csv_finish-%
    \expandafter\XINT_trim:f:csv_loop\the\numexpr#1#2\XINT_trim:f:csv_loop_trimnine
}%
\long\def\XINT_trim:f:csv_loop_trimnine #1,#2,#3,#4,#5,#6,#7,#8,#9,%
{%
    \xint_gob_til_xint: #9\XINT_trim:f:csv_toofew\xint:-\xint_c_ix.%
}%
\def\XINT_trim:f:csv_toofew\xint:{*\xint_c_}%
\def\XINT_trim:f:csv_finish-%
    \expandafter\XINT_trim:f:csv_loop\the\numexpr-#1\XINT_trim:f:csv_loop_trimnine
{%
    \csname XINT_trim:f:csv_finish#1\endcsname
}%
\long\expandafter\def\csname XINT_trim:f:csv_finish1\endcsname
  #1,#2,#3,#4,#5,#6,#7,#8,{ }%
\long\expandafter\def\csname XINT_trim:f:csv_finish2\endcsname
  #1,#2,#3,#4,#5,#6,#7,{ }%
\long\expandafter\def\csname XINT_trim:f:csv_finish3\endcsname
  #1,#2,#3,#4,#5,#6,{ }%
\long\expandafter\def\csname XINT_trim:f:csv_finish4\endcsname
  #1,#2,#3,#4,#5,{ }%
\long\expandafter\def\csname XINT_trim:f:csv_finish5\endcsname
  #1,#2,#3,#4,{ }%
\long\expandafter\def\csname XINT_trim:f:csv_finish6\endcsname
  #1,#2,#3,{ }%
\long\expandafter\def\csname XINT_trim:f:csv_finish7\endcsname
  #1,#2,{ }%
\long\expandafter\def\csname XINT_trim:f:csv_finish8\endcsname
  #1,{ }%
\expandafter\let\csname XINT_trim:f:csv_finish9\endcsname\space
\long\def\XINT_trim:f:csv_pos_done #1\xint:#2\xint_bye{#1}%
```

4.31.5 \xintNthEltPy:f:csv

Counts like Python starting at zero. Last refactored with 1.2j. Attention, makes currently no effort at removing leading spaces in the picked item.

```
\def\xintNthEltPy:f:csv {\romannumeral0\xintntheltpy:f:csv }%
\long\def\xintntheltpy:f:csv #1#2%
{%
   \expandafter\XINT_nthelt:f:csv_a
   \the\numexpr #1\expandafter.\expandafter{\romannumeral`&&@#2}%
}%
\def\XINT_nthelt:f:csv_a #1%
```

```
{%
    \xint_UDsignfork
        #1\XINT_nthelt:f:csv_neg
         -\XINT_nthelt:f:csv_pos
    \krof #1%
}%
\long\def\XINT_nthelt:f:csv_neg -#1.#2%
{%
    \expandafter\XINT_nthelt:f:csv_neg_fork
    \the\numexpr\XINT_length:f:csv_a
    #2\xint:,\xint:,\xint:,\xint:,%
      \xint:,\xint:,\xint:,\xint:,\xint:,%
      \xint_c_ix,\xint_c_viii,\xint_c_vii,\xint_c_vi,%
      \xint_c_v,\xint_c_iv,\xint_c_iii,\xint_c_ii,\xint_c_i,\xint_bye
    -#1.#2,\xint_bye
}%
\def\XINT_nthelt:f:csv_neg_fork #1%
{%
    \if#1-\expandafter\xint_stop_afterbye\fi
    \expandafter\XINT_nthelt:f:csv_neg_done
    \romannumeral0%
    \expandafter\XINT_keep:f:csv_trimloop\the\numexpr-\xint_c_ix+#1%
}%
\long\def\XINT_nthelt:f:csv_neg_done#1,#2\xint_bye{ #1}%
\long\def\XINT_nthelt:f:csv_pos #1.#2%
{%
    \expandafter\XINT_nthelt:f:csv_pos_done
    \romannumeral0%
    \expandafter\XINT_trim:f:csv_loop\the\numexpr#1-\xint_c_ix.%
    #2\xint:,\xint:,\xint:,\xint:,\xint:,%
       \xint:,\xint:,\xint:,\xint:,\xint:,\xint_bye
}%
\def\XINT_nthelt:f:csv_pos_done #1{%
\long\def\XINT_nthelt:f:csv_pos_done ##1,##2\xint_bye{%
  \xint_gob_til_xint:##1\XINT_nthelt:f:csv_pos_cleanup\xint:#1##1}%
}\XINT_nthelt:f:csv_pos_done{ }%
```

This strange thing is in case the picked item was the last one, hence there was an ending \xint: (we could not put a comma earlier for matters of not confusing empty list with a singleton list), and we do this here to activate brace-stripping of item as all other items may be brace-stripped if picked. This is done for coherence. Of course, in the context of the xintexpr.sty parsers, there are no braces in list items...

```
\xint_firstofone{\long\def\XINT_nthelt:f:csv_pos_cleanup\xint:} %
   #1\xint:{ #1}%
```

4.31.6 \xintReverse:f:csv

Added at 1.2g (2016/03/19) [on 2016/03/17]. Contrarily to \xintReverseOrder from xintkernel.sty, this one expands its argument. Handles empty list too. .

Modified at 1.2j (2016/12/22). Made \long.

```
\def\xintReverse:f:csv {\romannumeral0\xintreverse:f:csv }%
\long\def\xintreverse:f:csv #1%
{%
```

```
    \expandafter\XINT_reverse:f:csv_loop
    \expandafter{\expandafter}\romannumeral`&&@#1,%
      \xint:,%
        \xint_bye,\xint_bye,\xint_bye,\xint_bye,%
        \xint_bye,\xint_bye,\xint_bye,\xint_bye,%
      \xint:
}%
\long\def\XINT_reverse:f:csv_loop #1#2,#3,#4,#5,#6,#7,#8,#9,%
{%
    \xint_bye #9\XINT_reverse:f:csv_cleanup\xint_bye
    \XINT_reverse:f:csv_loop {,#9,#8,#7,#6,#5,#4,#3,#2#1}%
}%
\long\def\XINT_reverse:f:csv_cleanup\xint_bye\XINT_reverse:f:csv_loop #1#2\xint:
{%
    \XINT_reverse:f:csv_finish #1%
}%
\long\def\XINT_reverse:f:csv_finish #1\xint:,{ }%
```

4.31.7 \xintFirstItem:f:csv

Added at 1.2k (2017/01/06). For use by first() in \xintexpr-essions, and some amount of compatibility with \xintNewExpr.

```
\def\xintFirstItem:f:csv {\romannumeral0\xintfirstitem:f:csv}%
\long\def\xintfirstitem:f:csv #1%
{%
    \expandafter\XINT_first:f:csv_a\romannumeral`&&@#1,\xint_bye
}%
\long\def\XINT_first:f:csv_a #1,#2\xint_bye{ #1}%
```

4.31.8 \xintLastItem:f:csv

Added at 1.2k (2017/01/06). Based on and sharing code with xintkernel's \xintLastItem from 1.2i. Output empty if input empty. f-expands its argument (hence first item, if not protected.) For use by last() in \xintexpr-essions with to some extent \xintNewExpr compatibility.

```
\def\xintLastItem:f:csv {\romannumeral0\xintlastitem:f:csv}%
\long\def\xintlastitem:f:csv #1%
{%
    \expandafter\XINT_last:f:csv_loop\expandafter{\expandafter}\expandafter.%
    \romannumeral`&&@#1,%
    \xint:\XINT_last_loop_enda,\xint:\XINT_last_loop_endb,%
    \xint:\XINT_last_loop_endc,\xint:\XINT_last_loop_endd,%
    \xint:\XINT_last_loop_ende,\xint:\XINT_last_loop_endf,%
    \xint:\XINT_last_loop_endg,\xint:\XINT_last_loop_endh,\xint_bye
}%
\long\def\XINT_last:f:csv_loop #1.#2,#3,#4,#5,#6,#7,#8,#9,%
{%
    \xint_gob_til_xint: #9%
        {#8}{#7}{#6}{#5}{#4}{#3}{#2}{#1}\xint:
    \XINT_last:f:csv_loop {#9}.%
}%
```

4.31.9 \xintKeep:x:csv

Added at 1.2j (2016/12/22). To xintexpr. Moved here at 1.4. Not part of publicly supported macros, may be removed at any time.

```
\def\xintKeep:x:csv #1#2%
{%
    \expandafter\xint_gobble_i
    \romannumeral0\expandafter\XINT_keep:x:csv_pos
    \the\numexpr #1\expandafter.\expandafter{\romannumeral`&&@#2}%
}%
\def\XINT_keep:x:csv_pos #1.#2%
{%
    \expandafter\XINT_keep:x:csv_loop\the\numexpr#1-\xint_c_viii.%
    #2\xint_Bye,\xint_Bye,\xint_Bye,\xint_Bye,%
      \xint_Bye,\xint_Bye,\xint_Bye,\xint_Bye,\xint_bye
}%
\def\XINT_keep:x:csv_loop #1%
{%
    \xint_gob_til_minus#1\XINT_keep:x:csv_finish-%
    \XINT_keep:x:csv_loop_pickeight #1%
}%
\def\XINT_keep:x:csv_loop_pickeight #1.#2,#3,#4,#5,#6,#7,#8,#9,%
{%
    ,#2,#3,#4,#5,#6,#7,#8,#9%
    \expandafter\XINT_keep:x:csv_loop\the\numexpr#1-\xint_c_viii.%
}%
\def\XINT_keep:x:csv_finish-\XINT_keep:x:csv_loop_pickeight -#1.%
{%
    \csname XINT_keep:x:csv_finish#1\endcsname
}%
\expandafter\def\csname XINT_keep:x:csv_finish1\endcsname
  #1,#2,#3,#4,#5,#6,#7,{,#1,#2,#3,#4,#5,#6,#7\xint_Bye}%
\expandafter\def\csname XINT_keep:x:csv_finish2\endcsname
  #1,#2,#3,#4,#5,#6,{,#1,#2,#3,#4,#5,#6\xint_Bye}%
\expandafter\def\csname XINT_keep:x:csv_finish3\endcsname
  #1,#2,#3,#4,#5,{,#1,#2,#3,#4,#5\xint_Bye}%
\expandafter\def\csname XINT_keep:x:csv_finish4\endcsname
  #1,#2,#3,#4,{,#1,#2,#3,#4\xint_Bye}%
\expandafter\def\csname XINT_keep:x:csv_finish5\endcsname
  #1,#2,#3,{,#1,#2,#3\xint_Bye}%
\expandafter\def\csname XINT_keep:x:csv_finish6\endcsname
  #1,#2,{,#1,#2\xint_Bye}%
\expandafter\def\csname XINT_keep:x:csv_finish7\endcsname
  #1,{,#1\xint_Bye}%
\expandafter\let\csname XINT_keep:x:csv_finish8\endcsname\xint_Bye
```

4.31.10 Public names for the undocumented csv macros: \xintCSVLength, \xintCSVKeep, \xintCSVKeepx, \xintCSVTrim, \xintCSVNthEltPy, \xintCSVReverse, \xintCSVFirstItem, \xintCSVLastItem

Completely unstable macros: currently they expand the list argument and want no final comma. But for matters of xintexpr.sty I could as well decide to require a final comma, and then I could simplify implementation but of course this would break the macros if used with current functionalities.

```
\let\xintCSVLength   \xintLength:f:csv
\let\xintCSVKeep     \xintKeep:f:csv
\let\xintCSVKeepx    \xintKeep:x:csv
\let\xintCSVTrim     \xintTrim:f:csv
\let\xintCSVNthEltPy \xintNthEltPy:f:csv
\let\xintCSVReverse  \xintReverse:f:csv
\let\xintCSVFirstItem\xintFirstItem:f:csv
\let\xintCSVLastItem \xintLastItem:f:csv
\let\XINT_tmpa\relax \let\XINT_tmpb\relax \let\XINT_tmpc\relax
\XINTrestorecatcodesendinput%
```

5 Package xintcore implementation

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Got split off from xint with release 1.1.

The core arithmetic routines have been entirely rewritten for release 1.2. The 1.2i and 1.2l brought again some improvements.

The commenting continues (2022/06/11) to be very sparse: actually it got worse than ever with release 1.2. I will possibly add comments at a later date, but for the time being the new routines are not commented at all.

1.3 removes all macros which were deprecated at 1.2o.

5.1 Catcodes, ε-TEX and reload detection

The code for reload detection was initially copied from HEIKO OBERDIEK's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5    % ^^M
  \endlinechar=13 %
  \catcode123=1   % {
  \catcode125=2   % }
  \catcode64=11   % @
  \catcode44=12   % ,
  \catcode46=12   % .
  \catcode58=12   % :
  \catcode94=7    % ^
  \def\empty{}\def\space{ }\newlinechar10
```

```
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xintcore.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xintkernel.sty\endcsname
  \expandafter\ifx\csname numexpr\endcsname\relax
    \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
      \immediate\write128{^^JPackage xintcore Warning:^^J%
                        \space\space\space\space
                        \numexpr not available, aborting input.^^J}%
    \else
      \PackageWarningNoLine{xintcore}{\numexpr not available, aborting input}%
    \fi
    \def\z{\endgroup\endinput}%
  \else
    \ifx\x\relax   % plain-TeX, first loading of xintcore.sty
      \ifx\w\relax % but xintkernel.sty not yet loaded.
         \def\z{\endgroup\input xintkernel.sty\relax}%
      \fi
    \else
      \ifx\x\empty % LaTeX, first loading,
      % variable is initialized, but \ProvidesPackage not yet seen
          \ifx\w\relax % xintkernel.sty not yet loaded.
            \def\z{\endgroup\RequirePackage{xintkernel}}%
          \fi
      \else
        \def\z{\endgroup\endinput}% xintkernel already loaded.
      \fi
    \fi
  \fi
\z%
\XINTsetupcatcodes% defined in xintkernel.sty
```

5.2 Package identification

```
\XINT_providespackage
\ProvidesPackage{xintcore}%
  [2022/06/10 v1.4m Expandable arithmetic on big integers (JFB)]%
```

5.3 (WIP!) Error conditions and exceptions

As per the Mike Cowlishaw/IBM's General Decimal Arithmetic Specification

http://speleotrove.com/decimal/decarith.html

and the Python3 implementation in its Decimal module.

Clamped, ConversionSyntax, DivisionByZero, DivisionImpossible, DivisionUndefined, Inexact, InsufficientStorage, InvalidContext, InvalidOperation, Overflow, Inexact, Rounded, Subnormal, Underflow.

X3.274 rajoute LostDigits

Python rajoute FloatOperation (et n'inclut pas InsufficientStorage)

quote de decarith.pdf: The Clamped, Inexact, Rounded, and Subnormal conditions can coincide with each other or with other conditions. In these cases then any trap enabled for another condition takes precedence over (is handled before) all of these, any Subnormal trap takes precedence over Inexact, any Inexact trap takes precedence over Rounded, and any Rounded trap takes precedence over Clamped.

WORK IN PROGRESS ! (1.2l, 2017/07/26)

I follow the Python terminology: a trapped signal means it raises an exception which for us means an expandable error message with some possible user interaction. In this WIP state, the interaction is commented out. A non-trapped signal or condition would activate a (presumably silent) handler.

Here, no signal-raising condition is "ignored" and all are "trapped" which means that error handlers are never activated, thus left in garbage state in the code.

Various conditions can raise the same signal.

Only signals, not conditions, raise Flags.

If a signal is ignored it does not raise a Flag, but it activates the signal handler (by default now no signal is ignored.)

If a signal is not ignored it raises a Flag and then if it is not trapped it activates the handler of the _condition_.

If trapped (which is default now) an «exception» is raised, which means an expandable error message (I copied over the LaTeX3 code for expandable error messages, basically) interrupts the TeX run. In future, user input could be solicited, but currently this is commented out.

For now macros to reset flags are done but without public interface nor documentation.

Only four conditions are currently possibly encountered:

- InvalidOperation
- DivisionByZero
- DivisionUndefined (which signals InvalidOperation)
- Underflow

I did it quickly, anyhow this will become more palpable when some of the Decimal Specification is actually implemented. The plan is to first do the X3.274 norm, then more complete implementation will follow... perhaps...

```
\csname XINT_Clamped_istrapped\endcsname
\csname XINT_ConversionSyntax_istrapped\endcsname
\csname XINT_DivisionByZero_istrapped\endcsname
\csname XINT_DivisionImpossible_istrapped\endcsname
\csname XINT_DivisionUndefined_istrapped\endcsname
\csname XINT_InvalidOperation_istrapped\endcsname
\csname XINT_Overflow_istrapped\endcsname
\csname XINT_Underflow_istrapped\endcsname
\catcode`- 11
\def\XINT_ConversionSyntax-signal  {{InvalidOperation}}%
\let\XINT_DivisionImpossible-signal\XINT_ConversionSyntax-signal
\let\XINT_DivisionUndefined-signal \XINT_ConversionSyntax-signal
\let\XINT_InvalidContext-signal    \XINT_ConversionSyntax-signal
\catcode`- 12
\def\XINT_signalcondition #1{\expandafter\XINT_signalcondition_a
    \romannumeral0\ifcsname XINT_#1-signal\endcsname
                \xint_dothis{\csname XINT_#1-signal\endcsname}%
               \fi\xint_orthat{{#1}}{#1}}%
\def\XINT_signalcondition_a #1#2#3#4#5{% copied over from Python Decimal module
```

#1=signal, #2=condition, #3=explanation for user, #4=context for error handlers, #5=used.

```
\ifcsname XINT_#1_isignoredflag\endcsname
      \xint_dothis{\csname XINT_#1.handler\endcsname {#4}}%
    \fi
    \expandafter\xint_gobble_i\csname XINT_#1Flag_ON\endcsname
    \unless\ifcsname XINT_#1_istrapped\endcsname
      \xint_dothis{\csname XINT_#2.handler\endcsname {#4}}%
    \fi
    \xint_orthat{%
```

```
        % the flag raised is named after the signal #1, but we show condition
        % #2
```

On 2021/05/19, 1.4g, I re-examined \XINT_expandableerror experimenting at first with an added ^^J to shift to next line the actual message.

Previously I was calling it thrice (condition #2, user context #3, next tokens #5) here but it seems more reasonable to use it only once. As total size is so limited, I decided to only display #3 (information for user) and drop the #2 (condition, first argument of \XINT_signalcondition) and the display of the #5 (next tokens, fourth argument of \XINT_signalcondition).

Besides, why was I doing here \xint_stop_atfirstofone{#5}, which adds limitations to usage? Now inserting #5 directly so callers will have to insert a \romannumeral0 stopping space token if needed. I thus have to update all usages across (mainly, I think) xintfrac. Done, but using here \xint_firstofone{#5}. This looks silly, but allows some hypothetical future usage by user of I\xintUse{stuff} usage where \xintUse would be \xint_firstofthree.

The problem is that this would have to be explained to user in the error context but space there is so extremely limited...

After having reviewed existing usage of \XINT_signalcondition, I noticed there was free space in most cases and added here " (hit RET)" after #3.

I experimented with ^^J here too (its effect in the "context" is independent of the \newlinechar setting, but it depends on the engine: works with TeXLive pdftex, requires -8bit with xetex)

However, due to \errorcontextlines being 5 by default in etex (but xintsession 0.2b sets it to 0), I finally decided to not insert a ^^J (&&J) at all to separate the " (hit RET)" hint.

On 2021/05/20 evening I found another completely different method for \XINT_expandableerror, which has some advantages. In particular it allows me to not use here "#3 (hit RET)" but simply "#3" as such information can be integrated in a non size limited generic message.

The maximal size of #3 here was increased from 48 characters (method with \xint/ being badly delimited), to now 55 characters, longer messages being truncated at 56 characters with an appended "\ETC.".

```
        \XINT_expandableerror{#3}%
        % not for X3.274
        % \XINT_expandableerror{<RET>, or I\xintUse{...}<RET>, or I\xintCTRLC<RET>}%
        \xint_firstofone{#5}%
    }%
}%
%% \def\xintUse{\xint_firstofthree} % defined in xint.sty
\def\XINT_ifFlagRaised #1{%
    \ifcsname XINT_#1Flag_ON\endcsname
        \expandafter\xint_firstoftwo
    \else
        \expandafter\xint_secondoftwo
    \fi}%
\def\XINT_resetFlag #1%
    {\expandafter\let\csname XINT_#1Flag_ON\endcsname\XINT_undefined}%
\def\XINT_resetFlags {% WIP
    \XINT_resetFlag{InvalidOperation}% also from DivisionUndefined
    \XINT_resetFlag{DivisionByZero}%
    \XINT_resetFlag{Underflow}% (\xintiiPow with negative exponent)
    \XINT_resetFlag{Overflow}%   not encountered so far in xint code 1.2l
    % .. others ..
}%
\def\XINT_RaiseFlag #1{\expandafter\xint_gobble_i\csname XINT_#1Flag_ON\endcsname}%
```

NOT IMPLEMENTED! WORK IN PROGRESS! (ALL SIGNALS TRAPPED, NO HANDLERS USED)

```
\catcode`. 11
```

```
\let\XINT_Clamped.handler\xint_firstofone % WIP
\def\XINT_InvalidOperation.handler#1{_NaN}% WIP
\def\XINT_ConversionSyntax.handler#1{_NaN}% WIP
\def\XINT_DivisionByZero.handler#1{_SignedInfinity(#1)}% WIP
\def\XINT_DivisionImpossible.handler#1{_NaN}% WIP
\def\XINT_DivisionUndefined.handler#1{_NaN}%  WIP
\let\XINT_Inexact.handler\xint_firstofone  %  WIP
\def\XINT_InvalidContext.handler#1{_NaN}%     WIP
\let\XINT_Rounded.handler\xint_firstofone  %  WIP
\let\XINT_Subnormal.handler\xint_firstofone%  WIP
\def\XINT_Overflow.handler#1{_NaN}%  WIP
\def\XINT_Underflow.handler#1{_NaN}% WIP
\catcode`. 12
```

5.4 Counts for holding needed constants

```
\ifdefined\m@ne\let\xint_c_mone\m@ne
          \else\csname newcount\endcsname\xint_c_mone \xint_c_mone -1 \fi
\ifdefined\xint_c_x^viii\else
\csname newcount\endcsname\xint_c_x^viii \xint_c_x^viii   100000000
\fi
\ifdefined\xint_c_x^ix\else
\csname newcount\endcsname\xint_c_x^ix   \xint_c_x^ix     1000000000
\fi
\newcount\xint_c_x^viii_mone        \xint_c_x^viii_mone     99999999
\newcount\xint_c_xii_e_viii          \xint_c_xii_e_viii   1200000000
\newcount\xint_c_xi_e_viii_mone   \xint_c_xi_e_viii_mone  1099999999
```

Routines handling integers as lists of token digits

Routines handling big integers which are lists of digit tokens with no special additional structure.

Some routines do not accept non properly terminated inputs like "\the\numexpr1", or "\the\mathcode`\-", others do.

These routines or their sub-routines are mainly for internal usage.

5.5 \XINT_cuz_small

\XINT_cuz_small removes leading zeroes from the first eight digits. Expands following \romannumeral0. At least one digit is produced.

```
\def\XINT_cuz_small#1{%
\def\XINT_cuz_small ##1##2##3##4##5##6##7##8%
{%
    \expandafter#1\the\numexpr ##1##2##3##4##5##6##7##8\relax
}}\XINT_cuz_small{ }%
```

5.6 \xintNum, \xintiNum

For example \xintNum {----+-+++---+----000000000000003}

Very old routine got completely rewritten at 1.21.

New code uses \numexpr governed expansion and fixes some issues of former version particularly regarding inputs of the \numexpr...\relax type without \the or \number prefix, and/or possibly no terminating \relax.

\xintiNum{\numexpr 1}\foo in earlier versions caused premature expansion of \foo.
\xintiNum{\the\numexpr 1} was ok, but a bit luckily so.
Also, up to 1.2k inclusive, the macro fetched tokens eight by eight, and not nine by nine as is done now. I have no idea why.

```
\def\xintiNum {\romannumeral0\xintinum }%
\def\xintinum #1%
{%
    \expandafter\XINT_num_cleanup\the\numexpr\expandafter\XINT_num_loop
    \romannumeral`&&@#1\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\Z
}%
\def\xintNum {\romannumeral0\xintnum }%
\let\xintnum\xintinum
```

Attention \xintnum (hence \xintNum) gets redefined by xintfrac. Click on names to see the redefinition there.

```
\def\XINT_num #1%
{%
    \expandafter\XINT_num_cleanup\the\numexpr\XINT_num_loop
    #1\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\Z
}%
\def\XINT_num_loop #1#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_xint: #9\XINT_num_end\xint:
    #1#2#3#4#5#6#7#8#9%
    \ifnum \numexpr #1#2#3#4#5#6#7#8#9+\xint_c_ = \xint_c_
```

means that so far only signs encountered, (if syntax is legal) then possibly zeroes or a terminated or not terminated \numexpr evaluating to zero In that latter case a correct zero will be produced in the end.

```
      \expandafter\XINT_num_loop
    \else
```

non terminated \numexpr (with nine tokens total) are safe as after \fi, there is then \xint:

```
     \expandafter\relax
    \fi
}%
\def\XINT_num_end\xint:#1\xint:{#1+\xint_c_\xint:}% empty input ok
\def\XINT_num_cleanup #1\xint:#2\Z { #1}%
```

5.7 \xintiiSgn

1.2l made \xintiiSgn robust against non terminated input.
1.2o deprecates here \xintSgn (it requires xintfrac.sty).

```
\def\xintiiSgn {\romannumeral0\xintiisgn }%
\def\xintiisgn #1%
{%
    \expandafter\XINT_sgn \romannumeral`&&@#1\xint:
}%
\def\XINT_sgn #1#2\xint:
{%
    \xint_UDzerominusfork
      #1-{ 0}%
      0#1{-1}%
       0-{ 1}%
```

```
    \krof
}%
\def\XINT_Sgn #1#2\xint:
{%
    \xint_UDzerominusfork
      #1-{0}%
      0#1{-1}%
       0-{1}%
    \krof
}%
\def\XINT_cntSgn #1#2\xint:
{%
    \xint_UDzerominusfork
      #1-\xint_c_
      0#1\xint_c_mone
       0-\xint_c_i
    \krof
}%
```

5.8 \xintiiOpp

Attention, \xintiiOpp non robust against non terminated inputs. Reason is I don't want to have to grab a delimiter at the end, as everything happens "upfront".

```
\def\xintiiOpp {\romannumeral0\xintiiopp }%
\def\xintiiopp #1%
{%
    \expandafter\XINT_opp \romannumeral`&&@#1%
}%
\def\XINT_Opp #1{\romannumeral0\XINT_opp #1}%
\def\XINT_opp #1%
{%
    \xint_UDzerominusfork
      #1-{ 0}%      zero
      0#1{ }%     negative
       0-{ -#1}%  positive
    \krof
}%
```

5.9 \xintiiAbs

Attention \xintiiAbs non robust against non terminated input.

```
\def\xintiiAbs {\romannumeral0\xintiiabs }%
\def\xintiiabs #1%
{%
    \expandafter\XINT_abs \romannumeral`&&@#1%
}%
\def\XINT_abs #1%
{%
    \xint_UDsignfork
      #1{ }%
       -{ #1}%
    \krof
```

```
}%
\def\XINT_Abs #1%
{%
    \xint_UDsignfork
      #1{}%
       -{#1}%
    \krof
}%
```

5.10 \xintFDg

FIRST DIGIT.

1.2l: \xintiiFDg made robust against non terminated input.

1.2o deprecates \xintiiFDg, gives to \xintFDg former meaning of \xintiiFDg.

```
\def\xintFDg {\romannumeral0\xintfdg }%
\def\xintfdg #1{\expandafter\XINT_fdg \romannumeral`&&@#1\xint:\Z}%
\def\XINT_FDg #1%
   {\romannumeral0\expandafter\XINT_fdg\romannumeral`&&@\xintnum{#1}\xint:\Z }%
\def\XINT_fdg #1#2#3\Z
{%
    \xint_UDzerominusfork
      #1-{ 0}%   zero
      0#1{ #2}%  negative
       0-{ #1}%  positive
    \krof
}%
```

5.11 \xintLDg

LAST DIGIT.

Rewritten for 1.2i (2016/12/10). Surprisingly perhaps, it is faster than \xintLastItem from xintkernel.sty despite the \numexpr operations.

1.2o deprecates \xintiiLDg, gives to \xintLDg former meaning of \xintiiLDg.

Attention \xintLDg non robust against non terminated input.

```
\def\xintLDg {\romannumeral0\xintldg }%
\def\xintldg #1{\expandafter\XINT_ldg_fork\romannumeral`&&@#1%
    \XINT_ldg_c{}{}{}{}{}{}{}{}{}\xint_bye\relax}%
\def\XINT_ldg_fork #1%
{%
    \xint_UDsignfork
      #1\XINT_ldg
       -{\XINT_ldg#1}%
    \krof
}%
\def\XINT_ldg #1{%
\def\XINT_ldg ##1##2##3##4##5##6##7##8##9%
   {\expandafter#1%
    \the\numexpr##9##8##7##6##5##4##3##2##1*\xint_c_+\XINT_ldg_a##9}%
}\XINT_ldg{ }%
\def\XINT_ldg_a#1#2{\XINT_ldg_cbye#2\XINT_ldg_d#1\XINT_ldg_c\XINT_ldg_b#2}%
\def\XINT_ldg_b#1#2#3#4#5#6#7#8#9{#9#8#7#6#5#4#3#2#1*\xint_c_+\XINT_ldg_a#9}%
\def\XINT_ldg_c    #1#2\xint_bye{#1}%
```

```
\def\XINT_ldg_cbye #1\XINT_ldg_c{}%
\def\XINT_ldg_d#1#2\xint_bye{#1}%
```

5.12 \xintDouble

Attention \xintDouble non robust against non terminated input.

```
\def\xintDouble {\romannumeral0\xintdouble}%
\def\xintdouble #1{\expandafter\XINT_dbl_fork\romannumeral`&&@#1%
                   \xint_bye2345678\xint_bye*\xint_c_ii\relax}%
\def\XINT_dbl_fork #1%
{%
    \xint_UDsignfork
     #1\XINT_dbl_neg
      -\XINT_dbl
    \krof #1%
}%
\def\XINT_dbl_neg-{\expandafter-\romannumeral0\XINT_dbl}%
\def\XINT_dbl #1{%
\def\XINT_dbl ##1##2##3##4##5##6##7##8%
   {\expandafter#1\the\numexpr##1##2##3##4##5##6##7##8\XINT_dbl_a}%
}\XINT_dbl{ }%
\def\XINT_dbl_a #1#2#3#4#5#6#7#8%
   {\expandafter\XINT_dbl_e\the\numexpr 1#1#2#3#4#5#6#7#8\XINT_dbl_a}%
\def\XINT_dbl_e#1{*\xint_c_ii\if#13+\xint_c_i\fi\relax}%
```

5.13 \xintHalf

Attention \xintHalf non robust against non terminated input.

```
\def\xintHalf {\romannumeral0\xinthalf}%
\def\xinthalf #1{\expandafter\XINT_half_fork\romannumeral`&&@#1%
    \xint_bye\xint_Bye345678\xint_bye
    *\xint_c_v+\xint_c_v)/\xint_c_x-\xint_c_i\relax}%
\def\XINT_half_fork #1%
{%
  \xint_UDsignfork
     #1\XINT_half_neg
      -\XINT_half
    \krof #1%
}%
\def\XINT_half_neg-{\xintiiopp\XINT_half}%
\def\XINT_half #1{%
\def\XINT_half ##1##2##3##4##5##6##7##8%
   {\expandafter#1\the\numexpr(##1##2##3##4##5##6##7##8\XINT_half_a}%
}\XINT_half{ }%
\def\XINT_half_a#1{\xint_Bye#1\xint_bye\XINT_half_b#1}%
\def\XINT_half_b #1#2#3#4#5#6#7#8%
   {\expandafter\XINT_half_e\the\numexpr(1#1#2#3#4#5#6#7#8\XINT_half_a}%
\def\XINT_half_e#1{*\xint_c_v+#1-\xint_c_v)\relax}%
```

5.14 \xintInc

1.2i much delayed complete rewrite in 1.2 style.

As we take 9 by 9 with the input save stack at 5000 this allows a bit less than 9 times 2500 = 22500 digits on input.

Attention \xintInc non robust against non terminated input.

```
\def\xintInc {\romannumeral0\xintinc}%
\def\xintinc #1{\expandafter\XINT_inc_fork\romannumeral`&&@#1%
                \xint_bye23456789\xint_bye+\xint_c_i\relax}%
\def\XINT_inc_fork #1%
{%
    \xint_UDsignfork
      #1\XINT_inc_neg
       -\XINT_inc
    \krof #1%
}%
\def\XINT_inc_neg-#1\xint_bye#2\relax
   {\xintiiopp\XINT_dec #1\XINT_dec_bye234567890\xint_bye}%
\def\XINT_inc #1{%
\def\XINT_inc ##1##2##3##4##5##6##7##8##9%
   {\expandafter#1\the\numexpr##1##2##3##4##5##6##7##8##9\XINT_inc_a}%
}\XINT_inc{ }%
\def\XINT_inc_a #1#2#3#4#5#6#7#8#9%
   {\expandafter\XINT_inc_e\the\numexpr 1#1#2#3#4#5#6#7#8#9\XINT_inc_a}%
\def\XINT_inc_e#1{\if#12+\xint_c_i\fi\relax}%
```

5.15 \xintDec

1.2i much delayed complete rewrite in the 1.2 style. Things are a bit more complicated than \xintInc because 2999999999 is too big for TeX.

Attention \xintDec non robust against non terminated input.

```
\def\xintDec {\romannumeral0\xintdec}%
\def\xintdec #1{\expandafter\XINT_dec_fork\romannumeral`&&@#1%
                \XINT_dec_bye234567890\xint_bye}%
\def\XINT_dec_fork #1%
{%
    \xint_UDsignfork
      #1\XINT_dec_neg
       -\XINT_dec
    \krof #1%
}%
\def\XINT_dec_neg-#1\XINT_dec_bye#2\xint_bye
   {\expandafter-%
    \romannumeral0\XINT_inc #1\xint_bye23456789\xint_bye+\xint_c_i\relax}%
\def\XINT_dec #1{%
\def\XINT_dec ##1##2##3##4##5##6##7##8##9%
   {\expandafter#1\the\numexpr##1##2##3##4##5##6##7##8##9\XINT_dec_a}%
}\XINT_dec{ }%
\def\XINT_dec_a #1#2#3#4#5#6#7#8#9%
   {\expandafter\XINT_dec_e\the\numexpr 1#1#2#3#4#5#6#7#8#9\XINT_dec_a}%
\def\XINT_dec_bye #1\XINT_dec_a#2#3\xint_bye
         {\if#20-\xint_c_ii\relax+\else-\fi\xint_c_i\relax}%
\def\XINT_dec_e#1{\unless\if#11\xint_dothis{-\xint_c_i#1}\fi\xint_orthat\relax}%
```

5.16 \xintDSL

DECIMAL SHIFT LEFT (=MULTIPLICATION PAR 10). Rewritten for 1.2i. This was very old code... I never came back to it, but I should have rewritten it long time ago.

Attention \xintDSL non robust against non terminated input.

```
\def\xintDSL {\romannumeral0\xintdsl }%
\def\xintdsl #1{\expandafter\XINT_dsl\romannumeral`&&@#10}%
\def\XINT_dsl#1{%
\def\XINT_dsl ##1{\xint_gob_til_zero ##1\xint_dsl_zero 0#1##1}%
}\XINT_dsl{ }%
\def\xint_dsl_zero 0 0{ }%
```

5.17 \xintDSR

Decimal shift right, truncates towards zero. Rewritten for 1.2i. Limited to 22483 digits on input.

Attention \xintDSR non robust against non terminated input.

```
\def\xintDSR{\romannumeral0\xintdsr}%
\def\xintdsr #1{\expandafter\XINT_dsr_fork\romannumeral`&&@#1%
    \xint_bye\xint_Bye3456789\xint_bye+\xint_c_v)/\xint_c_x-\xint_c_i\relax}%
\def\XINT_dsr_fork #1%
{%
    \xint_UDsignfork
      #1\XINT_dsr_neg
       -\XINT_dsr
    \krof #1%
}%
\def\XINT_dsr_neg-{\xintiiopp\XINT_dsr}%
\def\XINT_dsr #1{%
\def\XINT_dsr ##1##2##3##4##5##6##7##8##9%
   {\expandafter#1\the\numexpr(##1##2##3##4##5##6##7##8##9\XINT_dsr_a}%
}\XINT_dsr{ }%
\def\XINT_dsr_a#1{\xint_Bye#1\xint_bye\XINT_dsr_b#1}%
\def\XINT_dsr_b #1#2#3#4#5#6#7#8#9%
   {\expandafter\XINT_dsr_e\the\numexpr(1#1#2#3#4#5#6#7#8#9\XINT_dsr_a}%
\def\XINT_dsr_e #1{)\relax}%
```

5.18 \xintDSRr

New with 1.2i. Decimal shift right, rounds away from zero; done in the 1.2 spirit (with much delay, sorry). Used by \xintRound, \xintDivRound.

This is about the first time I am happy that the division in \numexpr rounds!

Attention \xintDSRr non robust against non terminated input.

```
\def\xintDSRr{\romannumeral0\xintdsrr}%
\def\xintdsrr #1{\expandafter\XINT_dsrr_fork\romannumeral`&&@#1%
                \xint_bye\xint_Bye3456789\xint_bye/\xint_c_x\relax}%
\def\XINT_dsrr_fork #1%
{%
    \xint_UDsignfork
      #1\XINT_dsrr_neg
       -\XINT_dsrr
    \krof #1%
}%
\def\XINT_dsrr_neg-{\xintiiopp\XINT_dsrr}%
```

```
\def\XINT_dsrr #1{%
\def\XINT_dsrr ##1##2##3##4##5##6##7##8##9%
   {\expandafter#1\the\numexpr##1##2##3##4##5##6##7##8##9\XINT_dsrr_a}%
}\XINT_dsrr{ }%
\def\XINT_dsrr_a#1{\xint_Bye#1\xint_bye\XINT_dsrr_b#1}%
\def\XINT_dsrr_b #1#2#3#4#5#6#7#8#9%
   {\expandafter\XINT_dsrr_e\the\numexpr1#1#2#3#4#5#6#7#8#9\XINT_dsrr_a}%
\let\XINT_dsrr_e\XINT_inc_e
```

Blocks of eight digits

The lingua of release 1.2.

5.19 \XINT_cuz

This (launched by \romannumeral0) iterately removes all leading zeroes from a sequence of 8N digits ended by \R.

Rewritten for 1.2l, now uses \numexpr governed expansion and \ifnum test rather than delimited gobbling macros.

Note 2015/11/28: with only four digits the gob_til_fourzeroes had proved in some old testing faster than \ifnum test. But with eight digits, the execution times are much closer, as I tested back then.

```
\def\XINT_cuz #1{%
\def\XINT_cuz {\expandafter#1\the\numexpr\XINT_cuz_loop}%
}\XINT_cuz{ }%
\def\XINT_cuz_loop #1#2#3#4#5#6#7#8#9%
{%
    #1#2#3#4#5#6#7#8%
       \xint_gob_til_R #9\XINT_cuz_hitend\R
       \ifnum #1#2#3#4#5#6#7#8>\xint_c_
             \expandafter\XINT_cuz_cleantoend
       \else\expandafter\XINT_cuz_loop
       \fi #9%
}%
\def\XINT_cuz_hitend\R #1\R{\relax}%
\def\XINT_cuz_cleantoend #1\R{\relax #1}%
```

5.20 \XINT_cuz_byviii

This removes eight by eight leading zeroes from a sequence of 8N digits ended by \R. Thus, we still have 8N digits on output. Expansion started by \romannumeral0

```
\def\XINT_cuz_byviii #1#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_R #9\XINT_cuz_byviii_e \R
    \xint_gob_til_eightzeroes #1#2#3#4#5#6#7#8\XINT_cuz_byviii_z 00000000%
    \XINT_cuz_byviii_done #1#2#3#4#5#6#7#8#9%
}%
\def\XINT_cuz_byviii_z 00000000\XINT_cuz_byviii_done 00000000{\XINT_cuz_byviii}%
\def\XINT_cuz_byviii_done #1\R { #1}%
\def\XINT_cuz_byviii_e\R #1\XINT_cuz_byviii_done #2\R{ #2}%
```

5.21 \XINT_unsep_loop

This is used as

```
\the\numexpr0\XINT_unsep_loop (blocks of 1<8digits>!)
              \xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax
```

It removes the 1's and !'s, and outputs the 8N digits with a 0 token as as prefix which will have to be cleaned out by caller.

Actually it does not matter whether the blocks contain really 8 digits, all that matters is that they have 1 as first digit (and at most 9 digits after that to obey the TeX-\numexpr bound).

Done at 1.2l for usage by other macros. The similar code in earlier releases was strangely in O(N^2) style, apparently to avoid some memory constraints. But these memory constraints related to \numexpr chaining seems to be in many places in xint code base. The 1.2l version is written in the 1.2i style of \xintInc etc... and is compatible with some 1! block without digits among the treated blocks, they will disappear.

```
\def\XINT_unsep_loop #1!#2!#3!#4!#5!#6!#7!#8!#9!%
{%
    \expandafter\XINT_unsep_clean
    \the\numexpr #1\expandafter\XINT_unsep_clean
    \the\numexpr #2\expandafter\XINT_unsep_clean
    \the\numexpr #3\expandafter\XINT_unsep_clean
    \the\numexpr #4\expandafter\XINT_unsep_clean
    \the\numexpr #5\expandafter\XINT_unsep_clean
    \the\numexpr #6\expandafter\XINT_unsep_clean
    \the\numexpr #7\expandafter\XINT_unsep_clean
    \the\numexpr #8\expandafter\XINT_unsep_clean
    \the\numexpr #9\XINT_unsep_loop
}%
\def\XINT_unsep_clean 1{\relax}%
```

5.22 \XINT_unsep_cuzsmall

This is used as

```
\romannumeral0\XINT_unsep_cuzsmall (blocks of 1<8d>!)
              \xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax
```

It removes the 1's and !'s, and removes the leading zeroes *of the first block*.

Redone for 1.2l: the 1.2 variant was strangely in O(N^2) style.

```
\def\XINT_unsep_cuzsmall
{%
    \expandafter\XINT_unsep_cuzsmall_x\the\numexpr0\XINT_unsep_loop
}%
\def\XINT_unsep_cuzsmall_x #1{%
\def\XINT_unsep_cuzsmall_x 0##1##2##3##4##5##6##7##8%
{%
    \expandafter#1\the\numexpr ##1##2##3##4##5##6##7##8\relax
}}\XINT_unsep_cuzsmall_x{ }%
```

5.23 \XINT_div_unsepQ

This is used by division to remove separators from the produced quotient. The quotient is produced in the correct order. The routine will also remove leading zeroes. An extra initial block of 8 zeroes is possible and thus if present must be removed. Then the next eight digits must be cleaned of leading zeroes. Attention that there might be a single block of 8 zeroes. Expansion launched by \romannumeral0.

Rewritten for 1.2l in 1.2i style.

```
\def\XINT_div_unsepQ_delim {\xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax\Z}%
\def\XINT_div_unsepQ
{%
    \expandafter\XINT_div_unsepQ_x\the\numexpr0\XINT_unsep_loop
}%
\def\XINT_div_unsepQ_x #1{%
\def\XINT_div_unsepQ_x 0##1##2##3##4##5##6##7##8##9%
{%
    \xint_gob_til_Z ##9\XINT_div_unsepQ_one\Z
    \xint_gob_til_eightzeroes ##1##2##3##4##5##6##7##8\XINT_div_unsepQ_y 00000000%
    \expandafter#1\the\numexpr ##1##2##3##4##5##6##7##8\relax ##9%
}}\XINT_div_unsepQ_x{ }%
\def\XINT_div_unsepQ_y #1{%
\def\XINT_div_unsepQ_y ##1\relax ##2##3##4##5##6##7##8##9%
{%
    \expandafter#1\the\numexpr ##2##3##4##5##6##7##8##9\relax
}}\XINT_div_unsepQ_y{ }%
\def\XINT_div_unsepQ_one#1\expandafter{\expandafter}%
```

5.24 \XINT_div_unsepR

This is used by division to remove separators from the produced remainder. The remainder is here in correct order. It must be cleaned of leading zeroes, possibly all the way.

Also rewritten for 1.2l, the 1.2 version was O(N^2) style.

Terminator \xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax\R

We have a need for something like \R because it is not guaranteed the thing is not actually zero.

```
\def\XINT_div_unsepR
{%
    \expandafter\XINT_div_unsepR_x\the\numexpr0\XINT_unsep_loop
}%
\def\XINT_div_unsepR_x#1{%
\def\XINT_div_unsepR_x 0{\expandafter#1\the\numexpr\XINT_cuz_loop}%
}\XINT_div_unsepR_x{ }%
```

5.25 \XINT_zeroes_forviii

\romannumeral0\XINT_zeroes_forviii #1\R\R\R\R\R\R\R\R{10}0000001\W

produces a string of k 0's such that k+length(#1) is smallest bigger multiple of eight.

```
\def\XINT_zeroes_forviii #1#2#3#4#5#6#7#8%
{%
    \xint_gob_til_R #8\XINT_zeroes_forviii_end\R\XINT_zeroes_forviii
}%
\def\XINT_zeroes_forviii_end#1{%
\def\XINT_zeroes_forviii_end\R\XINT_zeroes_forviii ##1##2##3##4##5##6##7##8##9\W
{%
    \expandafter#1\xint_gob_til_one ##2##3##4##5##6##7##8%
}}\XINT_zeroes_forviii_end{ }%
```

5.26 \XINT_sepbyviii_Z

This is used as

```
\the\numexpr\XINT_sepbyviii_Z <8Ndigits>\XINT_sepbyviii_Z_end 2345678\relax
```

It produces 1<8d>!...1<8d>!1;!

Prior to 1.2l it used \Z as terminator not the semi-colon (hence the name). The switch to ; was done at a time I thought perhaps I would use an internal format maintaining such 8 digits blocks, and this has to be compatible with the \csname...\endcsname encapsulation in \xintexpr parsers.

```
\def\XINT_sepbyviii_Z #1#2#3#4#5#6#7#8%
{%
    1#1#2#3#4#5#6#7#8\expandafter!\the\numexpr\XINT_sepbyviii_Z
}%
\def\XINT_sepbyviii_Z_end #1\relax {;!}%
```

5.27 \XINT_sepbyviii_andcount

This is used as

```
\the\numexpr\XINT_sepbyviii_andcount <8Ndigits>%
    \XINT_sepbyviii_end 2345678\relax
    \xint_c_vii!\xint_c_vi!\xint_c_v!\xint_c_iv!%
    \xint_c_iii!\xint_c_ii!\xint_c_i!\xint_c_\W
```

It will produce

```
1<8d>!1<8d>!....1<8d>!1\xint:<count of blocks>\xint:
```

Used by \XINT_div_prepare_g for \XINT_div_prepare_h, and also by \xintiiCmp.

```
\def\XINT_sepbyviii_andcount
{%
    \expandafter\XINT_sepbyviii_andcount_a\the\numexpr\XINT_sepbyviii
}%
\def\XINT_sepbyviii #1#2#3#4#5#6#7#8%
{%
    1#1#2#3#4#5#6#7#8\expandafter!\the\numexpr\XINT_sepbyviii
}%
\def\XINT_sepbyviii_end #1\relax {\relax\XINT_sepbyviii_andcount_end!}%
\def\XINT_sepbyviii_andcount_a {\XINT_sepbyviii_andcount_b \xint_c_\xint:}%
\def\XINT_sepbyviii_andcount_b #1\xint:#2!#3!#4!#5!#6!#7!#8!#9!%
{%
    #2\expandafter!\the\numexpr#3\expandafter!\the\numexpr#4\expandafter
    !\the\numexpr#5\expandafter!\the\numexpr#6\expandafter!\the\numexpr
    #7\expandafter!\the\numexpr#8\expandafter!\the\numexpr#9\expandafter!\the\numexpr
    \expandafter\XINT_sepbyviii_andcount_b\the\numexpr #1+\xint_c_viii\xint:%
}%
\def\XINT_sepbyviii_andcount_end #1\XINT_sepbyviii_andcount_b\the\numexpr
    #2+\xint_c_viii\xint:#3#4\W {\expandafter\xint:\the\numexpr #2+#3\xint:}%
```

5.28 \XINT_rsepbyviii

This is used as

```
\the\numexpr1\XINT_rsepbyviii <8Ndigits>%
             \XINT_rsepbyviii_end_A 2345678%
             \XINT_rsepbyviii_end_B 2345678\relax UV%
```

and will produce

```
1<8digits>!1<8digits>\xint:1<8digits>!...
```

where the original digits are organized by eight, and the order inside successive pairs of blocks separated by \xint: has been reversed. Output ends either in 1<8d>!1<8d>\xint:1U\xint: (even) or 1<8d>!1<8d>\xint:1V!1<8d>\xint: (odd)

The U an V should be \numexpr1 stoppers (or will expand and be ended by !). This macro is currently (1.2..1.2l) exclusively used in combination with \XINT_sepandrev_andcount or \XINT_sepandrev.

```
\def\XINT_rsepbyviii #1#2#3#4#5#6#7#8%
{%
    \XINT_rsepbyviii_b {#1#2#3#4#5#6#7#8}%
}%
\def\XINT_rsepbyviii_b #1#2#3#4#5#6#7#8#9%
{%
    #2#3#4#5#6#7#8#9\expandafter!\the\numexpr
    1#1\expandafter\xint:\the\numexpr 1\XINT_rsepbyviii
}%
\def\XINT_rsepbyviii_end_B #1\relax #2#3{#2\xint:}%
\def\XINT_rsepbyviii_end_A #11#2\expandafter #3\relax #4#5{#5!1#2\xint:}%
```

5.29 \XINT_sepandrev

This is used typically as

```
\romannumeral0\XINT_sepandrev <8Ndigits>%
              \XINT_rsepbyviii_end_A 2345678%
              \XINT_rsepbyviii_end_B 2345678\relax UV%
              \R\xint:\R\xint:\R\xint:\R\xint:\R\xint:\R\xint:\R\xint:\R\xint:\W
```

and will produce

```
1<8digits>!1<8digits>!1<8digits>!...
```

where the blocks have been globally reversed. The UV here are only place holders (must be \numexpr1 stoppers) to share same syntax as \XINT_sepandrev_andcount, they are gobbled (#2 in \XINT_sepandrev_done).

```
\def\XINT_sepandrev
{%
    \expandafter\XINT_sepandrev_a\the\numexpr 1\XINT_rsepbyviii
}%
\def\XINT_sepandrev_a {\XINT_sepandrev_b {}}%
\def\XINT_sepandrev_b #1#2\xint:#3\xint:#4\xint:#5\xint:#6\xint:#7\xint:#8\xint:#9\xint:%
{%
    \xint_gob_til_R #9\XINT_sepandrev_end\R
    \XINT_sepandrev_b {#9!#8!#7!#6!#5!#4!#3!#2!#1}%
}%
\def\XINT_sepandrev_end\R\XINT_sepandrev_b #1#2\W {\XINT_sepandrev_done #1}%
\def\XINT_sepandrev_done #11#2!{ }%
```

5.30 \XINT_sepandrev_andcount

This is used typically as

```
\romannumeral0\XINT_sepandrev_andcount <8Ndigits>%
             \XINT_rsepbyviii_end_A 2345678%
             \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
             \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
             \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
```

and will produce

```
<length>.1<8digits>!1<8digits>!1<8digits>!...
```

where the blocks have been globally reversed and <length> is the number of blocks.

```
\def\XINT_sepandrev_andcount
```

```
{%
    \expandafter\XINT_sepandrev_andcount_a\the\numexpr 1\XINT_rsepbyviii
}%
\def\XINT_sepandrev_andcount_a {\XINT_sepandrev_andcount_b 0!{}}%
\def\XINT_sepandrev_andcount_b #1!#2#3\xint:#4\xint:#5\xint:#6\xint:#7\xint:#8\xint:#9\xint:%
{%
    \xint_gob_til_R #9\XINT_sepandrev_andcount_end\R
    \expandafter\XINT_sepandrev_andcount_b \the\numexpr #1+\xint_c_i!%
    {#9!#8!#7!#6!#5!#4!#3!#2}%
}%
\def\XINT_sepandrev_andcount_end\R
    \expandafter\XINT_sepandrev_andcount_b\the\numexpr #1+\xint_c_i!#2#3#4\W
{\expandafter\XINT_sepandrev_andcount_done\the\numexpr #3+\xint_c_xiv*#1!#2}%
\def\XINT_sepandrev_andcount_done#1{%
\def\XINT_sepandrev_andcount_done##1!##21##3!{\expandafter#1\the\numexpr##1-##3\xint:}%
}\XINT_sepandrev_andcount_done{ }%
```

5.31 \XINT_rev_nounsep

This is used as
\romannumeral0\XINT_rev_nounsep {}<blocks 1<8d>!>\R!\R!\R!\R!\R!\R!\R!\R!\W
It reverses the blocks, keeping the 1's and ! separators. Used multiple times in the division algorithm. The inserted {} here is not optional.

```
\def\XINT_rev_nounsep #1#2!#3!#4!#5!#6!#7!#8!#9!%
{%
    \xint_gob_til_R #9\XINT_rev_nounsep_end\R
    \XINT_rev_nounsep {#9!#8!#7!#6!#5!#4!#3!#2!#1}%
}%
\def\XINT_rev_nounsep_end\R\XINT_rev_nounsep #1#2\W {\XINT_rev_nounsep_done #1}%
\def\XINT_rev_nounsep_done #11{ 1}%
```

5.32 \XINT_unrevbyviii

Used as \romannumeral0\XINT_unrevbyviii 1<8d>!....1<8d>! terminated by
1;!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
The \romannumeral in unrevbyviii_a is for special effects (expand some token which was put as 1<token>! at the end of the original blocks). This mechanism is used by 1.2 subtraction (still true for 1.2l).

```
\def\XINT_unrevbyviii #11#2!1#3!1#4!1#5!1#6!1#7!1#8!1#9!%
{%
    \xint_gob_til_R #9\XINT_unrevbyviii_a\R
    \XINT_unrevbyviii {#9#8#7#6#5#4#3#2#1}%
}%
\def\XINT_unrevbyviii_a#1{%
\def\XINT_unrevbyviii_a\R\XINT_unrevbyviii ##1##2\W
    {\expandafter#1\romannumeral`&&@\xint_gob_til_sc ##1}%
}\XINT_unrevbyviii_a{ }%
```

Can work with shorter ending pattern: 1;!1\R!1\R!1\R!1\R!1\R!1\R!\W but the longer one of unrevbyviii is ok here too. Used currently (1.2) only by addition, now (1.2c) with long ending pattern. Does the final clean up of leading zeroes contrarily to general \XINT_unrevbyviii.

```
\def\XINT_smallunrevbyviii 1#1!1#2!1#3!1#4!1#5!1#6!1#7!1#8!#9\W%
{%
```

```
    \expandafter\XINT_cuz_small\xint_gob_til_sc #8#7#6#5#4#3#2#1%
}%
```

Core arithmetic

The four operations have been rewritten entirely for release 1.2. The new routines works with separated blocks of eight digits. They all measure first the lengths of the arguments, even addition and subtraction (this was not the case with xintcore.sty 1.1 or earlier.)

The technique of chaining \the\numexpr induces a limitation on the maximal size depending on the size of the input save stack and the maximum expansion depth. For the current (TL2015) settings (5000, resp. 10000), the induced limit for addition of numbers is at 19968 and for multiplication it is observed to be 19959 (valid as of 2015/10/07).

Side remark: I tested that \the\numexpr was more efficient than \number. But it reduced the allowable numbers for addition from 19976 digits to 19968 digits.

5.33 \xintiiAdd

1.2l: \xintiiAdd made robust against non terminated input.

```
\def\xintiiAdd   {\romannumeral0\xintiiadd }%
\def\xintiiadd #1{\expandafter\XINT_iiadd\romannumeral`&&@#1\xint:}%
\def\XINT_iiadd #1#2\xint:#3%
{%
    \expandafter\XINT_add_nfork\expandafter#1\romannumeral`&&@#3\xint:#2\xint:
}%
\def\XINT_add_fork #1#2\xint:#3\xint:{\XINT_add_nfork #1#3\xint:#2\xint:}%
\def\XINT_add_nfork #1#2%
{%
    \xint_UDzerofork
      #1\XINT_add_firstiszero
      #2\XINT_add_secondiszero
       0{}%
    \krof
    \xint_UDsignsfork
          #1#2\XINT_add_minusminus
           #1-\XINT_add_minusplus
           #2-\XINT_add_plusminus
            --\XINT_add_plusplus
    \krof #1#2%
}%
\def\XINT_add_firstiszero  #1\krof 0#2#3\xint:#4\xint:{ #2#3}%
\def\XINT_add_secondiszero #1\krof #20#3\xint:#4\xint:{ #2#4}%
\def\XINT_add_minusminus   #1#2%
   {\expandafter-\romannumeral0\XINT_add_pp_a {}{}}%
\def\XINT_add_minusplus    #1#2{\XINT_sub_mm_a {}#2}%
\def\XINT_add_plusminus    #1#2%
   {\expandafter\XINT_opp\romannumeral0\XINT_sub_mm_a #1{}}%
\def\XINT_add_pp_a #1#2#3\xint:
{%
  \expandafter\XINT_add_pp_b
      \romannumeral0\expandafter\XINT_sepandrev_andcount
      \romannumeral0\XINT_zeroes_forviii #2#3\R\R\R\R\R\R\R\R{10}0000001\W
      #2#3\XINT_rsepbyviii_end_A 2345678%
          \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
```

```
              \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
              \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
   \X #1%
}%
\let\XINT_add_plusplus \XINT_add_pp_a
\def\XINT_add_pp_b #1\xint:#2\X #3\xint:
{%
    \expandafter\XINT_add_checklengths
    \the\numexpr #1\expandafter\xint:%
    \romannumeral0\expandafter\XINT_sepandrev_andcount
    \romannumeral0\XINT_zeroes_forviii #3\R\R\R\R\R\R\R\R{10}0000001\W
    #3\XINT_rsepbyviii_end_A 2345678%
      \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
              \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
              \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
     1;!1;!1;!1;!\W #21;!1;!1;!1;!\W
     1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
}%
```

I keep #1.#2. to check if at most 6 + 6 base 10^8 digits which can be treated faster for final reverse. But is this overhead at all useful ?

```
\def\XINT_add_checklengths #1\xint:#2\xint:%
{%
    \ifnum #2>#1
       \expandafter\XINT_add_exchange
    \else
       \expandafter\XINT_add_A
    \fi
    #1\xint:#2\xint:%
}%
\def\XINT_add_exchange #1\xint:#2\xint:#3\W #4\W
{%
    \XINT_add_A #2\xint:#1\xint:#4\W #3\W
}%
\def\XINT_add_A #1\xint:#2\xint:%
{%
    \ifnum #1>\xint_c_vi
          \expandafter\XINT_add_aa
    \else \expandafter\XINT_add_aa_small
    \fi
}%
\def\XINT_add_aa {\expandafter\XINT_add_out\the\numexpr\XINT_add_a \xint_c_ii}%
\def\XINT_add_out{\expandafter\XINT_cuz_small\romannumeral0\XINT_unrevbyviii {}}%
\def\XINT_add_aa_small
    {\expandafter\XINT_smallunrevbyviii\the\numexpr\XINT_add_a \xint_c_ii}%
```

2 as first token of #1 stands for "no carry", 3 will mean a carry (we are adding 1<8digits> to 1<8digits>.) Version 1.2c has terminators of the shape 1;!, replacing the \Z! used in 1.2.

Call: \the\numexpr\XINT_add_a 2#11;!1;!1;!1;!\W #21;!1;!1;!1;!\W where #1 and #2 are blocks of 1<8d>!, and #1 is at most as long as #2. This last requirement is a bit annoying (if one wants to do recursive algorithms but not have to check lengths), and I will probably remove it at some point.

Output: blocks of 1<8d>! representing the addition, (least significant first), and a final 1;!. In recursive algorithm this 1;! terminator can thus conveniently be reused as part of input terminator (up to the length problem).

```
\def\XINT_add_a #1!#2!#3!#4!#5\W
                #6!#7!#8!#9!%
{%
    \XINT_add_b
        #1!#6!#2!#7!#3!#8!#4!#9!%
        #5\W
}%
\def\XINT_add_b #11#2#3!#4!%
{%
    \xint_gob_til_sc #2\XINT_add_bi ;%
    \expandafter\XINT_add_c\the\numexpr#1+1#2#3+#4-\xint_c_ii\xint:%
}%
\def\XINT_add_bi;\expandafter\XINT_add_c
    \the\numexpr#1+#2+#3-\xint_c_ii\xint:#4!#5!#6!#7!#8!#9!\W
{%
    \XINT_add_k #1#3!#5!#7!#9!%
}%
\def\XINT_add_c #1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_add_d #1%
}%
\def\XINT_add_d #11#2#3!#4!%
{%
    \xint_gob_til_sc #2\XINT_add_di ;%
    \expandafter\XINT_add_e\the\numexpr#1+1#2#3+#4-\xint_c_ii\xint:%
}%
\def\XINT_add_di;\expandafter\XINT_add_e
    \the\numexpr#1+#2+#3-\xint_c_ii\xint:#4!#5!#6!#7!#8\W
{%
    \XINT_add_k #1#3!#5!#7!%
}%
\def\XINT_add_e #1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_add_f #1%
}%
\def\XINT_add_f #11#2#3!#4!%
{%
    \xint_gob_til_sc #2\XINT_add_fi ;%
    \expandafter\XINT_add_g\the\numexpr#1+1#2#3+#4-\xint_c_ii\xint:%
}%
\def\XINT_add_fi;\expandafter\XINT_add_g
    \the\numexpr#1+#2+#3-\xint_c_ii\xint:#4!#5!#6\W
{%
    \XINT_add_k #1#3!#5!%
}%
\def\XINT_add_g #1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_add_h #1%
}%
\def\XINT_add_h #11#2#3!#4!%
{%
    \xint_gob_til_sc #2\XINT_add_hi ;%
```

```
    \expandafter\XINT_add_i\the\numexpr#1+1#2#3+#4-\xint_c_ii\xint:%
}%
\def\XINT_add_hi;%
    \expandafter\XINT_add_i\the\numexpr#1+#2+#3-\xint_c_ii\xint:#4\W
{%
    \XINT_add_k #1#3!%
}%
\def\XINT_add_i #1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_add_a #1%
}%
\def\XINT_add_k #1{\if #12\expandafter\XINT_add_ke\else\expandafter\XINT_add_l \fi}%
\def\XINT_add_ke #11;#2\W {\XINT_add_kf #11;!}%
\def\XINT_add_kf 1{1\relax }%
\def\XINT_add_l 1#1#2{\xint_gob_til_sc #1\XINT_add_lf ;\XINT_add_m 1#1#2}%
\def\XINT_add_lf #1\W {1\relax 00000001!1;!}%
\def\XINT_add_m #1!{\expandafter\XINT_add_n\the\numexpr\xint_c_i+#1\xint:}%
\def\XINT_add_n #1#2\xint:{1#2\expandafter!\the\numexpr\XINT_add_o #1}%
```

Here 2 stands for "carry", and 1 for "no carry" (we have been adding 1 to 1<8digits>.)

```
\def\XINT_add_o #1{\if #12\expandafter\XINT_add_l\else\expandafter\XINT_add_ke \fi}%
```

5.34 \xintiiCmp

Modified at 1.4m (2022/06/10). Now uses the \xintstrcmp engine primitive.

```
\def\xintiiCmp   {\romannumeral0\xintiicmp }%
\def\xintiicmp #1{\expandafter\XINT_iicmp\romannumeral`&&@#1\xint:}%
\def\XINT_iicmp #1#2\xint:#3%
{%
    \expandafter\XINT_cmp_nfork\expandafter #1\romannumeral`&&@#3\xint:#2\xint:
}%
\def\XINT_cmp_nfork #1#2%
{%
    \xint_UDzerofork
      #1\XINT_cmp_firstiszero
      #2\XINT_cmp_secondiszero
       0{}%
    \krof
    \xint_UDsignsfork
          #1#2\XINT_cmp_minusminus
           #1-\XINT_cmp_minusplus
           #2-\XINT_cmp_plusminus
            --\XINT_cmp_plusplus
    \krof #1#2%
}%
\def\XINT_cmp_firstiszero  #1\krof 0#2#3\xint:#4\xint:
{%
    \xint_UDzerominusfork
      #2-{ 0}%
      0#2{ 1}%
       0-{ -1}%
    \krof
}%
```

```
\def\XINT_cmp_secondiszero #1\krof #20#3\xint:#4\xint:
{%
    \xint_UDzerominusfork
      #2-{ 0}%
      0#2{ -1}%
       0-{ 1}%
    \krof
}%
\def\XINT_cmp_plusminus    #1\xint:#2\xint:{ 1}%
\def\XINT_cmp_minusplus    #1\xint:#2\xint:{ -1}%
\def\XINT_cmp_minusminus
    --{\expandafter\XINT_opp\romannumeral0\XINT_cmp_plusplus {}{}}%
```

The \romannumeral0 trigger induces some complications here to terminate nicely without grabbing too many tokens in the stream or deteriorating expansion quality of the non-equal-length branches. \expanded simplifies things.

```
\def\XINT_cmp_plusplus #1#2#3\xint:#4\xint:{\expanded{ %
    \ifcase\expandafter\XINT_cntSgn\the\numexpr\xintLength{#1#4}-\xintLength{#2#3}\xint:
        \xintstrcmp{#1#4}{#2#3}\or1\else-1\fi
    }%
}%
```

Prior to 1.4m the «strcmp» primitive was not used by xintcore. Here is the old implementation:

```
\def\XINT_cmp_plusplus  #1#2#3\xint:
{%
    \expandafter\XINT_cmp_pp
    \the\numexpr\expandafter\XINT_sepbyviii_andcount
    \romannumeral0\XINT_zeroes_forviii #2#3\R\R\R\R\R\R\R\R{10}0000001\W
    #2#3\XINT_sepbyviii_end 2345678\relax
        \xint_c_vii!\xint_c_vi!\xint_c_v!\xint_c_iv!%
        \xint_c_iii!\xint_c_ii!\xint_c_i!\xint_c_\W
    #1%
}%
\def\XINT_cmp_pp #1\xint:#2\xint:#3\xint:
{%
    \expandafter\XINT_cmp_checklengths
    \the\numexpr #2\expandafter\xint:%
    \the\numexpr\expandafter\XINT_sepbyviii_andcount
    \romannumeral0\XINT_zeroes_forviii #3\R\R\R\R\R\R\R\R{10}0000001\W
    #3\XINT_sepbyviii_end 2345678\relax
        \xint_c_vii!\xint_c_vi!\xint_c_v!\xint_c_iv!%
        \xint_c_iii!\xint_c_ii!\xint_c_i!\xint_c_\W
    #1;!1;!1;!1;!\W
}%
\def\XINT_cmp_checklengths #1\xint:#2\xint:#3\xint:
{%
    \ifnum #1=#3
       \expandafter\xint_firstoftwo
    \else
       \expandafter\xint_secondoftwo
    \fi
    \XINT_cmp_a {\XINT_cmp_distinctlengths {#1}{#3}}#2;!1;!1;!1;!\W
}%
\def\XINT_cmp_distinctlengths #1#2#3\W #4\W
```

```
{%
    \ifnum #1>#2
        \expandafter\xint_firstoftwo
    \else
        \expandafter\xint_secondoftwo
    \fi
    { -1}{ 1}%
}%
\def\XINT_cmp_a 1#1!1#2!1#3!1#4!#5\W 1#6!1#7!1#8!1#9!%
{%
    \xint_gob_til_sc #1\XINT_cmp_equal ;%
    \ifnum #1>#6 \XINT_cmp_gt\fi
    \ifnum #1<#6 \XINT_cmp_lt\fi
    \xint_gob_til_sc #2\XINT_cmp_equal ;%
    \ifnum #2>#7 \XINT_cmp_gt\fi
    \ifnum #2<#7 \XINT_cmp_lt\fi
    \xint_gob_til_sc #3\XINT_cmp_equal ;%
    \ifnum #3>#8 \XINT_cmp_gt\fi
    \ifnum #3<#8 \XINT_cmp_lt\fi
    \xint_gob_til_sc #4\XINT_cmp_equal ;%
    \ifnum #4>#9 \XINT_cmp_gt\fi
    \ifnum #4<#9 \XINT_cmp_lt\fi
    \XINT_cmp_a #5\W
}%
\def\XINT_cmp_lt#1{\def\XINT_cmp_lt\fi ##1\W ##2\W {\fi#1-1}}\XINT_cmp_lt{ }%
\def\XINT_cmp_gt#1{\def\XINT_cmp_gt\fi ##1\W ##2\W {\fi#11}}\XINT_cmp_gt{ }%
\def\XINT_cmp_equal #1\W #2\W { 0}%
```

5.35 \xintiiSub

Entirely rewritten for 1.2.

Refactored at 1.2l. I was initially aiming at clinching some internal format of the type 1<8digits>!....1<8digits>! for chaining the arithmetic operations (as a preliminary step to deciding upon some internal format for xintfrac macros), thus I wanted to uniformize delimiters in particular and have some core macros inputting and outputting such formats. But the way division is implemented makes it currently very hard to obtain a satisfactory solution. For subtraction I got there almost, but there was added overhead and, as the core sub-routine still assumed the shorter number will be positioned first, one would need to record the length also in the basic internal format, or add the overhead to not make assumption on which one is shorter. I thus but back-tracked my steps but in passing I improved the efficiency (probably) in the worst case branch.

Sadly this 1.2l refactoring left an extra ! in macro \XINT_sub_l_Ida. This bug shows only in rare circumstances which escaped out test suite :(Fixed at 1.2q.

The other reason for backtracking was in relation with the decimal numbers. Having a core format in base 10^8 but ultimately the radix is actually 10 leads to complications. I could use radix 10^8 for \xintiiexpr only, but then I need to make it compatible with sub-\xintiiexpr in \xintexpr, etc... there are many issues of this type.

I considered also an approach like in the 1.2l \xintiiCmp, but decided to stick with the method here for now.

```
\def\xintiiSub   {\romannumeral0\xintiisub }%
\def\xintiisub #1{\expandafter\XINT_iisub\romannumeral`&&@#1\xint:}%
\def\XINT_iisub #1#2\xint:#3%
{%
```

```
    \expandafter\XINT_sub_nfork\expandafter
    #1\romannumeral`&&@#3\xint:#2\xint:
}%
\def\XINT_sub_nfork #1#2%
{%
    \xint_UDzerofork
      #1\XINT_sub_firstiszero
      #2\XINT_sub_secondiszero
       0{}%
    \krof
    \xint_UDsignsfork
          #1#2\XINT_sub_minusminus
           #1-\XINT_sub_minusplus
           #2-\XINT_sub_plusminus
            --\XINT_sub_plusplus
    \krof #1#2%
}%
\def\XINT_sub_firstiszero  #1\krof 0#2#3\xint:#4\xint:{\XINT_opp #2#3}%
\def\XINT_sub_secondiszero #1\krof #20#3\xint:#4\xint:{ #2#4}%
\def\XINT_sub_plusminus    #1#2{\XINT_add_pp_a #1{}}%
\def\XINT_sub_plusplus   #1#2%
   {\expandafter\XINT_opp\romannumeral0\XINT_sub_mm_a #1#2}%
\def\XINT_sub_minusplus    #1#2%
   {\expandafter-\romannumeral0\XINT_add_pp_a {}#2}%
\def\XINT_sub_minusminus #1#2{\XINT_sub_mm_a {}{}}%
\def\XINT_sub_mm_a  #1#2#3\xint:
{%
  \expandafter\XINT_sub_mm_b
      \romannumeral0\expandafter\XINT_sepandrev_andcount
      \romannumeral0\XINT_zeroes_forviii #2#3\R\R\R\R\R\R\R\R{10}0000001\W
      #2#3\XINT_rsepbyviii_end_A 2345678%
          \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
              \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
              \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
  \X #1%
}%
\def\XINT_sub_mm_b #1\xint:#2\X #3\xint:
{%
    \expandafter\XINT_sub_checklengths
    \the\numexpr #1\expandafter\xint:%
    \romannumeral0\expandafter\XINT_sepandrev_andcount
    \romannumeral0\XINT_zeroes_forviii #3\R\R\R\R\R\R\R\R{10}0000001\W
    #3\XINT_rsepbyviii_end_A 2345678%
      \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
              \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
              \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
      1;!1;!1;!1;!\W
    #21;!1;!1;!1;!\W
    1;!1\R!1\R!1\R!1\R!%
    1\R!1\R!1\R!1\R!\W
}%
\def\XINT_sub_checklengths #1\xint:#2\xint:%
```

```
{%
    \ifnum #2>#1
      \expandafter\XINT_sub_exchange
    \else
      \expandafter\XINT_sub_aa
    \fi
}%
\def\XINT_sub_exchange #1\W #2\W
{%
    \expandafter\XINT_opp\romannumeral0\XINT_sub_aa #2\W #1\W
}%
\def\XINT_sub_aa
{%
    \expandafter\XINT_sub_out\the\numexpr\XINT_sub_a\xint_c_i
}%
```

The post-processing (clean-up of zeros, or rescue of situation with A-B where actually B turns out bigger than A) will be done by a macro which depends on circumstances and will be initially last token before the reversion done by \XINT_unrevbyviii.

```
\def\XINT_sub_out {\XINT_unrevbyviii{}}%
```

1 as first token of #1 stands for "no carry", 0 will mean a carry.

```
   Call: \the\numexpr
         \XINT_sub_a 1#11;!1;!1;!1;!\W
                      #21;!1;!1;!1;!\W
```

where #1 and #2 are blocks of 1<8d>!, #1 (=B) *must* be at most as long as #2 (=A), (in radix 10^8) and the routine wants to compute #2-#1 = A - B

1.2l uses 1;! delimiters to match those of addition (and multiplication). But in the end I reverted the code branch which made it possible to chain such operations keeping internal format in 8 digits blocks throughout.

\numexpr governed expansion stops with various possibilities:

- Type Ia: #1 shorter than #2, no final carry
- Type Ib: #1 shorter than #2, a final carry but next block of #2 > 1
- Type Ica: #1 shorter than #2, a final carry, next block of #2 is final and = 1
- Type Icb: as Ica except that 00000001 block from #2 was not final
- Type Id: #1 shorter than #2, a final carry, next block of #2 = 0
- Type IIa: #1 same length as #2, turns out it was <= #2.
- Type IIb: #1 same length as #2, but turned out > #2.

Various type of post actions are then needed:

- Ia: clean up of zeros in most significant block of 8 digits
- Ib: as Ia
- Ic: there may be significant blocks of 8 zeros to clean up from result. Only case Ica may have arbitrarily many of them, case Icb has only one such block.
- Id: blocks of 99999999 may propagate and there might a be final zero block created which has to be cleaned up.
- IIa: arbitrarily many zeros might have to be removed.
- IIb: We wanted #2-#1 = - (#1-#2), but we got 10^{8N}+#2 -#1 = 10^{8N}-(#1-#2). We need to do the correction then we are as in IIa situation, except that final result can not be zero.

The 1.2l method for this correction is (presumably, testing takes lots of time, which I do not have) more efficient than in 1.2 release.

```
\def\XINT_sub_a #1!#2!#3!#4!#5\W #6!#7!#8!#9!%
{%
    \XINT_sub_b
    #1!#6!#2!#7!#3!#8!#4!#9!%
```

```
    #5\W
}%
```

As 1.2l code uses 1<8digits>! blocks one has to be careful with the carry digit 1 or 0: A #11#2#3 pattern would result into an empty #1 if the carry digit which is upfront is 1, rather than setting #1=1.

```
\def\XINT_sub_b #1#2#3#4!#5!%
{%
    \xint_gob_til_sc #3\XINT_sub_bi ;%
    \expandafter\XINT_sub_c\the\numexpr#1+1#5-#3#4-\xint_c_i\xint:%
}%
\def\XINT_sub_c 1#1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_sub_d #1%
}%
\def\XINT_sub_d #1#2#3#4!#5!%
{%
    \xint_gob_til_sc #3\XINT_sub_di ;%
    \expandafter\XINT_sub_e\the\numexpr#1+1#5-#3#4-\xint_c_i\xint:
}%
\def\XINT_sub_e 1#1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_sub_f #1%
}%
\def\XINT_sub_f #1#2#3#4!#5!%
{%
    \xint_gob_til_sc #3\XINT_sub_fi ;%
    \expandafter\XINT_sub_g\the\numexpr#1+1#5-#3#4-\xint_c_i\xint:
}%
\def\XINT_sub_g 1#1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_sub_h #1%
}%
\def\XINT_sub_h #1#2#3#4!#5!%
{%
    \xint_gob_til_sc #3\XINT_sub_hi ;%
    \expandafter\XINT_sub_i\the\numexpr#1+1#5-#3#4-\xint_c_i\xint:
}%
\def\XINT_sub_i 1#1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_sub_a #1%
}%
\def\XINT_sub_bi;%
    \expandafter\XINT_sub_c\the\numexpr#1+1#2-#3\xint:
    #4!#5!#6!#7!#8!#9!\W
{%
    \XINT_sub_k #1#2!#5!#7!#9!%
}%
\def\XINT_sub_di;%
    \expandafter\XINT_sub_e\the\numexpr#1+1#2-#3\xint:
    #4!#5!#6!#7!#8\W
{%
    \XINT_sub_k #1#2!#5!#7!%
```

```
}%
\def\XINT_sub_fi;%
    \expandafter\XINT_sub_g\the\numexpr#1+1#2-#3\xint:
    #4!#5!#6\W
{%
    \XINT_sub_k #1#2!#5!%
}%
\def\XINT_sub_hi;%
    \expandafter\XINT_sub_i\the\numexpr#1+1#2-#3\xint:
    #4\W
{%
    \XINT_sub_k #1#2!%
}%
```

B terminated. Have we reached the end of A (necessarily at least as long as B) ? (we are computing A-B, digits of B come first).

If not, then we are certain that even if there is carry it will not propagate beyond the end of A. But it may propagate far transforming chains of 00000000 into 99999999, and if it does go to the final block which possibly is just 1<00000001>!, we will have those eight zeros to clean up.

If A and B have the same length (in base 10^8) then arbitrarily many zeros might have to be cleaned up, and if A<B, the whole result will have to be complemented first.

```
\def\XINT_sub_k #1#2#3%
{%
    \xint_gob_til_sc #3\XINT_sub_p;\XINT_sub_l #1#2#3%
}%
\def\XINT_sub_l #1%
   {\xint_UDzerofork #1\XINT_sub_l_carry 0\XINT_sub_l_Ia\krof}%
\def\XINT_sub_l_Ia 1#1;!#2\W{1\relax#1;!1\XINT_sub_fix_none!}%

\def\XINT_sub_l_carry 1#1!{\ifcase #1
         \expandafter \XINT_sub_l_Id
    \or  \expandafter \XINT_sub_l_Ic
    \else\expandafter \XINT_sub_l_Ib\fi 1#1!}%
\def\XINT_sub_l_Ib #1;#2\W {-\xint_c_i+#1;!1\XINT_sub_fix_none!}%
\def\XINT_sub_l_Ic 1#1!1#2#3!#4;#5\W
{%
    \xint_gob_til_sc #2\XINT_sub_l_Ica;%
    1\relax 00000000!1#2#3!#4;!1\XINT_sub_fix_none!%
}%
```

We need to add some extra delimiters at the end for post-action by \XINT_num, so we first grab the material up to \W

```
\def\XINT_sub_l_Ica#1\W
{%
    1;!1\XINT_sub_fix_cuz!%
    1;!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
    \xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\Z
}%
\def\XINT_sub_l_Id 1#1!%
    {199999999\expandafter!\the\numexpr \XINT_sub_l_Id_a}%
\def\XINT_sub_l_Id_a 1#1!{\ifcase #1
         \expandafter \XINT_sub_l_Id
    \or  \expandafter \XINT_sub_l_Id_b
    \else\expandafter \XINT_sub_l_Ib\fi 1#1!}%
```

```
\def\XINT_sub_l_Id_b 1#1!1#2#3!#4;#5\W
{%
    \xint_gob_til_sc #2\XINT_sub_l_Ida;%
    1\relax 00000000!1#2#3!#4;!1\XINT_sub_fix_none!%
}%
\def\XINT_sub_l_Ida#1\XINT_sub_fix_none{1;!1\XINT_sub_fix_none}%
```

This is the case where both operands have same 10^8-base length.

We were handling A-B but perhaps B>A. The situation with A=B is also annoying because we then have to clean up all zeros but don't know where to stop (if A>B the first non-zero 8 digits block would tell use when).

Here again we need to grab #3\W to position the actually used terminating delimiters.

```
\def\XINT_sub_p;\XINT_sub_l #1#2\W #3\W
{%
    \xint_UDzerofork
       #1{1;!1\XINT_sub_fix_neg!%
          1;!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
          \xint_bye2345678\xint_bye1099999988\relax}% A - B, B > A
        0{1;!1\XINT_sub_fix_cuz!%
          1;!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W}%
    \krof
    \xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\Z
}%
```

Routines for post-processing after reversal, and removal of separators. It is a matter of cleaning up zeros, and possibly in the bad case to take a complement before that.

```
\def\XINT_sub_fix_none;{\XINT_cuz_small}%
\def\XINT_sub_fix_cuz ;{\expandafter\XINT_num_cleanup\the\numexpr\XINT_num_loop}%
```

Case with A and B same number of digits in base 10^8 and B>A.

1.2l subtle chaining on the model of the 1.2i rewrite of \xintInc and similar routines. After taking complement, leading zeroes need to be cleaned up as in B<=A branch.

```
\def\XINT_sub_fix_neg;%
{%
    \expandafter-\romannumeral0\expandafter
    \XINT_sub_comp_finish\the\numexpr\XINT_sub_comp_loop
}%
\def\XINT_sub_comp_finish 0{\XINT_sub_fix_cuz;}%
\def\XINT_sub_comp_loop #1#2#3#4#5#6#7#8%
{%
    \expandafter\XINT_sub_comp_clean
    \the\numexpr \xint_c_xi_e_viii_mone-#1#2#3#4#5#6#7#8\XINT_sub_comp_loop
}%
```

#1 = 0 signifie une retenue, #1 = 1 pas de retenue, ce qui ne peut arriver que tant qu'il n'y a que des zéros du côté non significatif. Lorsqu'on est revenu au début on a forcément une retenue.

```
\def\XINT_sub_comp_clean 1#1{+#1\relax}%
```

5.36 \xintiiMul

Completely rewritten for 1.2.

1.2l: \xintiiMul made robust against non terminated input.

```
\def\xintiiMul {\romannumeral0\xintiimul }%
\def\xintiimul #1%
{%
```

```
    \expandafter\XINT_iimul\romannumeral`&&@#1\xint:
}%
\def\XINT_iimul #1#2\xint:#3%
{%
    \expandafter\XINT_mul_nfork\expandafter #1\romannumeral`&&@#3\xint:#2\xint:
}%
```

1.2 I have changed the fork, and it complicates matters elsewhere.
ATTENTION for example that 1.4 \xintiiPrd uses \XINT_mul_nfork now.

```
\def\XINT_mul_fork #1#2\xint:#3\xint:{\XINT_mul_nfork #1#3\xint:#2\xint:}%
\def\XINT_mul_nfork #1#2%
{%
    \xint_UDzerofork
      #1\XINT_mul_zero
      #2\XINT_mul_zero
       0{}%
    \krof
    \xint_UDsignsfork
          #1#2\XINT_mul_minusminus
           #1-\XINT_mul_minusplus
           #2-\XINT_mul_plusminus
            --\XINT_mul_plusplus
    \krof #1#2%
}%
\def\XINT_mul_zero  #1\krof #2#3\xint:#4\xint:{ 0}%
\def\XINT_mul_minusminus   #1#2{\XINT_mul_plusplus {}{}}%
\def\XINT_mul_minusplus    #1#2%
   {\expandafter-\romannumeral0\XINT_mul_plusplus {}#2}%
\def\XINT_mul_plusminus    #1#2%
   {\expandafter-\romannumeral0\XINT_mul_plusplus #1{}}%
\def\XINT_mul_plusplus #1#2#3\xint:
{%
  \expandafter\XINT_mul_pre_b
      \romannumeral0\expandafter\XINT_sepandrev_andcount
      \romannumeral0\XINT_zeroes_forviii #2#3\R\R\R\R\R\R\R\R{10}0000001\W
      #2#3\XINT_rsepbyviii_end_A 2345678%
          \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
              \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
              \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
  \W #1%
}%
\def\XINT_mul_pre_b #1\xint:#2\W #3\xint:
{%
    \expandafter\XINT_mul_checklengths
    \the\numexpr #1\expandafter\xint:%
    \romannumeral0\expandafter\XINT_sepandrev_andcount
    \romannumeral0\XINT_zeroes_forviii #3\R\R\R\R\R\R\R\R{10}0000001\W
    #3\XINT_rsepbyviii_end_A 2345678%
      \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
              \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
              \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
     1;!\W #21;!%
    1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
```

```
}%
```

Cooking recipe, 2015/10/05.

```
\def\XINT_mul_checklengths #1\xint:#2\xint:%
{%
    \ifnum #2=\xint_c_i\expandafter\XINT_mul_smallbyfirst\fi
    \ifnum #1=\xint_c_i\expandafter\XINT_mul_smallbysecond\fi
    \ifnum #2<#1
       \ifnum \numexpr (#2-\xint_c_i)*(#1-#2)<383
          \XINT_mul_exchange
       \fi
    \else
       \ifnum \numexpr (#1-\xint_c_i)*(#2-#1)>383
          \XINT_mul_exchange
       \fi
    \fi
    \XINT_mul_start
}%
\def\XINT_mul_smallbyfirst #1\XINT_mul_start 1#2!1;!\W
{%
    \ifnum#2=\xint_c_i\expandafter\XINT_mul_oneisone\fi
    \ifnum#2<\xint_c_xxii\expandafter\XINT_mul_verysmall\fi
    \expandafter\XINT_mul_out\the\numexpr\XINT_smallmul 1#2!%
}%
\def\XINT_mul_smallbysecond #1\XINT_mul_start #2\W 1#3!1;!%
{%
    \ifnum#3=\xint_c_i\expandafter\XINT_mul_oneisone\fi
    \ifnum#3<\xint_c_xxii\expandafter\XINT_mul_verysmall\fi
    \expandafter\XINT_mul_out\the\numexpr\XINT_smallmul 1#3!#2%
}%
\def\XINT_mul_oneisone #1!{\XINT_mul_out }%
\def\XINT_mul_verysmall\expandafter\XINT_mul_out
                       \the\numexpr\XINT_smallmul 1#1!%
    {\expandafter\XINT_mul_out\the\numexpr\XINT_verysmallmul 0\xint:#1!}%
\def\XINT_mul_exchange #1\XINT_mul_start #2\W #31;!%
   {\fi\fi\XINT_mul_start #31;!\W #2}%
\def\XINT_mul_start
   {\expandafter\XINT_mul_out\the\numexpr\XINT_mul_loop 100000000!1;!\W}%
\def\XINT_mul_out
   {\expandafter\XINT_cuz_small\romannumeral0\XINT_unrevbyviii {}}%
```

Call:

`\the\numexpr \XINT_mul_loop 100000000!1;!\W #11;!\W #21;!`

where #1 and #2 are (globally reversed) blocks 1<8d>!. Its is generally more efficient if #1 is the shorter one, but a better recipe is implemented in \XINT_mul_checklengths. One may call \XINT_mul_loop directly (but multiplication by zero will produce many 100000000! blocks on output).

Ends after having produced: 1<8d>!....1<8d>!1;!. The last 8-digits block is significant one. It can not be 100000000! except if the loop was called with a zero operand.

Thus \XINT_mul_loop can be conveniently called directly in recursive routines, as the output terminator can serve as input terminator, we can arrange to not have to grab the whole thing again.

```
\def\XINT_mul_loop #1\W #2\W 1#3!%
{%
    \xint_gob_til_sc #3\XINT_mul_e ;%
    \expandafter\XINT_mul_a\the\numexpr \XINT_smallmul 1#3!#2\W
```

```
    #1\W #2\W
}%
```

Each of #1 and #2 brings its 1;! for \XINT_add_a.

```
\def\XINT_mul_a #1\W #2\W
{%
    \expandafter\XINT_mul_b\the\numexpr
    \XINT_add_a \xint_c_ii #21;!1;!1;!\W #11;!1;!1;!\W\W
}%
\def\XINT_mul_b 1#1!{1#1\expandafter!\the\numexpr\XINT_mul_loop }%
\def\XINT_mul_e;#1\W 1#2\W #3\W {1\relax #2}%
```

1.2 small and mini multiplication in base 10^8 with carry. Used by the main multiplication routines. But division, float factorial, etc.. have their own variants as they need output with specific constraints.

The minimulwc has 1<8digits carry>.<4 high digits>.<4 low digits!<8digits>.

It produces a block 1<8d>! and then jump back into \XINT_smallmul_a with the new 8digits carry as argument. The \XINT_smallmul_a fetches a new 1<8d>! block to multiply, and calls back \XINT_minimul_wc having stored the multiplicand for re-use later. When the loop terminates, the final carry is checked for being nul, and in all cases the output is terminated by a 1;!

Multiplication by zero will produce blocks of zeros.

```
\def\XINT_minimulwc_a 1#1\xint:#2\xint:#3!#4#5#6#7#8\xint:%
{%
    \expandafter\XINT_minimulwc_b
    \the\numexpr \xint_c_x^ix+#1+#3*#8\xint:
                     #3*#4#5#6#7+#2*#8\xint:
                           #2*#4#5#6#7\xint:%
}%
\def\XINT_minimulwc_b 1#1#2#3#4#5#6\xint:#7\xint:%
{%
    \expandafter\XINT_minimulwc_c
    \the\numexpr \xint_c_x^ix+#1#2#3#4#5+#7\xint:#6\xint:%
}%
\def\XINT_minimulwc_c 1#1#2#3#4#5#6\xint:#7\xint:#8\xint:%
{%
    1#6#7\expandafter!%
    \the\numexpr\expandafter\XINT_smallmul_a
    \the\numexpr \xint_c_x^viii+#1#2#3#4#5+#8\xint:%
}%
\def\XINT_smallmul 1#1#2#3#4#5!{\XINT_smallmul_a 100000000\xint:#1#2#3#4\xint:#5!}%
\def\XINT_smallmul_a #1\xint:#2\xint:#3!1#4!%
{%
    \xint_gob_til_sc #4\XINT_smallmul_e;%
    \XINT_minimulwc_a #1\xint:#2\xint:#3!#4\xint:#2\xint:#3!%
}%
\def\XINT_smallmul_e;\XINT_minimulwc_a 1#1\xint:#2;#3!%
    {\xint_gob_til_eightzeroes #1\XINT_smallmul_f 000000001\relax #1!1;!}%
\def\XINT_smallmul_f 000000001\relax 00000000!1{1\relax}%
\def\XINT_verysmallmul #1\xint:#2!1#3!%
{%
    \xint_gob_til_sc #3\XINT_verysmallmul_e;%
    \expandafter\XINT_verysmallmul_a
    \the\numexpr #2*#3+#1\xint:#2!%
}%
```

```
\def\XINT_verysmallmul_e;\expandafter\XINT_verysmallmul_a\the\numexpr
    #1+#2#3\xint:#4!%
{\xint_gob_til_zero #2\XINT_verysmallmul_f 0\xint_c_x^viii+#2#3!1;!}%
\def\XINT_verysmallmul_f #1!1{1\relax}%
\def\XINT_verysmallmul_a #1#2\xint:%
{%
    \unless\ifnum #1#2<\xint_c_x^ix
    \expandafter\XINT_verysmallmul_bi\else
    \expandafter\XINT_verysmallmul_bj\fi
    \the\numexpr \xint_c_x^ix+#1#2\xint:%
}%
\def\XINT_verysmallmul_bj{\expandafter\XINT_verysmallmul_cj }%
\def\XINT_verysmallmul_cj 1#1#2\xint:%
    {1#2\expandafter!\the\numexpr\XINT_verysmallmul #1\xint:}%
\def\XINT_verysmallmul_bi\the\numexpr\xint_c_x^ix+#1#2#3\xint:%
    {1#3\expandafter!\the\numexpr\XINT_verysmallmul #1#2\xint:}%
```

Used by division and by squaring, not by multiplication itself.

This routine does not loop, it only does one mini multiplication with input format <4 high digits>.<4 low digits>!<8 digits>!, and on output 1<8d>!1<8d>!, with least significant block first.

```
\def\XINT_minimul_a #1\xint:#2!#3#4#5#6#7!%
{%
    \expandafter\XINT_minimul_b
    \the\numexpr \xint_c_x^viii+#2*#7\xint:#2*#3#4#5#6+#1*#7\xint:#1*#3#4#5#6\xint:%
}%
\def\XINT_minimul_b 1#1#2#3#4#5\xint:#6\xint:%
{%
    \expandafter\XINT_minimul_c
    \the\numexpr \xint_c_x^ix+#1#2#3#4+#6\xint:#5\xint:%
}%
\def\XINT_minimul_c 1#1#2#3#4#5#6\xint:#7\xint:#8\xint:%
{%
    1#6#7\expandafter!\the\numexpr \xint_c_x^viii+#1#2#3#4#5+#8!%
}%
```

5.37 \xintiiDivision

Completely rewritten for 1.2.

WARNING: some comments below try to describe the flow of tokens but they date back to xint 1.09j and I updated them on the fly while doing the 1.2 version. As the routine now works in base 10^8, not 10^4 and "drops" the quotient digits,rather than store them upfront as the earlier code, I may well have not correctly converted all such comments. At the last minute some previously #1 became stuff like #1#2#3#4, then of course the old comments describing what the macro parameters stand for are necessarily wrong.

Side remark: the way tokens are grouped was not essentially modified in 1.2, although the situation has changed. It was fine-tuned in xint 1.0/1.1 but the context has changed, and perhaps I should revisit this. As a corollary to the fact that quotient digits are now left behind thanks to the chains of \numexpr, some macros which in 1.0/1.1 fetched up to 9 parameters now need handle less such parameters. Thus, some rationale for the way the code was structured has disappeared.

1.2l: \xintiiDivision et al. made robust against non terminated input.

#1 = A, #2 = B. On calcule le quotient et le reste dans la division euclidienne de A par B: A=BQ+R, 0<= R < |B|.

```
\def\xintiiDivision   {\romannumeral0\xintiidivision }%
```

```
\def\xintiidivision  #1{\expandafter\XINT_iidivision \romannumeral`&&@#1\xint:}%
\def\XINT_iidivision #1#2\xint:#3{\expandafter\XINT_iidivision_a\expandafter #1%
                              \romannumeral`&&@#3\xint:#2\xint:}%
```

On regarde les signes de A et de B.

```
\def\XINT_iidivision_a #1#2% #1 de A, #2 de B.
{%
    \if0#2\xint_dothis{\XINT_iidivision_divbyzero #1#2}\fi
    \if0#1\xint_dothis\XINT_iidivision_aiszero\fi
    \if-#2\xint_dothis{\expandafter\XINT_iidivision_bneg
                      \romannumeral0\XINT_iidivision_bpos #1}\fi
    \xint_orthat{\XINT_iidivision_bpos #1#2}%
}%
\def\XINT_iidivision_divbyzero#1#2#3\xint:#4\xint:
   {\if0#1\xint_dothis{\XINT_signalcondition{DivisionUndefined}}\fi
          \xint_orthat{\XINT_signalcondition{DivisionByZero}}%
    {Division by zero: #1#4/#2#3.}{}{{0}{0}}}%
\def\XINT_iidivision_aiszero #1\xint:#2\xint:{{0}{0}}%
\def\XINT_iidivision_bneg #1% q->-q, r unchanged
                          {\expandafter{\romannumeral0\XINT_opp #1}}%
\def\XINT_iidivision_bpos #1%
{%
    \xint_UDsignfork
            #1\XINT_iidivision_aneg
             -{\XINT_iidivision_apos #1}%
    \krof
}%
```

Donc attention malgré son nom \XINT_div_prepare va jusqu'au bout. C'est donc en fait l'entrée principale (pour B>0, A>0) mais elle va regarder si B est < 10^8 et s'il vaut alors 1 ou 2, et si A < 10^8. Dans tous les cas le résultat est produit sous la forme {Q}{R}, avec Q et R sous leur forme final. On doit ensuite ajuster si le B ou le A initial était négatif. Je n'ai pas fait beaucoup d'efforts pour être un minimum efficace si A ou B n'est pas positif.

```
\def\XINT_iidivision_apos #1#2\xint:#3\xint:{\XINT_div_prepare {#2}{#1#3}}%
\def\XINT_iidivision_aneg #1\xint:#2\xint:
   {\expandafter
    \XINT_iidivision_aneg_b\romannumeral0\XINT_div_prepare {#1}{#2}{#1}}%
\def\XINT_iidivision_aneg_b #1#2{\if0\XINT_Sgn #2\xint:
                              \expandafter\XINT_iidivision_aneg_rzero
                           \else
                              \expandafter\XINT_iidivision_aneg_rpos
                           \fi {#1}{#2}}%
\def\XINT_iidivision_aneg_rzero #1#2#3{{-#1}{0}}% necessarily q was >0
\def\XINT_iidivision_aneg_rpos #1%
{%
    \expandafter\XINT_iidivision_aneg_end\expandafter
               {\expandafter-\romannumeral0\xintinc {#1}}% q-> -(1+q)
}%
\def\XINT_iidivision_aneg_end #1#2#3%
{%
     \expandafter\xint_exchangetwo_keepbraces
     \expandafter{\romannumeral0\XINT_sub_mm_a {}{}#3\xint:#2\xint:}{#1}% r-> b-r
}%
```

Le diviseur B va être étendu par des zéros pour que sa longueur soit multiple de huit. Les zéros seront mis du côté non significatif.

```
\def\XINT_div_prepare #1%
{%
    \XINT_div_prepare_a #1\R\R\R\R\R\R\R {10}0000001\W !{#1}%
}%
\def\XINT_div_prepare_a #1#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_R #9\XINT_div_prepare_small\R
    \XINT_div_prepare_b #9%
}%
```

B a au plus huit chiffres. On se débarrasse des trucs superflus. Si B>0 n'est ni 1 ni 2, le point d'entrée est \XINT_div_small_a {B}{A} (avec un A positif).

```
\def\XINT_div_prepare_small\R #1!#2%
{%
    \ifcase #2
    \or\expandafter\XINT_div_BisOne
    \or\expandafter\XINT_div_BisTwo
    \else\expandafter\XINT_div_small_a
    \fi {#2}%
}%
\def\XINT_div_BisOne #1#2{{#2}{0}}%
\def\XINT_div_BisTwo #1#2%
{%
    \expandafter\expandafter\expandafter\XINT_div_BisTwo_a
    \ifodd\xintLDg{#2} \expandafter1\else \expandafter0\fi {#2}%
}%
\def\XINT_div_BisTwo_a #1#2%
{%
    \expandafter{\romannumeral0\XINT_half
     #2\xint_bye\xint_Bye345678\xint_bye
     *\xint_c_v+\xint_c_v)/\xint_c_x-\xint_c_i\relax}{#1}%
}%
```

B a au plus huit chiffres et est au moins 3. On va l'utiliser directement, sans d'abord le multiplier par une puissance de 10 pour qu'il ait 8 chiffres.

```
\def\XINT_div_small_a #1#2%
{%
    \expandafter\XINT_div_small_b
    \the\numexpr #1/\xint_c_ii\expandafter
    \xint:\the\numexpr \xint_c_x^viii+#1\expandafter!%
    \romannumeral0%
    \XINT_div_small_ba #2\R\R\R\R\R\R\R\R{10}0000001\W
       #2\XINT_sepbyviii_Z_end 2345678\relax
}%
```

Le #2 poursuivra l'expansion par \XINT_div_dosmallsmall ou par \XINT_smalldivx_a suivi de \XINT_sdiv_out.

```
\def\XINT_div_small_b #1!#2{#2#1!}%
```

On ajoute des zéros avant A, puis on le prépare sous la forme de blocs 1<8d>! Au passage on repère le cas d'un A<10^8.

```
\def\XINT_div_small_ba #1#2#3#4#5#6#7#8#9%
{%
```

```
    \xint_gob_til_R #9\XINT_div_smallsmall\R
    \expandafter\XINT_div_dosmalldiv
    \the\numexpr\expandafter\XINT_sepbyviii_Z
           \romannumeral0\XINT_zeroes_forviii
    #1#2#3#4#5#6#7#8#9%
}%
```

Si A<10^8, on va poursuivre par \XINT_div_dosmallsmall round(B/2).10^8+B!{A}. On fait la division directe par \numexpr. Le résultat est produit sous la forme {Q}{R}.

```
\def\XINT_div_smallsmall\R
    \expandafter\XINT_div_dosmalldiv
    \the\numexpr\expandafter\XINT_sepbyviii_Z
    \romannumeral0\XINT_zeroes_forviii #1\R #2\relax
   {{\XINT_div_dosmallsmall}{#1}}%
\def\XINT_div_dosmallsmall #1\xint:1#2!#3%
{%
    \expandafter\XINT_div_smallsmallend
    \the\numexpr (#3+#1)/#2-\xint_c_i\xint:#2\xint:#3\xint:%
}%
\def\XINT_div_smallsmallend #1\xint:#2\xint:#3\xint:{\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #3-#1*#2}}%
```

Si A>=10^8, il est maintenant sous la forme 1<8d>!...1<8d>!1;! avec plus significatifs en premier. Donc on poursuit par \expandafter\XINT_sdiv_out\the\numexpr\XINT_smalldivx_a x.1B!1<8d>!...1<8d>!1;! avec x =round(B/2), 1B=10^8+B.

```
\def\XINT_div_dosmalldiv
    {{\expandafter\XINT_sdiv_out\the\numexpr\XINT_smalldivx_a}}%
```

Ici B est au moins 10^8, on détermine combien de zéros lui adjoindre pour qu'il soit de longueur 8N.

```
\def\XINT_div_prepare_b
   {\expandafter\XINT_div_prepare_c\romannumeral0\XINT_zeroes_forviii }%
\def\XINT_div_prepare_c #1!%
{%
     \XINT_div_prepare_d  #1.00000000!{#1}%
}%
\def\XINT_div_prepare_d #1#2#3#4#5#6#7#8#9%
{%
    \expandafter\XINT_div_prepare_e\xint_gob_til_dot #1#2#3#4#5#6#7#8#9!%
}%
\def\XINT_div_prepare_e #1!#2!#3#4%
{%
    \XINT_div_prepare_f #4#3\X {#1}{#3}%
}%
```

attention qu'on calcule ici x'=x+1 (x = huit premiers chiffres du diviseur) et que si x=99999999, x' aura donc 9 chiffres, pas compatible avec div_mini (avant 1.2, x avait 4 chiffres, et on faisait la division avec x' dans un \numexpr). Bon, facile à dire après avoir laissé passer ce bug dans 1.2. C'est le problème lorsqu'au lieu de tout refaire à partir de zéro on recycle d'anciennes routines qui avaient un contexte différent.

```
\def\XINT_div_prepare_f #1#2#3#4#5#6#7#8#9\X
{%
    \expandafter\XINT_div_prepare_g
     \the\numexpr  #1#2#3#4#5#6#7#8+\xint_c_i\expandafter
```

```
    \xint:\the\numexpr (#1#2#3#4#5#6#7#8+\xint_c_i)/\xint_c_ii\expandafter
    \xint:\the\numexpr #1#2#3#4#5#6#7#8\expandafter
    \xint:\romannumeral0\XINT_sepandrev_andcount
    #1#2#3#4#5#6#7#8#9\XINT_rsepbyviii_end_A 2345678%
                      \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
             \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
             \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
    \X
}%
\def\XINT_div_prepare_g #1\xint:#2\xint:#3\xint:#4\xint:#5\X #6#7#8%
{%
    \expandafter\XINT_div_prepare_h
    \the\numexpr\expandafter\XINT_sepbyviii_andcount
    \romannumeral0\XINT_zeroes_forviii #8#7\R\R\R\R\R\R\R\R{10}0000001\W
    #8#7\XINT_sepbyviii_end 2345678\relax
     \xint_c_vii!\xint_c_vi!\xint_c_v!\xint_c_iv!%
     \xint_c_iii!\xint_c_ii!\xint_c_i!\xint_c_\W
    {#1}{#2}{#3}{#4}{#5}{#6}%
}%
\def\XINT_div_prepare_h #11\xint:#2\xint:#3#4#5#6%#7#8%
{%
    \XINT_div_start_a {#2}{#6}{#1}{#3}{#4}{#5}%{#7}{#8}%
}%
```

L, K, A, x',y,x, B, «c». Attention que K est diminué de 1 plus loin. Comme xint 1.2 a déjà repéré K=1, on a ici au minimum K=2. Attention B est à l'envers, A est à l'endroit et les deux avec séparateurs. Attention que ce n'est pas ici qu'on boucle mais en \XINT_div_I_a.

```
\def\XINT_div_start_a #1#2%
{%
    \ifnum #1 < #2
      \expandafter\XINT_div_zeroQ
    \else
      \expandafter\XINT_div_start_b
    \fi
    {#1}{#2}%
}%
\def\XINT_div_zeroQ #1#2#3#4#5#6#7%
{%
    \expandafter\XINT_div_zeroQ_end
    \romannumeral0\XINT_unsep_cuzsmall
    #3\xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax\xint:
}%
\def\XINT_div_zeroQ_end #1\xint:#2%
    {\expandafter{\expandafter0\expandafter}\XINT_div_cleanR #1#2\xint:}%
```

L, K, A, x',y,x, B, «c»->K.A.x{LK{x'y}x}B«c»

```
\def\XINT_div_start_b #1#2#3#4#5#6%
{%
    \expandafter\XINT_div_finish\the\numexpr
    \XINT_div_start_c {#2}\xint:#3\xint:{#6}{{#1}{#2}{{#4}{#5}}{#6}}%
}%
\def\XINT_div_finish
{%
    \expandafter\XINT_div_finish_a \romannumeral`&&@\XINT_div_unsepQ
```

```
}%
\def\XINT_div_finish_a #1\Z #2\xint:{\XINT_div_finish_b #2\xint:{#1}}%
```

Ici ce sont routines de fin. Le reste déjà nettoyé. R.Q«c».

```
\def\XINT_div_finish_b #1%
{%
    \if0#1%
       \expandafter\XINT_div_finish_bRzero
    \else
       \expandafter\XINT_div_finish_bRpos
    \fi
    #1%
}%
\def\XINT_div_finish_bRzero 0\xint:#1#2{{#1}{0}}%
\def\XINT_div_finish_bRpos #1\xint:#2#3%
{%
    \expandafter\xint_exchangetwo_keepbraces\XINT_div_cleanR  #1#3\xint:{#2}%
}%
\def\XINT_div_cleanR #100000000\xint:{{#1}}%
```

Kalpha.A.x{LK{x'y}x}, B, «c», au début #2=alpha est vide. On fait une boucle pour prendre K unités de A (on a au moins L égal à K) et les mettre dans alpha.

```
\def\XINT_div_start_c #1%
{%
    \ifnum #1>\xint_c_vi
       \expandafter\XINT_div_start_ca
    \else
       \expandafter\XINT_div_start_cb
    \fi {#1}%
}%
\def\XINT_div_start_ca #1#2\xint:#3!#4!#5!#6!#7!#8!#9!%
{%
    \expandafter\XINT_div_start_c\expandafter
    {\the\numexpr #1-\xint_c_vii}#2#3!#4!#5!#6!#7!#8!#9!\xint:%
}%
\def\XINT_div_start_cb #1%
   {\csname XINT_div_start_c_\romannumeral\numexpr#1\endcsname}%
\def\XINT_div_start_c_i   #1\xint:#2!%
    {\XINT_div_start_c_   #1#2!\xint:}%
\def\XINT_div_start_c_ii  #1\xint:#2!#3!%
    {\XINT_div_start_c_   #1#2!#3!\xint:}%
\def\XINT_div_start_c_iii #1\xint:#2!#3!#4!%
    {\XINT_div_start_c_   #1#2!#3!#4!\xint:}%
\def\XINT_div_start_c_iv  #1\xint:#2!#3!#4!#5!%
    {\XINT_div_start_c_   #1#2!#3!#4!#5!\xint:}%
\def\XINT_div_start_c_v   #1\xint:#2!#3!#4!#5!#6!%
    {\XINT_div_start_c_   #1#2!#3!#4!#5!#6!\xint:}%
\def\XINT_div_start_c_vi  #1\xint:#2!#3!#4!#5!#6!#7!%
    {\XINT_div_start_c_   #1#2!#3!#4!#5!#6!#7!\xint:}%
```

#1=a, #2=alpha (de longueur K, à l'endroit).#3=reste de A.#4=x, #5={LK{x'y}x},#6=B,«c» -> a, x, alpha, B, {00000000}, L, K, {x'y},x, alpha'=reste de A, B«c».

```
\def\XINT_div_start_c_ 1#1!#2\xint:#3\xint:#4#5#6%
{%
```

```
    \XINT_div_I_a {#1}{#4}{1#1!#2}{#6}{00000000}#5{#3}{#6}%
}%
```

Ceci est le point de retour de la boucle principale. a, x, alpha, B, q0, L, K, {x'y}, x, alpha', B«c»

```
\def\XINT_div_I_a #1#2%
{%
    \expandafter\XINT_div_I_b\the\numexpr #1/#2\xint:{#1}{#2}%
}%
\def\XINT_div_I_b #1%
{%
    \xint_gob_til_zero #1\XINT_div_I_czero 0\XINT_div_I_c #1%
}%
```

On intercepte petit quotient nul: #1=a, x, alpha, B, #5=q0, L, K, {x'y}, x, alpha', B«c» -> on lâche un q puis {alpha} L, K, {x'y}, x, alpha', B«c».

```
\def\XINT_div_I_czero 0\XINT_div_I_c 0\xint:#1#2#3#4#5{1#5\XINT_div_I_g {#3}}%
\def\XINT_div_I_c #1\xint:#2#3%
{%
    \expandafter\XINT_div_I_da\the\numexpr #2-#1*#3\xint:#1\xint:{#2}{#3}%
}%
```

r.q.alpha, B, q0, L, K, {x'y}, x, alpha', B«c»

```
\def\XINT_div_I_da #1\xint:%
{%
    \ifnum #1>\xint_c_ix
       \expandafter\XINT_div_I_dP
    \else
       \ifnum #1<\xint_c_
        \expandafter\expandafter\expandafter\XINT_div_I_dN
       \else
        \expandafter\expandafter\expandafter\XINT_div_I_db
       \fi
    \fi
}%
```

attention très mauvaises notations avec _b et _db.

```
\def\XINT_div_I_dN #1\xint:%
{%
    \expandafter\XINT_div_I_b\the\numexpr #1-\xint_c_i\xint:%
}%
\def\XINT_div_I_db #1\xint:#2#3#4#5%
{%
    \expandafter\XINT_div_I_dc\expandafter #1%
    \romannumeral0\expandafter\XINT_div_sub\expandafter
       {\romannumeral0\XINT_rev_nounsep {}#4\R!\R!\R!\R!\R!\R!\R!\R!\W}%
       {\the\numexpr\XINT_div_verysmallmul #1!#51;!}%
    \Z {#4}{#5}%
}%
```

La soustraction spéciale renvoie simplement - si le chiffre q est trop grand. On invoque dans ce cas I_dP.

```
\def\XINT_div_I_dc #1#2%
{%
    \if-#2\expandafter\XINT_div_I_dd\else\expandafter\XINT_div_I_de\fi
```

```
     #1#2%
}%
\def\XINT_div_I_dd #1-\Z
{%
    \if #11\expandafter\XINT_div_I_dz\fi
    \expandafter\XINT_div_I_dP\the\numexpr #1-\xint_c_i\xint: XX%
}%
\def\XINT_div_I_dz #1XX#2#3#4%
{%
    1#4\XINT_div_I_g {#2}%
}%
\def\XINT_div_I_de #1#2\Z #3#4#5{1#5+#1\XINT_div_I_g {#2}}%
```

q.alpha, B, q0, L, K, {x'y},x, alpha'B«c» (q=0 has been intercepted) -> 1nouveauq.nouvel alpha, L, K, {x'y}, x, alpha',B«c»

```
\def\XINT_div_I_dP #1\xint:#2#3#4#5#6%
{%
    1#6+#1\expandafter\XINT_div_I_g\expandafter
    {\romannumeral0\expandafter\XINT_div_sub\expandafter
      {\romannumeral0\XINT_rev_nounsep {}#4\R!\R!\R!\R!\R!\R!\R!\R!\W}%
      {\the\numexpr\XINT_div_verysmallmul #1!#51;!}%
    }%
}%
```

1#1=nouveau q. nouvel alpha, L, K, {x'y},x,alpha', BQ«c»

#1=q,#2=nouvel alpha,#3=L, #4=K, #5={x'y}, #6=x, #7= alpha',#8=B, «c» -> on laisse q puis {x'y}alpha.alpha'.{{x'y}xKL}B«c»

```
\def\XINT_div_I_g #1#2#3#4#5#6#7%
{%
     \expandafter !\the\numexpr
     \ifnum#2=#3
          \expandafter\XINT_div_exittofinish
     \else
          \expandafter\XINT_div_I_h
     \fi
     {#4}#1\xint:#6\xint:{{#4}{#5}{#3}{#2}}{#7}%
}%
```

{x'y}alpha.alpha'.{{x'y}xKL}B«c» -> Attention retour à l'envoyeur ici par terminaison des \the\numexpr. On doit reprendre le Q déjà sorti, qui n'a plus de séparateurs, ni de leading 1. Ensuite R sans leading zeros.«c»

```
\def\XINT_div_exittofinish #1#2\xint:#3\xint:#4#5%
{%
    1\expandafter\expandafter\expandafter!\expandafter\XINT_div_unsepQ_delim
    \romannumeral0\XINT_div_unsepR #2#3%
    \xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax\R\xint:
}%
```

ATTENTION DESCRIPTION OBSOLÈTE. #1={x'y}alpha.#2!#3=reste de A. #4={{x'y},x,K,L},#5=B,«c» devient {x'y},alpha sur K+4 chiffres.B, {{x'y},x,K,L}, #6= nouvel alpha',B,«c»

```
\def\XINT_div_I_h #1\xint:#2!#3\xint:#4#5%
{%
    \XINT_div_II_b #1#2!\xint:{#5}{#4}{#3}{#5}%
}%
```

{x'y}alpha.B, {{x'y},x,K,L}, nouveau alpha',B,«c»

```
\def\XINT_div_II_b #11#2!#3!%
{%
    \xint_gob_til_eightzeroes #2\XINT_div_II_skipc 00000000%
    \XINT_div_II_c #1{1#2}{#3}%
}%
```

x'y{100000000}{1<8>}reste de alpha.#6=B,#7={{x'y},x,K,L}, alpha',B, «c» -> {x'y}x,K,L (à diminuer de 4), {alpha sur K}B{q1=00000000}{alpha'}B,«c»

```
\def\XINT_div_II_skipc 00000000\XINT_div_II_c #1#2#3#4#5\xint:#6#7%
{%
    \XINT_div_II_k #7{#4!#5}{#6}{00000000}%
}%
```

x'ya->1qx'yalpha.B, {{x'y},x,K,L}, nouveau alpha',B, «c». En fait, attention, ici #3 et #4 sont les 16 premiers chiffres du numérateur,sous la forme blocs 1<8chiffres>.

```
\def\XINT_div_II_c #1#2#3#4%
{%
     \expandafter\XINT_div_II_d\the\numexpr\XINT_div_xmini
     #1\xint:#2!#3!#4!{#1}{#2}#3!#4!%
}%
\def\XINT_div_xmini #1%
{%
    \xint_gob_til_one #1\XINT_div_xmini_a 1\XINT_div_mini #1%
}%
\def\XINT_div_xmini_a 1\XINT_div_mini 1#1%
{%
    \xint_gob_til_zero #1\XINT_div_xmini_b 0\XINT_div_mini 1#1%
}%
\def\XINT_div_xmini_b 0\XINT_div_mini 10#1#2#3#4#5#6#7%
{%
    \xint_gob_til_zero #7\XINT_div_xmini_c 0\XINT_div_mini 10#1#2#3#4#5#6#7%
}%
```

x'=10^8 and we return #1=1<8digits>.

```
\def\XINT_div_xmini_c 0\XINT_div_mini 100000000\xint:50000000!#1!#2!{#1!}%
```

1 suivi de q1 sur huit chiffres! #2=x', #3=y, #4=alpha.#5=B, {{x'y},x,K,L}, alpha', B, «c» --> nouvel alpha.x',y,B,q1,{{x'y},x,K,L}, alpha', B, «c»

```
\def\XINT_div_II_d 1#1#2#3#4#5!#6#7#8\xint:#9%
{%
    \expandafter\XINT_div_II_e
    \romannumeral0\expandafter\XINT_div_sub\expandafter
      {\romannumeral0\XINT_rev_nounsep {}#8\R!\R!\R!\R!\R!\R!\R!\R!\W}%
      {\the\numexpr\XINT_div_smallmul_a 100000000\xint:#1#2#3#4\xint:#5!#91;!}%
    \xint:{#6}{#7}{#9}{#1#2#3#4#5}%
}%
```

alpha.x',y,B,q1, {{x'y},x,K,L}, alpha', B, «c». Attention la soustraction spéciale doit maintenir les blocs 1<8>!

```
\def\XINT_div_II_e 1#1!%
{%
    \xint_gob_til_eightzeroes #1\XINT_div_II_skipf 00000000%
    \XINT_div_II_f 1#1!%
}%
```

100000000! alpha sur K chiffres.#2=x',#3=y,#4=B,#5=q1, #6={{x'y},x,K,L}, #7=alpha',B«c» -> {x'y}x,K,L (à diminuer de 1), {alpha sur K}B{q1}{alpha'}B«c»

```
\def\XINT_div_II_skipf 00000000\XINT_div_II_f 100000000!#1\xint:#2#3#4#5#6%
{%
    \XINT_div_II_k #6{#1}{#4}{#5}%
}%
```

1<a1>!1<a2>!, alpha (sur K+1 blocs de 8). x', y, B, q1, {{x'y},x,K,L}, alpha', B,«c».

Here also we are dividing with x' which could be 10^8 in the exceptional case x=99999999. Must intercept it before sending to \XINT_div_mini.

```
\def\XINT_div_II_f #1!#2!#3\xint:%
{%
    \XINT_div_II_fa {#1!#2!}{#1!#2!#3}%
}%
\def\XINT_div_II_fa #1#2#3#4%
{%
    \expandafter\XINT_div_II_g \the\numexpr\XINT_div_xmini #3\xint:#4!#1{#2}%
}%
```

#1=q, #2=alpha (K+4), #3=B, #4=q1, {{x'y},x,K,L}, alpha', BQ«c» -> 1 puis nouveau q sur 8 chiffres. nouvel alpha sur K blocs, B, {{x'y},x,K,L}, alpha',B«c»

```
\def\XINT_div_II_g 1#1#2#3#4#5!#6#7#8%
{%
    \expandafter \XINT_div_II_h
    \the\numexpr 1#1#2#3#4#5+#8\expandafter\expandafter\expandafter
    \xint:\expandafter\expandafter\expandafter
    {\expandafter\xint_gob_til_exclam
     \romannumeral0\expandafter\XINT_div_sub\expandafter
       {\romannumeral0\XINT_rev_nounsep {}#6\R!\R!\R!\R!\R!\R!\R!\R!\W}%
       {\the\numexpr\XINT_div_smallmul_a 100000000\xint:#1#2#3#4\xint:#5!#71;!}}%
    {#7}%
}%
```

1 puis nouveau q sur 8 chiffres, #2=nouvel alpha sur K blocs, #3=B, #4={{x'y},x,K,L} avec L à ajuster, alpha', BQ«c» -> {x'y}x,K,L à diminuer de 1, {alpha}B{q}, alpha', BQ«c»

```
\def\XINT_div_II_h 1#1\xint:#2#3#4%
{%
    \XINT_div_II_k #4{#2}{#3}{#1}%
}%
```

{x'y}x,K,L à diminuer de 1, alpha, B{q}alpha',B«c» ->nouveau L.K,x',y,x,alpha.B,q,alpha',B,«c» ->{LK{x'y}x},x,a,alpha.B,q,alpha',B,«c»

```
\def\XINT_div_II_k #1#2#3#4#5%
{%
    \expandafter\XINT_div_II_l \the\numexpr #4-\xint_c_i\xint:{#3}#1{#2}#5\xint:%
}%
\def\XINT_div_II_l #1\xint:#2#3#4#51#6!%
{%
    \XINT_div_II_m {{#1}{#2}{{#3}{#4}}{#5}}{#5}{#6}1#6!%
}%
```

{LK{x'y}x},x,a,alpha.B{q}alpha'B -> a, x, alpha, B, q, L, K, {x'y}, x, alpha', B«c»

```
\def\XINT_div_II_m #1#2#3#4\xint:#5#6%
{%
     \XINT_div_I_a {#3}{#2}{#4}{#5}{#6}#1%
```

```
}%
```

This multiplication is exactly like \XINT_smallmul -- apart from not inserting an ending 1;! --, but keeps ever a vanishing ending carry.

```
\def\XINT_div_minimulwc_a 1#1\xint:#2\xint:#3!#4#5#6#7#8\xint:%
{%
    \expandafter\XINT_div_minimulwc_b
    \the\numexpr \xint_c_x^ix+#1+#3*#8\xint:#3*#4#5#6#7+#2*#8\xint:#2*#4#5#6#7\xint:%
}%
\def\XINT_div_minimulwc_b 1#1#2#3#4#5#6\xint:#7\xint:%
{%
    \expandafter\XINT_div_minimulwc_c
    \the\numexpr \xint_c_x^ix+#1#2#3#4#5+#7\xint:#6\xint:%
}%
\def\XINT_div_minimulwc_c 1#1#2#3#4#5#6\xint:#7\xint:#8\xint:%
{%
    1#6#7\expandafter!%
    \the\numexpr\expandafter\XINT_div_smallmul_a
    \the\numexpr \xint_c_x^viii+#1#2#3#4#5+#8\xint:%
}%
\def\XINT_div_smallmul_a #1\xint:#2\xint:#3!1#4!%
{%
    \xint_gob_til_sc #4\XINT_div_smallmul_e;%
    \XINT_div_minimulwc_a #1\xint:#2\xint:#3!#4\xint:#2\xint:#3!%
}%
\def\XINT_div_smallmul_e;\XINT_div_minimulwc_a 1#1\xint:#2;#3!{1\relax #1!}%
```

Special very small multiplication for division. We only need to cater for multiplicands from 1 to 9. The ending is different from standard verysmallmul, a zero carry is not suppressed. And no final 1;! is added. If multiplicand is just 1 let's not forget to add the zero carry 100000000! at the end.

```
\def\XINT_div_verysmallmul #1%
   {\xint_gob_til_one #1\XINT_div_verysmallisone 1\XINT_div_verysmallmul_a 0\xint:#1}%
\def\XINT_div_verysmallisone 1\XINT_div_verysmallmul_a 0\xint:1!1#11;!%
   {1\relax #1100000000!}%
\def\XINT_div_verysmallmul_a #1\xint:#2!1#3!%
{%
    \xint_gob_til_sc #3\XINT_div_verysmallmul_e;%
    \expandafter\XINT_div_verysmallmul_b
    \the\numexpr \xint_c_x^ix+#2*#3+#1\xint:#2!%
}%
\def\XINT_div_verysmallmul_b 1#1#2\xint:%
    {1#2\expandafter!\the\numexpr\XINT_div_verysmallmul_a #1\xint:}%
\def\XINT_div_verysmallmul_e;#1;+#2#3!{1\relax 0000000#2!}%
```

Special subtraction for division purposes. If the subtracted thing turns out to be bigger, then just return a -. If not, then we must reverse the result, keeping the separators.

```
\def\XINT_div_sub #1#2%
{%
    \expandafter\XINT_div_sub_clean
    \the\numexpr\expandafter\XINT_div_sub_a\expandafter
    1#2;!;!;!;!;!\W #1;!;!;!;!;!\W
}%
\def\XINT_div_sub_clean #1-#2#3\W
```

```
{%
    \if1#2\expandafter\XINT_rev_nounsep\else\expandafter\XINT_div_sub_neg\fi
    {}#1\R!\R!\R!\R!\R!\R!\R!\R!\W
}%
\def\XINT_div_sub_neg #1\W { -}%
\def\XINT_div_sub_a #1!#2!#3!#4!#5\W #6!#7!#8!#9!%
{%
    \XINT_div_sub_b #1!#6!#2!#7!#3!#8!#4!#9!#5\W
}%
\def\XINT_div_sub_b #1#2#3!#4!%
{%
    \xint_gob_til_sc #4\XINT_div_sub_bi ;%
    \expandafter\XINT_div_sub_c\the\numexpr#1-#3+1#4-\xint_c_i\xint:%
}%
\def\XINT_div_sub_c 1#1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_div_sub_d #1%
}%
\def\XINT_div_sub_d #1#2#3!#4!%
{%
    \xint_gob_til_sc #4\XINT_div_sub_di ;%
    \expandafter\XINT_div_sub_e\the\numexpr#1-#3+1#4-\xint_c_i\xint:%
}%
\def\XINT_div_sub_e 1#1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_div_sub_f #1%
}%
\def\XINT_div_sub_f #1#2#3!#4!%
{%
    \xint_gob_til_sc #4\XINT_div_sub_fi ;%
    \expandafter\XINT_div_sub_g\the\numexpr#1-#3+1#4-\xint_c_i\xint:%
}%
\def\XINT_div_sub_g 1#1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_div_sub_h #1%
}%
\def\XINT_div_sub_h #1#2#3!#4!%
{%
    \xint_gob_til_sc #4\XINT_div_sub_hi ;%
    \expandafter\XINT_div_sub_i\the\numexpr#1-#3+1#4-\xint_c_i\xint:%
}%
\def\XINT_div_sub_i 1#1#2\xint:%
{%
    1#2\expandafter!\the\numexpr\XINT_div_sub_a #1%
}%
\def\XINT_div_sub_bi;%
    \expandafter\XINT_div_sub_c\the\numexpr#1-#2+#3\xint:#4!#5!#6!#7!#8!#9!;!\W
{%
    \XINT_div_sub_l #1#2!#5!#7!#9!%
}%
\def\XINT_div_sub_di;%
    \expandafter\XINT_div_sub_e\the\numexpr#1-#2+#3\xint:#4!#5!#6!#7!#8\W
```

```
{%
    \XINT_div_sub_l #1#2!#5!#7!%
}%
\def\XINT_div_sub_fi;%
    \expandafter\XINT_div_sub_g\the\numexpr#1-#2+#3\xint:#4!#5!#6\W
{%
    \XINT_div_sub_l #1#2!#5!%
}%
\def\XINT_div_sub_hi;%
    \expandafter\XINT_div_sub_i\the\numexpr#1-#2+#3\xint:#4\W
{%
    \XINT_div_sub_l #1#2!%
}%
\def\XINT_div_sub_l #1%
{%
   \xint_UDzerofork
      #1{-2\relax}%
       0\XINT_div_sub_r
   \krof
}%
\def\XINT_div_sub_r #1!%
{%
    -\ifnum 0#1=\xint_c_ 1\else2\fi\relax
}%
```

Ici B<10^8 (et est >2). On exécute \expandafter\XINT_sdiv_out\the\numexpr\XINT_smalldivx_a x.1B!1<8d>!...1<8d>!1;! avec x =round(B/2), 1B=10^8+B, et A déjà en blocs 1<8d>! (non renversés). Le \the\numexpr\XINT_smalldivx_a va produire Q\Z R\W avec un R<10^8, et un Q sous forme de blocs 1<8d>! terminé par 1! et nécessitant le nettoyage du premier bloc. Dans cette branche le B n'a pas été multiplié par une puissance de 10, il peut avoir moins de huit chiffres.

```
\def\XINT_sdiv_out #1;!#2!%
    {\expandafter
     {\romannumeral0\XINT_unsep_cuzsmall
      #1\xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax}%
     {#2}}%
```

La toute première étape fait la première division pour être sûr par la suite d'avoir un premier bloc pour A qui sera < B.

```
\def\XINT_smalldivx_a #1\xint:1#2!1#3!%
{%
    \expandafter\XINT_smalldivx_b
    \the\numexpr (#3+#1)/#2-\xint_c_i!#1\xint:#2!#3!%
}%
\def\XINT_smalldivx_b #1#2!%
{%
    \if0#1\else
          \xint_c_x^viii+#1#2\xint_afterfi{\expandafter!\the\numexpr}\fi
    \XINT_smalldiv_c #1#2!%
}%
\def\XINT_smalldiv_c #1!#2\xint:#3!#4!%
{%
    \expandafter\XINT_smalldiv_d\the\numexpr #4-#1*#3!#2\xint:#3!%
}%
```

On va boucler ici: #1 est un reste, #2 est x.B (avec B sans le 1 mais sur huit chiffres). #3#4 est le premier bloc qui reste de A. Si on a terminé avec A, alors #1 est le reste final. Le quotient lui est terminé par un 1! ce 1! disparaîtra dans le nettoyage par \XINT_unsep_cuzsmall.

```
\def\XINT_smalldiv_d #1!#2!1#3#4!%
{%
    \xint_gob_til_sc #3\XINT_smalldiv_end ;%
    \XINT_smalldiv_e #1!#2!1#3#4!%
}%
\def\XINT_smalldiv_end;\XINT_smalldiv_e #1!#2!1;!{1!;!#1!}%
```

Il est crucial que le reste #1 est < #3. J'ai documenté cette routine dans le fichier où j'ai préparé 1.2, il faudra transférer ici. Il n'est pas nécessaire pour cette routine que le diviseur B ait au moins 8 chiffres. Mais il doit être < 10^8.

```
\def\XINT_smalldiv_e #1!#2\xint:#3!%
{%
    \expandafter\XINT_smalldiv_f\the\numexpr
    \xint_c_xi_e_viii_mone+#1*\xint_c_x^viii/#3!#2\xint:#3!#1!%
}%
\def\XINT_smalldiv_f 1#1#2#3#4#5#6!#7\xint:#8!%
{%
     \xint_gob_til_zero #1\XINT_smalldiv_fz 0%
     \expandafter\XINT_smalldiv_g
     \the\numexpr\XINT_minimul_a #2#3#4#5\xint:#6!#8!#2#3#4#5#6!#7\xint:#8!%
}%
\def\XINT_smalldiv_fz 0%
    \expandafter\XINT_smalldiv_g\the\numexpr\XINT_minimul_a
    9999\xint:9999!#1!99999999!#2!0!1#3!%
{%
    \XINT_smalldiv_i \xint:#3!\xint_c_!#2!%
}%
\def\XINT_smalldiv_g 1#1!1#2!#3!#4!#5!#6!%
{%
    \expandafter\XINT_smalldiv_h\the\numexpr 1#6-#1\xint:#2!#5!#3!#4!%
}%
\def\XINT_smalldiv_h 1#1#2\xint:#3!#4!%
{%
    \expandafter\XINT_smalldiv_i\the\numexpr #4-#3+#1-\xint_c_i\xint:#2!%
}%
\def\XINT_smalldiv_i #1\xint:#2!#3!#4\xint:#5!%
{%
    \expandafter\XINT_smalldiv_j\the\numexpr (#1#2+#4)/#5-\xint_c_i!#3!#1#2!#4\xint:#5!%
}%
\def\XINT_smalldiv_j #1!#2!%
{%
    \xint_c_x^viii+#1+#2\expandafter!\the\numexpr\XINT_smalldiv_k
    #1!%
}%
```

On boucle vers \XINT_smalldiv_d.

```
\def\XINT_smalldiv_k #1!#2!#3\xint:#4!%
{%
    \expandafter\XINT_smalldiv_d\the\numexpr #2-#1*#4!#3\xint:#4!%
}%
```

Cette routine fait la division euclidienne d'un nombre de seize chiffres par #1 = C = diviseur sur huit chiffres >= 10^7, avec #2 = sa moitié utilisée dans \numexpr pour contrebalancer l'arrondi (ARRRRRRGGGGGHHHH) fait par /. Le nombre divisé XY = X*10^8+Y se présente sous la forme 1<8chiffres>!1<8chiffres>! avec plus significatif en premier.

Seul le quotient est calculé, pas le reste. En effet la routine de division principale va utiliser ce quotient pour déterminer le "grand" reste, et le petit reste ici ne nous serait d'à peu près aucune utilité.

ATTENTION UNIQUEMENT UTILISÉ POUR DES SITUATIONS OÙ IL EST GARANTI QUE X < C ! (et C au moins 10^7) le quotient euclidien de X*10^8+Y par C sera donc < 10^8. Il sera renvoyé sous la forme 1<8chiffres>.

```
\def\XINT_div_mini #1\xint:#2!1#3!%
{%
    \expandafter\XINT_div_mini_a\the\numexpr
    \xint_c_xi_e_viii_mone+#3*\xint_c_x^viii/#1!#1\xint:#2!#3!%
}%
```

Note (2015/10/08). Attention à la différence dans l'ordre des arguments avec ce que je vois en dans \XINT_smalldiv_f. Je ne me souviens plus du tout s'il y a une raison quelconque.

```
\def\XINT_div_mini_a 1#1#2#3#4#5#6!#7\xint:#8!%
{%
     \xint_gob_til_zero #1\XINT_div_mini_w 0%
     \expandafter\XINT_div_mini_b
     \the\numexpr\XINT_minimul_a #2#3#4#5\xint:#6!#7!#2#3#4#5#6!#7\xint:#8!%
}%
\def\XINT_div_mini_w 0%
    \expandafter\XINT_div_mini_b\the\numexpr\XINT_minimul_a
    9999\xint:9999!#1!99999999!#2\xint:#3!00000000!#4!%
{%
    \xint_c_x^viii_mone+(#4+#3)/#2!%
}%
\def\XINT_div_mini_b 1#1!1#2!#3!#4!#5!#6!%
{%
    \expandafter\XINT_div_mini_c
    \the\numexpr 1#6-#1\xint:#2!#5!#3!#4!%
}%
\def\XINT_div_mini_c 1#1#2\xint:#3!#4!%
{%
    \expandafter\XINT_div_mini_d
    \the\numexpr #4-#3+#1-\xint_c_i\xint:#2!%
}%
\def\XINT_div_mini_d #1\xint:#2!#3!#4\xint:#5!%
{%
    \xint_c_x^viii_mone+#3+(#1#2+#5)/#4!%
}%
```

Derived arithmetic

5.38 \xintiiQuo, \xintiiRem

```
\def\xintiiQuo {\romannumeral0\xintiiquo }%
\def\xintiiRem {\romannumeral0\xintiirem }%
\def\xintiiquo
   {\expandafter\xint_stop_atfirstoftwo\romannumeral0\xintiidivision }%
```

```
\def\xintiirem
   {\expandafter\xint_stop_atsecondoftwo\romannumeral0\xintiidivision }%
```

5.39 \xintiiDivRound

1.1, transferred from first release of bnumexpr. Rewritten for 1.2. Ending rewritten for 1.2i. (new \xintDSRr).

1.2l: \xintiiDivRound made robust against non terminated input.

```
\def\xintiiDivRound   {\romannumeral0\xintiidivround }%
\def\xintiidivround #1{\expandafter\XINT_iidivround\romannumeral`&&@#1\xint:}%
\def\XINT_iidivround #1#2\xint:#3%
    {\expandafter\XINT_iidivround_a\expandafter #1\romannumeral`&&@#3\xint:#2\xint:}%
\def\XINT_iidivround_a #1#2% #1 de A, #2 de B.
{%
    \if0#2\xint_dothis{\XINT_iidivround_divbyzero#1#2}\fi
    \if0#1\xint_dothis\XINT_iidivround_aiszero\fi
    \if-#2\xint_dothis{\XINT_iidivround_bneg #1}\fi
          \xint_orthat{\XINT_iidivround_bpos #1#2}%
}%
\def\XINT_iidivround_divbyzero #1#2#3\xint:#4\xint:
   {\XINT_signalcondition{DivisionByZero}{Division by zero: #1#4/#2#3.}{}{ 0}}%
\def\XINT_iidivround_aiszero   #1\xint:#2\xint:{ 0}%
\def\XINT_iidivround_bpos #1%
{%
    \xint_UDsignfork
            #1{\xintiiopp\XINT_iidivround_pos {}}%
             -{\XINT_iidivround_pos #1}%
    \krof
}%
\def\XINT_iidivround_bneg #1%
{%
    \xint_UDsignfork
            #1{\XINT_iidivround_pos {}}%
             -{\xintiiopp\XINT_iidivround_pos #1}%
    \krof
}%
\def\XINT_iidivround_pos #1#2\xint:#3\xint:
{%
    \expandafter\expandafter\expandafter\XINT_dsrr
    \expandafter\xint_firstoftwo
    \romannumeral0\XINT_div_prepare {#2}{#1#30}%
    \xint_bye\xint_Bye3456789\xint_bye/\xint_c_x\relax
}%
```

5.40 \xintiiDivTrunc

1.2l: \xintiiDivTrunc made robust against non terminated input.

```
\def\xintiiDivTrunc   {\romannumeral0\xintiidivtrunc }%
\def\xintiidivtrunc #1{\expandafter\XINT_iidivtrunc\romannumeral`&&@#1\xint:}%
\def\XINT_iidivtrunc #1#2\xint:#3{\expandafter\XINT_iidivtrunc_a\expandafter #1%
                                 \romannumeral`&&@#3\xint:#2\xint:}%
\def\XINT_iidivtrunc_a #1#2% #1 de A, #2 de B.
```

```
{%
    \if0#2\xint_dothis{\XINT_iidivtrunc_divbyzero#1#2}\fi
    \if0#1\xint_dothis\XINT_iidivtrunc_aiszero\fi
    \if-#2\xint_dothis{\XINT_iidivtrunc_bneg #1}\fi
          \xint_orthat{\XINT_iidivtrunc_bpos #1#2}%
}%
```

Attention to not move DivRound code beyond that point.

```
\let\XINT_iidivtrunc_divbyzero\XINT_iidivround_divbyzero
\let\XINT_iidivtrunc_aiszero  \XINT_iidivround_aiszero
\def\XINT_iidivtrunc_bpos #1%
{%
    \xint_UDsignfork
            #1{\xintiiopp\XINT_iidivtrunc_pos {}}%
             -{\XINT_iidivtrunc_pos #1}%
    \krof
}%
\def\XINT_iidivtrunc_bneg #1%
{%
    \xint_UDsignfork
            #1{\XINT_iidivtrunc_pos {}}%
             -{\xintiiopp\XINT_iidivtrunc_pos #1}%
    \krof
}%
\def\XINT_iidivtrunc_pos #1#2\xint:#3\xint:
    {\expandafter\xint_stop_atfirstoftwo
     \romannumeral0\XINT_div_prepare {#2}{#1#3}}%
```

5.41 \xintiiModTrunc

Renamed from \xintiiMod to \xintiiModTrunc at 1.2p.

```
\def\xintiiModTrunc {\romannumeral0\xintiimodtrunc }%
\def\xintiimodtrunc #1{\expandafter\XINT_iimodtrunc\romannumeral`&&@#1\xint:}%
\def\XINT_iimodtrunc #1#2\xint:#3{\expandafter\XINT_iimodtrunc_a\expandafter #1%
                               \romannumeral`&&@#3\xint:#2\xint:}%
\def\XINT_iimodtrunc_a #1#2% #1 de A, #2 de B.
{%
    \if0#2\xint_dothis{\XINT_iimodtrunc_divbyzero#1#2}\fi
    \if0#1\xint_dothis\XINT_iimodtrunc_aiszero\fi
    \if-#2\xint_dothis{\XINT_iimodtrunc_bneg #1}\fi
          \xint_orthat{\XINT_iimodtrunc_bpos #1#2}%
}%
```

Attention to not move DivRound code beyond that point. A bit of abuse here for divbyzero defaulted-to value, which happily works in both.

```
\let\XINT_iimodtrunc_divbyzero\XINT_iidivround_divbyzero
\let\XINT_iimodtrunc_aiszero  \XINT_iidivround_aiszero
\def\XINT_iimodtrunc_bpos #1%
{%
    \xint_UDsignfork
            #1{\xintiiopp\XINT_iimodtrunc_pos {}}%
             -{\XINT_iimodtrunc_pos #1}%
    \krof
}%
```

```
\def\XINT_iimodtrunc_bneg #1%
{%
    \xint_UDsignfork
            #1{\xintiiopp\XINT_iimodtrunc_pos {}}%
             -{\XINT_iimodtrunc_pos #1}%
    \krof
}%
\def\XINT_iimodtrunc_pos #1#2\xint:#3\xint:
    {\expandafter\xint_stop_atsecondoftwo\romannumeral0\XINT_div_prepare
      {#2}{#1#3}}%
```

5.42 \xintiiDivMod

Modified at 1.2p (2017/12/05). It is associated with floored division (like Python divmod function), and with the // operator in \xintiiexpr.

```
\def\xintiiDivMod   {\romannumeral0\xintiidivmod }%
\def\xintiidivmod #1{\expandafter\XINT_iidivmod\romannumeral`&&@#1\xint:}%
\def\XINT_iidivmod #1#2\xint:#3{\expandafter\XINT_iidivmod_a\expandafter #1%
                             \romannumeral`&&@#3\xint:#2\xint:}%
\def\XINT_iidivmod_a #1#2% #1 de A, #2 de B.
{%
    \if0#2\xint_dothis{\XINT_iidivmod_divbyzero#1#2}\fi
    \if0#1\xint_dothis\XINT_iidivmod_aiszero\fi
    \if-#2\xint_dothis{\XINT_iidivmod_bneg #1}\fi
          \xint_orthat{\XINT_iidivmod_bpos #1#2}%
}%
\def\XINT_iidivmod_divbyzero #1#2\xint:#3\xint:
{%
    \XINT_signalcondition{DivisionByZero}{Division by zero: #1#3/#2.}{}%
    {{0}{0}}% à revoir...
}%
\def\XINT_iidivmod_aiszero #1\xint:#2\xint:{{0}{0}}%
\def\XINT_iidivmod_bneg #1%
{%
    \expandafter\XINT_iidivmod_bneg_finish
    \romannumeral0\xint_UDsignfork
            #1{\XINT_iidivmod_bpos {}}%
             -{\XINT_iidivmod_bpos {-#1}}%
    \krof
}%
\def\XINT_iidivmod_bneg_finish#1#2%
{%
    \expandafter\xint_exchangetwo_keepbraces\expandafter
    {\romannumeral0\xintiiopp#2}{#1}%
}%
\def\XINT_iidivmod_bpos #1#2\xint:#3\xint:{\xintiidivision{#1#3}{#2}}%
```

5.43 \xintiiDivFloor

1.2p. For bnumexpr actually, because \xintiiexpr could use \xintDivFloor which also outputs an integer in strict format.

```
\def\xintiiDivFloor {\romannumeral0\xintiidivfloor}%
```

```
\def\xintiidivfloor {\expandafter\xint_stop_atfirstoftwo
                \romannumeral0\xintiidivmod}%
```

5.44 \xintiiMod

Associated with floored division at 1.2p. Formerly was associated with truncated division.

```
\def\xintiiMod {\romannumeral0\xintiimod}%
\def\xintiimod {\expandafter\xint_stop_atsecondoftwo
                \romannumeral0\xintiidivmod}%
```

5.45 \xintiiSqr

1.2l: \xintiiSqr made robust against non terminated input.

```
\def\xintiiSqr {\romannumeral0\xintiisqr }%
\def\xintiisqr #1%
{%
    \expandafter\XINT_sqr\romannumeral0\xintiiabs{#1}\xint:
}%
\def\XINT_sqr #1\xint:
{%
    \expandafter\XINT_sqr_a
      \romannumeral0\expandafter\XINT_sepandrev_andcount
      \romannumeral0\XINT_zeroes_forviii #1\R\R\R\R\R\R\R\R{10}0000001\W
      #1\XINT_rsepbyviii_end_A 2345678%
        \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
              \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
              \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
      \xint:
}%
```

1.2c \XINT_mul_loop can now be called directly even with small arguments, thus the following check is not anymore a necessity.

```
\def\XINT_sqr_a #1\xint:
{%
    \ifnum #1=\xint_c_i \expandafter\XINT_sqr_small
                  \else\expandafter\XINT_sqr_start\fi
}%
\def\XINT_sqr_small 1#1#2#3#4#5!\xint:
{%
    \ifnum #1#2#3#4#5<46341 \expandafter\XINT_sqr_verysmall\fi
    \expandafter\XINT_sqr_small_out
    \the\numexpr\XINT_minimul_a #1#2#3#4\xint:#5!#1#2#3#4#5!%
}%
\def\XINT_sqr_verysmall#1{%
\def\XINT_sqr_verysmall
    \expandafter\XINT_sqr_small_out\the\numexpr\XINT_minimul_a ##1!##2!%
    {\expandafter#1\the\numexpr ##2*##2\relax}%
}\XINT_sqr_verysmall{ }%
\def\XINT_sqr_small_out 1#1!1#2!%
{%
    \XINT_cuz #2#1\R
}%
```

An ending 1;! is produced on output for \XINT_mul_loop and gets incorporated to the delimiter needed by the \XINT_unrevbyviii done by \XINT_mul_out.

```
\def\XINT_sqr_start #1\xint:
{%
    \expandafter\XINT_mul_out
    \the\numexpr\XINT_mul_loop
                100000000!1;!\W #11;!\W #11;!%
    1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
}%
```

5.46 \xintiiPow

The exponent is not limited but with current default settings of tex memory, with xint 1.2, the maximal exponent for 2^N is N = 2^17 = 131072.

1.2f Modifies the initial steps: 1) in order to be able to let more easily \xintiPow use \xintNum on the exponent once xintfrac.sty is loaded; 2) also because I noticed it was not very well coded. And it did only a \numexpr on the exponent, contradicting the documentation related to the "i" convention in names.

1.2l: \xintiiPow made robust against non terminated input.

```
\def\xintiiPow {\romannumeral0\xintiipow }%
\def\xintiipow #1#2%
{%
    \expandafter\xint_pow\the\numexpr #2\expandafter
    .\romannumeral`&&@#1\xint:
}%
\def\xint_pow #1.#2%#3\xint:
{%
    \xint_UDzerominusfork
      #2-\XINT_pow_AisZero
      0#2\XINT_pow_Aneg
      0-{\XINT_pow_Apos #2}%
    \krof {#1}%
}%
\def\XINT_pow_AisZero #1#2\xint:
{%
     \ifcase\XINT_cntSgn #1\xint:
         \xint_afterfi { 1}%
     \or
         \xint_afterfi { 0}%
     \else
         \xint_afterfi
        {\XINT_signalcondition{DivisionByZero}{0 raised to power #1.}{}{ 0}}%
     \fi
}%
\def\XINT_pow_Aneg #1%
{%
   \ifodd #1
       \expandafter\XINT_opp\romannumeral0%
   \fi
   \XINT_pow_Apos {}{#1}%
}%
\def\XINT_pow_Apos #1#2{\XINT_pow_Apos_a {#2}#1}%
```

```
\def\XINT_pow_Apos_a #1#2#3%
{%
    \xint_gob_til_xint: #3\XINT_pow_Apos_short\xint:
    \XINT_pow_AatleastTwo {#1}#2#3%
}%
\def\XINT_pow_Apos_short\xint:\XINT_pow_AatleastTwo #1#2\xint:
{%
    \ifcase #2
         \xintError:thiscannothappen
    \or  \expandafter\XINT_pow_AisOne
    \else\expandafter\XINT_pow_AatleastTwo
    \fi {#1}#2\xint:
}%
\def\XINT_pow_AisOne #1\xint:{ 1}%
\def\XINT_pow_AatleastTwo #1%
{%
    \ifcase\XINT_cntSgn #1\xint:
        \expandafter\XINT_pow_BisZero
    \or
        \expandafter\XINT_pow_I_in
    \else
        \expandafter\XINT_pow_BisNegative
    \fi
    {#1}%
}%
\def\XINT_pow_BisNegative #1\xint:{\XINT_signalcondition{Underflow}%
    {Inverse power is not an integer.}{}{ 0}}%
\def\XINT_pow_BisZero #1\xint:{ 1}%
```

B = #1 > 0, A = #2 > 1. Earlier code checked if size of B did not exceed a given limit (for example 131000).

```
\def\XINT_pow_I_in #1#2\xint:
{%
    \expandafter\XINT_pow_I_loop
    \the\numexpr #1\expandafter\xint:%
    \romannumeral0\expandafter\XINT_sepandrev
    \romannumeral0\XINT_zeroes_forviii #2\R\R\R\R\R\R\R\R{10}0000001\W
    #2\XINT_rsepbyviii_end_A 2345678%
      \XINT_rsepbyviii_end_B 2345678\relax XX%
    \R\xint:\R\xint:\R\xint:\R\xint:\R\xint:\R\xint:\R\xint:\R\xint:\W
    1;!\W
    1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
}%
\def\XINT_pow_I_loop #1\xint:%
{%
    \ifnum #1 = \xint_c_i\expandafter\XINT_pow_I_exit\fi
    \ifodd #1
       \expandafter\XINT_pow_II_in
    \else
       \expandafter\XINT_pow_I_squareit
    \fi #1\xint:%
}%
\def\XINT_pow_I_exit \ifodd #1\fi #2\xint:#3\W {\XINT_mul_out #3}%
```

The 1.2c \XINT_mul_loop can be called directly even with small arguments, hence the "butcheckifsmall" is not a necessity as it was earlier with 1.2. On 2^30, it does bring roughly a 40% time gain though, and 30% gain for 2^60. The overhead on big computations should be negligible.

```
\def\XINT_pow_I_squareit #1\xint:#2\W%
{%
    \expandafter\XINT_pow_I_loop
    \the\numexpr #1/\xint_c_ii\expandafter\xint:%
    \the\numexpr\XINT_pow_mulbutcheckifsmall #2\W #2\W
}%
\def\XINT_pow_mulbutcheckifsmall #1!1#2%
{%
    \xint_gob_til_sc #2\XINT_pow_mul_small;%
    \XINT_mul_loop 100000000!1;!\W #1!1#2%
}%
\def\XINT_pow_mul_small;\XINT_mul_loop
    100000000!1;!\W 1#1!1;!\W
{%
    \XINT_smallmul 1#1!%
}%
\def\XINT_pow_II_in #1\xint:#2\W
{%
    \expandafter\XINT_pow_II_loop
    \the\numexpr #1/\xint_c_ii-\xint_c_i\expandafter\xint:%
    \the\numexpr\XINT_pow_mulbutcheckifsmall #2\W #2\W #2\W
}%
\def\XINT_pow_II_loop #1\xint:%
{%
    \ifnum #1 = \xint_c_i\expandafter\XINT_pow_II_exit\fi
    \ifodd #1
       \expandafter\XINT_pow_II_odda
    \else
       \expandafter\XINT_pow_II_even
    \fi #1\xint:%
}%
\def\XINT_pow_II_exit\ifodd #1\fi #2\xint:#3\W #4\W
{%
    \expandafter\XINT_mul_out
    \the\numexpr\XINT_pow_mulbutcheckifsmall #4\W #3%
}%
\def\XINT_pow_II_even #1\xint:#2\W
{%
    \expandafter\XINT_pow_II_loop
    \the\numexpr #1/\xint_c_ii\expandafter\xint:%
    \the\numexpr\XINT_pow_mulbutcheckifsmall #2\W #2\W
}%
\def\XINT_pow_II_odda #1\xint:#2\W #3\W
{%
    \expandafter\XINT_pow_II_oddb
    \the\numexpr #1/\xint_c_ii-\xint_c_i\expandafter\xint:%
    \the\numexpr\XINT_pow_mulbutcheckifsmall #3\W #2\W #2\W
}%
\def\XINT_pow_II_oddb #1\xint:#2\W #3\W
```

```
{%
    \expandafter\XINT_pow_II_loop
    \the\numexpr #1\expandafter\xint:%
    \the\numexpr\XINT_pow_mulbutcheckifsmall #3\W #3\W #2\W
}%
```

5.47 \xintiiFac

Moved here from xint.sty with release 1.2 (to be usable by \bnumexpr).

Partially rewritten with release 1.2 to benefit from the inner format of the 1.2 multiplication.

With current default settings of the etex memory and a.t.t.o.w (11/2015) the maximal possible computation is 5971! (which has 19956 digits).

Note (end november 2015): I also tried out a quickly written recursive (binary split) implementation

```
\catcode`_ 11
\catcode`^ 11
\long\def\xint_firstofthree  #1#2#3{#1}%
\long\def\xint_secondofthree #1#2#3{#2}%
\long\def\xint_thirdofthree  #1#2#3{#3}%
% quickly written factorial using binary split recursive method
\def\tFac   {\romannumeral-`0\tfac }%
\def\tfac #1{\expandafter\XINT_mul_out
             \romannumeral-`0\ufac {1}{#1}1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W}%
\def\ufac #1#2{\ifcase\numexpr#2-#1\relax
                 \expandafter\xint_firstofthree
               \or
                 \expandafter\xint_secondofthree
               \else
                 \expandafter\xint_thirdofthree
               \fi
               {\the\numexpr\xint_c_x^viii+#1!1;!}%
               {\the\numexpr\xint_c_x^viii+#1*#2!1;!}%
               {\expandafter\vfac\the\numexpr (#1+#2)/\xint_c_ii.#1.#2.}%
}%
\def\vfac #1.#2.#3.%
{%
    \expandafter
    \wfac\expandafter
        {\romannumeral-`0\expandafter
         \ufac\expandafter{\the\numexpr #1+\xint_c_i}{#3}}%
        {\ufac {#2}{#1}}%
}%
\def\wfac #1#2{\expandafter\zfac\romannumeral-`0#2\W #1}%
\def\zfac {\the\numexpr\XINT_mul_loop 100000000!1;!\W }% core multiplication...
\catcode`_ 8
\catcode`^ 7
```

and I was quite surprised that it was only about 1.6x--2x slower in the range N=200 to 2000 than the \xintiiFac here which attempts to be smarter...

Note (2017, 1.21): I found out some code comment of mine that the code here should be more in the style of \xintiiBinomial, but I left matters untouched.

```
\def\xintiiFac {\romannumeral0\xintiifac }%
\def\xintiifac #1{\expandafter\XINT_fac_fork\the\numexpr#1.}%
```

```
\def\XINT_fac_fork #1#2.%
{%
    \xint_UDzerominusfork
     #1-\XINT_fac_zero
     0#1\XINT_fac_neg
      0-\XINT_fac_checksize
    \krof #1#2.%
}%
\def\XINT_fac_zero #1.{ 1}%
\def\XINT_fac_neg  #1.{\XINT_signalcondition{InvalidOperation}{Factorial of
    negative argument: #1.}{}{ 0}}%
\def\XINT_fac_checksize #1.%
{%
    \ifnum #1>\xint_c_x^iv \xint_dothis{\XINT_fac_toobig #1.}\fi
    \ifnum #1>465 \xint_dothis{\XINT_fac_bigloop_a   #1.}\fi
    \ifnum #1>101 \xint_dothis{\XINT_fac_medloop_a   #1.\XINT_mul_out}\fi
                  \xint_orthat{\XINT_fac_smallloop_a #1.\XINT_mul_out}%
    1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
}%
\def\XINT_fac_toobig
#1.#2\W{\XINT_signalcondition{InvalidOperation}{Factorial
    argument is too large: #1 > 10^4.}{}{ 0}}%
\def\XINT_fac_bigloop_a #1.%
{%
    \expandafter\XINT_fac_bigloop_b \the\numexpr
    #1+\xint_c_i-\xint_c_ii*((#1-464)/\xint_c_ii).#1.%
}%
\def\XINT_fac_bigloop_b #1.#2.%
{%
    \expandafter\XINT_fac_medloop_a
        \the\numexpr #1-\xint_c_i.{\XINT_fac_bigloop_loop #1.#2.}%
}%
\def\XINT_fac_bigloop_loop #1.#2.%
{%
    \ifnum #1>#2 \expandafter\XINT_fac_bigloop_exit\fi
    \expandafter\XINT_fac_bigloop_loop
    \the\numexpr #1+\xint_c_ii\expandafter.%
    \the\numexpr #2\expandafter.\the\numexpr\XINT_fac_bigloop_mul #1!%
}%
\def\XINT_fac_bigloop_exit #1!{\XINT_mul_out}%
\def\XINT_fac_bigloop_mul #1!%
{%
    \expandafter\XINT_smallmul
        \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)!%
}%
\def\XINT_fac_medloop_a #1.%
{%
    \expandafter\XINT_fac_medloop_b
        \the\numexpr #1+\xint_c_i-\xint_c_iii*((#1-100)/\xint_c_iii).#1.%
}%
\def\XINT_fac_medloop_b #1.#2.%
{%
```

```
    \expandafter\XINT_fac_smallloop_a
        \the\numexpr #1-\xint_c_i.{\XINT_fac_medloop_loop #1.#2.}%
}%
\def\XINT_fac_medloop_loop #1.#2.%
{%
    \ifnum #1>#2 \expandafter\XINT_fac_loop_exit\fi
    \expandafter\XINT_fac_medloop_loop
    \the\numexpr #1+\xint_c_iii\expandafter.%
    \the\numexpr #2\expandafter.\the\numexpr\XINT_fac_medloop_mul #1!%
}%
\def\XINT_fac_medloop_mul #1!%
{%
    \expandafter\XINT_smallmul
    \the\numexpr
        \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_fac_smallloop_a #1.%
{%
    \csname
      XINT_fac_smallloop_\the\numexpr #1-\xint_c_iv*(#1/\xint_c_iv)\relax
    \endcsname #1.%
}%
\expandafter\def\csname XINT_fac_smallloop_1\endcsname #1.%
{%
    \XINT_fac_smallloop_loop 2.#1.100000001!1;!%
}%
\expandafter\def\csname XINT_fac_smallloop_-2\endcsname #1.%
{%
    \XINT_fac_smallloop_loop 3.#1.100000002!1;!%
}%
\expandafter\def\csname XINT_fac_smallloop_-1\endcsname #1.%
{%
    \XINT_fac_smallloop_loop 4.#1.100000006!1;!%
}%
\expandafter\def\csname XINT_fac_smallloop_0\endcsname #1.%
{%
    \XINT_fac_smallloop_loop 5.#1.1000000024!1;!%
}%
\def\XINT_fac_smallloop_loop #1.#2.%
{%
    \ifnum #1>#2 \expandafter\XINT_fac_loop_exit\fi
    \expandafter\XINT_fac_smallloop_loop
    \the\numexpr #1+\xint_c_iv\expandafter.%
    \the\numexpr #2\expandafter.\the\numexpr\XINT_fac_smallloop_mul #1!%
}%
\def\XINT_fac_smallloop_mul #1!%
{%
    \expandafter\XINT_smallmul
    \the\numexpr
        \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_fac_loop_exit #1!#2;!#3{#3#2;!}%
```

5.48 \XINT_useiimessage

1.2o

```
\def\XINT_useiimessage #1% used in LaTeX only
{%
    \XINT_ifFlagRaised {#1}%
    {\@backslashchar#1
     (load xintfrac or use \@backslashchar xintii\xint_gobble_iv#1!)\MessageBreak}%
    {}%
}%
\XINTrestorecatcodesendinput%
```

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With release 1.1 the core arithmetic routines \xintiiAdd, \xintiiSub, \xintiiMul, \xintiiQuo, \xintiiPow were separated to be the main component of the then new xintcore.

1.3b adds randomness related macros.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5     % ^^M
  \endlinechar=13 %
  \catcode123=1    % {
  \catcode125=2    % }
  \catcode64=11    % @
  \catcode44=12    % ,
  \catcode46=12    % .
  \catcode58=12    % :
  \catcode94=7     % ^
  \def\empty{}\def\space{ }\newlinechar10
```

```
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xint.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xintcore.sty\endcsname
  \expandafter\ifx\csname numexpr\endcsname\relax
    \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
      \immediate\write128{^^JPackage xint Warning:^^J%
                          \space\space\space\space
                          \numexpr not available, aborting input.^^J}%
    \else
      \PackageWarningNoLine{xint}{\numexpr not available, aborting input}%
    \fi
    \def\z{\endgroup\endinput}%
  \else
    \ifx\x\relax   % plain-TeX, first loading of xintcore.sty
      \ifx\w\relax % but xintkernel.sty not yet loaded.
         \def\z{\endgroup\input xintcore.sty\relax}%
      \fi
    \else
      \ifx\x\empty % LaTeX, first loading,
      % variable is initialized, but \ProvidesPackage not yet seen
          \ifx\w\relax % xintcore.sty not yet loaded.
            \def\z{\endgroup\RequirePackage{xintcore}}%
          \fi
      \else
        \def\z{\endgroup\endinput}% xint already loaded.
      \fi
    \fi
  \fi
\z%
\XINTsetupcatcodes% defined in xintkernel.sty (loaded by xintcore.sty)
```

6.1 Package identification

```
\XINT_providespackage
\ProvidesPackage{xint}%
  [2022/06/10 v1.4m Expandable operations on big integers (JFB)]%
```

6.2 More token management

```
\long\def\xint_firstofthree  #1#2#3{#1}%
\long\def\xint_secondofthree #1#2#3{#2}%
\long\def\xint_thirdofthree  #1#2#3{#3}%
\long\def\xint_stop_atfirstofthree  #1#2#3{ #1}%
\long\def\xint_stop_atsecondofthree #1#2#3{ #2}%
\long\def\xint_stop_atthirdofthree  #1#2#3{ #3}%
```

6.3 (WIP) A constant needed by \xintRandomDigits et al.

```
\ifdefined\xint_texuniformdeviate
  \unless\ifdefined\xint_c_nine_x^viii
      \csname newcount\endcsname\xint_c_nine_x^viii
      \xint_c_nine_x^viii 900000000
  \fi
```

```
\fi
```

6.4 \xintLen, \xintiLen

\xintLen gets extended to fractions by xintfrac.sty: A/B is given length len(A)+len(B)-1 (somewhat arbitrary). It applies \xintNum to its argument. A minus sign is accepted and ignored.

For parallelism with \xintiNum/\xintNum, 1.2o defines \xintiLen.

\xintLen gets redefined by xintfrac.

```
\def\xintiLen {\romannumeral0\xintilen }%
\def\xintilen #1{\def\xintilen ##1%
{%
    \expandafter#1\the\numexpr
    \expandafter\XINT_len_fork\romannumeral0\xintinum{##1}%
      \xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye\relax
}}\xintilen{ }%
\def\xintLen {\romannumeral0\xintlen }%
\let\xintlen\xintilen
\def\XINT_len_fork #1%
{%
    \expandafter\XINT_length_loop\xint_UDsignfork#1{}-#1\krof
}%
```

6.5 \xintiiLogTen

1.3e. Support for ilog10() function in \xintiiexpr. See \XINTiLogTen in xintfrac.sty which also currently uses -"7FFF8000 as value if input is zero.

```
\def\xintiiLogTen {\the\numexpr\xintiilogten }%
\def\xintiilogten #1%
{%
    \expandafter\XINT_iilogten\romannumeral`&&@#1%
      \xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    \relax
}%
\def\XINT_iilogten #1{\if#10-"7FFF8000\fi -1+%
                      \expandafter\XINT_length_loop\xint_UDsignfork#1{}-#1\krof}%
```

6.6 \xintReverseDigits

1.2.

This puts digits in reverse order, not suppressing leading zeros after reverse. Despite lacking the "ii" in its name, it does not apply \xintNum to its argument (contrarily to \xintLen, this is not very coherent).

1.2l variant is robust against non terminated \the\numexpr input.

This macro is currently not used elsewhere in xint code.

```
\def\xintReverseDigits {\romannumeral0\xintreversedigits }%
\def\xintreversedigits #1%
{%
    \expandafter\XINT_revdigits\romannumeral`&&@#1%
```

```
     {\XINT_microrevsep_end\W}\XINT_microrevsep_end
      \XINT_microrevsep_end\XINT_microrevsep_end
      \XINT_microrevsep_end\XINT_microrevsep_end
      \XINT_microrevsep_end\XINT_microrevsep_end\XINT_microrevsep_end\Z
    1\Z!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
}%
\def\XINT_revdigits #1%
{%
    \xint_UDsignfork
      #1{\expandafter-\romannumeral0\XINT_revdigits_a}%
       -{\XINT_revdigits_a #1}%
    \krof
}%
\def\XINT_revdigits_a
{%
    \expandafter\XINT_revdigits_b\expandafter{\expandafter}%
    \the\numexpr\XINT_microrevsep
}%
\def\XINT_microrevsep #1#2#3#4#5#6#7#8#9%
{%
    1#9#8#7#6#5#4#3#2#1\expandafter!\the\numexpr\XINT_microrevsep
}%
\def\XINT_microrevsep_end #1\W #2\expandafter #3\Z{\relax#2!}%
\def\XINT_revdigits_b #11#2!1#3!1#4!1#5!1#6!1#7!1#8!1#9!%
{%
    \xint_gob_til_R #9\XINT_revdigits_end\R
                      \XINT_revdigits_b {#9#8#7#6#5#4#3#2#1}%
}%
\def\XINT_revdigits_end#1{%
\def\XINT_revdigits_end\R\XINT_revdigits_b ##1##2\W
   {\expandafter#1\xint_gob_til_Z ##1}%
}\XINT_revdigits_end{ }%
\let\xintRev\xintReverseDigits
```

6.7 \xintiiE

Originally was used in \xintiiexpr. Transferred from xintfrac for 1.1. Code rewritten for 1.2i. \xintiiE{x}{e} extends x with e zeroes if e is positive and simply outputs x if e is zero or negative. Attention, le comportement pour e < 0 ne doit pas être modifié car \xintMod et autres macros en dépendent.

```
\def\xintiiE {\romannumeral0\xintiie }%
\def\xintiie #1#2%
   {\expandafter\XINT_iie_fork\the\numexpr #2\expandafter.\romannumeral`&&@#1;}%
\def\XINT_iie_fork #1%
{%
    \xint_UDsignfork
      #1\XINT_iie_neg
       -\XINT_iie_a
    \krof #1%
}%
```

le #2 a le bon pattern terminé par ; #1=0 est OK pour \XINT_rep.

```
\def\XINT_iie_a #1.%
```

```
 {\expandafter\XINT_dsx_append\romannumeral\XINT_rep #1\endcsname 0.}%
\def\XINT_iie_neg #1.#2;{ #2}%
```

6.8 \xintDecSplit

DECIMAL SPLIT

The macro \xintDecSplit {x}{A} cuts A which is composed of digits (leading zeroes ok, but no sign) (*) into two (each possibly empty) pieces L and R. The concatenation LR always reproduces A.

The position of the cut is specified by the first argument x. If x is zero or positive the cut location is x slots to the left of the right end of the number. If x becomes equal to or larger than the length of the number then L becomes empty. If x is negative the location of the cut is |x| slots to the right of the left end of the number.

(*) versions earlier than 1.2i first replaced A with its absolute value. This is not the case anymore. This macro should NOT be used for A with a leading sign (+ or -).

Entirely rewritten for 1.2i (2016/12/11).

Attention: \xintDecSplit not robust against non terminated second argument.

```
\def\xintDecSplit {\romannumeral0\xintdecsplit }%
\def\xintdecsplit #1#2%
{%
    \expandafter\XINT_split_finish
    \romannumeral0\expandafter\XINT_split_xfork
    \the\numexpr #1\expandafter.\romannumeral`&&@#2%
    \xint_bye2345678\xint_bye..%
}%
\def\XINT_split_finish  #1.#2.{{#1}{#2}}%
\def\XINT_split_xfork #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_split_zerosplit
      0#1\XINT_split_fromleft
       0-{\XINT_split_fromright #1}%
    \krof
}%
\def\XINT_split_zerosplit .#1\xint_bye#2\xint_bye..{ #1..}%
\def\XINT_split_fromleft
    {\expandafter\XINT_split_fromleft_a\the\numexpr\xint_c_viii-}%
\def\XINT_split_fromleft_a #1%
{%
    \xint_UDsignfork
      #1\XINT_split_fromleft_b
       -{\XINT_split_fromleft_end_a #1}%
    \krof
}%
\def\XINT_split_fromleft_b #1.#2#3#4#5#6#7#8#9%
{%
    \expandafter\XINT_split_fromleft_clean
    \the\numexpr1#2#3#4#5#6#7#8#9\expandafter
    \XINT_split_fromleft_a\the\numexpr\xint_c_viii-#1.%
}%
\def\XINT_split_fromleft_end_a #1.%
{%
    \expandafter\XINT_split_fromleft_clean
```

```
    \the\numexpr1\csname XINT_split_fromleft_end#1\endcsname
}%
\def\XINT_split_fromleft_clean 1{ }%
\expandafter\def\csname XINT_split_fromleft_end7\endcsname #1%
   {#1\XINT_split_fromleft_end_b}%
\expandafter\def\csname XINT_split_fromleft_end6\endcsname #1#2%
   {#1#2\XINT_split_fromleft_end_b}%
\expandafter\def\csname XINT_split_fromleft_end5\endcsname #1#2#3%
   {#1#2#3\XINT_split_fromleft_end_b}%
\expandafter\def\csname XINT_split_fromleft_end4\endcsname #1#2#3#4%
   {#1#2#3#4\XINT_split_fromleft_end_b}%
\expandafter\def\csname XINT_split_fromleft_end3\endcsname #1#2#3#4#5%
   {#1#2#3#4#5\XINT_split_fromleft_end_b}%
\expandafter\def\csname XINT_split_fromleft_end2\endcsname #1#2#3#4#5#6%
   {#1#2#3#4#5#6\XINT_split_fromleft_end_b}%
\expandafter\def\csname XINT_split_fromleft_end1\endcsname #1#2#3#4#5#6#7%
   {#1#2#3#4#5#6#7\XINT_split_fromleft_end_b}%
\expandafter\def\csname XINT_split_fromleft_end0\endcsname #1#2#3#4#5#6#7#8%
   {#1#2#3#4#5#6#7#8\XINT_split_fromleft_end_b}%
\def\XINT_split_fromleft_end_b #1\xint_bye#2\xint_bye.{.#1}% puis .
\def\XINT_split_fromright #1.#2\xint_bye
{%
    \expandafter\XINT_split_fromright_a
    \the\numexpr#1-\numexpr\XINT_length_loop
    #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    .#2\xint_bye
}%
\def\XINT_split_fromright_a #1%
{%
    \xint_UDsignfork
      #1\XINT_split_fromleft
       -\XINT_split_fromright_Lempty
    \krof
}%
\def\XINT_split_fromright_Lempty #1.#2\xint_bye#3..{.#2.}%
```

6.9 \xintDecSplitL

```
\def\xintDecSplitL {\romannumeral0\xintdecsplitl }%
\def\xintdecsplitl #1#2%
{%
    \expandafter\XINT_splitl_finish
    \romannumeral0\expandafter\XINT_split_xfork
    \the\numexpr #1\expandafter.\romannumeral`&&@#2%
    \xint_bye2345678\xint_bye..%
}%
\def\XINT_splitl_finish #1.#2.{ #1}%
```

6.10 \xintDecSplitR

```
\def\xintDecSplitR {\romannumeral0\xintdecsplitr }%
```

```
\def\xintdecsplitr #1#2%
{%
    \expandafter\XINT_splitr_finish
    \romannumeral0\expandafter\XINT_split_xfork
    \the\numexpr #1\expandafter.\romannumeral`&&@#2%
    \xint_bye2345678\xint_bye..%
}%
\def\XINT_splitr_finish #1.#2.{ #2}%
```

6.11 \xintDSHr

DECIMAL SHIFTS \xintDSH {x}{A}
si x <= 0, fait A -> A.10^(|x|). si x > 0, et A >=0, fait A -> quo(A,10^(x))
si x > 0, et A < 0, fait A -> -quo(-A,10^(x))
(donc pour x > 0 c'est comme DSR itéré x fois)
\xintDSHr donne le `reste' (si x<=0 donne zéro).

Badly named macros.

Rewritten for 1.2i, this was old code and \xintDSx has changed interface.

```
\def\xintDSHr {\romannumeral0\xintdshr }%
\def\xintdshr #1#2%
{%
    \expandafter\XINT_dshr_fork\the\numexpr#1\expandafter.\romannumeral`&&@#2;%
}%
\def\XINT_dshr_fork #1%
{%
    \xint_UDzerominusfork
      0#1\XINT_dshr_xzeroorneg
      #1-\XINT_dshr_xzeroorneg
       0-\XINT_dshr_xpositive
    \krof #1%
}%
\def\XINT_dshr_xzeroorneg #1;{ 0}%
\def\XINT_dshr_xpositive
{%
    \expandafter\xint_stop_atsecondoftwo\romannumeral0\XINT_dsx_xisPos
}%
```

6.12 \xintDSH

```
\def\xintDSH {\romannumeral0\xintdsh }%
\def\xintdsh #1#2%
{%
    \expandafter\XINT_dsh_fork\the\numexpr#1\expandafter.\romannumeral`&&@#2;%
}%
\def\XINT_dsh_fork #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_dsh_xiszero
      0#1\XINT_dsx_xisNeg_checkA
       0-{\XINT_dsh_xisPos #1}%
    \krof
}%
\def\XINT_dsh_xiszero #1.#2;{ #2}%
```

```
\def\XINT_dsh_xisPos
{%
    \expandafter\xint_stop_atfirstoftwo\romannumeral0\XINT_dsx_xisPos
}%
```

6.13 \xintDSx

```
--> Attention le cas x=0 est traité dans la même catégorie que x > 0 <--
   si x < 0, fait A -> A.10^(|x|)
   si x >=  0, et A >=0, fait A -> {quo(A,10^(x))}{rem(A,10^(x))}
   si x >=  0, et A < 0, d'abord on calcule {quo(-A,10^(x))}{rem(-A,10^(x))}
      puis, si le premier n'est pas nul on lui donne le signe -
            si le premier est nul on donne le signe - au second.
```

On peut donc toujours reconstituer l'original A par 10^x Q \pm R où il faut prendre le signe plus si Q est positif ou nul et le signe moins si Q est strictement négatif.

Rewritten for 1.2i, this was old code.

```
\def\xintDSx {\romannumeral0\xintdsx }%
\def\xintdsx #1#2%
{%
    \expandafter\XINT_dsx_fork\the\numexpr#1\expandafter.\romannumeral`&&@#2;%
}%
\def\XINT_dsx_fork #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_dsx_xisZero
      0#1\XINT_dsx_xisNeg_checkA
       0-{\XINT_dsx_xisPos #1}%
    \krof
}%
\def\XINT_dsx_xisZero #1.#2;{{#2}{0}}%
\def\XINT_dsx_xisNeg_checkA #1.#2%
{%
    \xint_gob_til_zero #2\XINT_dsx_xisNeg_Azero 0%
    \expandafter\XINT_dsx_append\romannumeral\XINT_rep #1\endcsname 0.#2%
}%
\def\XINT_dsx_xisNeg_Azero #1;{ 0}%
\def\XINT_dsx_addzeros #1%
   {\expandafter\XINT_dsx_append\romannumeral\XINT_rep#1\endcsname0.}%
\def\XINT_dsx_addzerosnofuss #1%
   {\expandafter\XINT_dsx_append\romannumeral\xintreplicate{#1}0.}%
\def\XINT_dsx_append #1.#2;{ #2#1}%
\def\XINT_dsx_xisPos #1.#2%
{%
    \xint_UDzerominusfork
      #2-\XINT_dsx_AisZero
      0#2\XINT_dsx_AisNeg
       0-\XINT_dsx_AisPos
    \krof #1.#2%
}%
\def\XINT_dsx_AisZero #1;{{0}{0}}%
\def\XINT_dsx_AisNeg #1.-#2;%
{%
```

```
    \expandafter\XINT_dsx_AisNeg_checkiffirstempty
    \romannumeral0\XINT_split_xfork #1.#2\xint_bye2345678\xint_bye..%
}%
\def\XINT_dsx_AisNeg_checkiffirstempty #1%
{%
    \xint_gob_til_dot #1\XINT_dsx_AisNeg_finish_zero.%
    \XINT_dsx_AisNeg_finish_notzero #1%
}%
\def\XINT_dsx_AisNeg_finish_zero.\XINT_dsx_AisNeg_finish_notzero.#1.%
{%
    \expandafter\XINT_dsx_end
    \expandafter {\romannumeral0\XINT_num {-#1}}{0}%
}%
\def\XINT_dsx_AisNeg_finish_notzero #1.#2.%
{%
    \expandafter\XINT_dsx_end
    \expandafter {\romannumeral0\XINT_num {#2}}{-#1}%
}%
\def\XINT_dsx_AisPos #1.#2;%
{%
    \expandafter\XINT_dsx_AisPos_finish
    \romannumeral0\XINT_split_xfork #1.#2\xint_bye2345678\xint_bye..%
}%
\def\XINT_dsx_AisPos_finish #1.#2.%
{%
    \expandafter\XINT_dsx_end
    \expandafter {\romannumeral0\XINT_num {#2}}%
                 {\romannumeral0\XINT_num {#1}}%
}%
\def\XINT_dsx_end #1#2{\expandafter{#2}{#1}}%
```

6.14 \xintiiEq

no \xintiieq.

```
\def\xintiiEq #1#2{\romannumeral0\xintiiifeq{#1}{#2}{1}{0}}%
```

6.15 \xintiiNotEq

Pour xintexpr. Pas de version en lowercase.

```
\def\xintiiNotEq #1#2{\romannumeral0\xintiiifeq {#1}{#2}{0}{1}}%
```

6.16 \xintiiGeq

PLUS GRAND OU ÉGAL attention compare les **valeurs absolues**

1.2l made \xintiiGeq robust against non terminated items.

1.2l rewrote \xintiiCmp, but forgot to handle \xintiiGeq too. Done at 1.2m.

This macro should have been called \xintGEq for example.

```
\def\xintiiGeq   {\romannumeral0\xintiigeq }%
\def\xintiigeq #1{\expandafter\XINT_iigeq\romannumeral`&&@#1\xint:}%
\def\XINT_iigeq #1#2\xint:#3%
{%
    \expandafter\XINT_geq_fork\expandafter #1\romannumeral`&&@#3\xint:#2\xint:
```

```
}%
\def\XINT_geq #1#2\xint:#3%
{%
    \expandafter\XINT_geq_fork\expandafter #1\romannumeral0\xintnum{#3}\xint:#2\xint:
}%
\def\XINT_geq_fork #1#2%
{%
    \xint_UDzerofork
      #1\XINT_geq_firstiszero
      #2\XINT_geq_secondiszero
       0{}%
    \krof
    \xint_UDsignsfork
          #1#2\XINT_geq_minusminus
           #1-\XINT_geq_minusplus
           #2-\XINT_geq_plusminus
            --\XINT_geq_plusplus
    \krof #1#2%
}%
\def\XINT_geq_firstiszero  #1\krof 0#2#3\xint:#4\xint:
                              {\xint_UDzerofork #2{ 1}0{ 0}\krof }%
\def\XINT_geq_secondiszero #1\krof #20#3\xint:#4\xint:{ 1}%
\def\XINT_geq_plusminus    #1-{\XINT_geq_plusplus #1{}}%
\def\XINT_geq_minusplus    -#1{\XINT_geq_plusplus {}#1}%
\def\XINT_geq_minusminus    --{\XINT_geq_plusplus {}{}}%
\def\XINT_geq_plusplus
   {\expandafter\XINT_geq_finish\romannumeral0\XINT_cmp_plusplus}%
\def\XINT_geq_finish #1{\if-#1\expandafter\XINT_geq_no
                         \else\expandafter\XINT_geq_yes\fi}%
\def\XINT_geq_no 1{ 0}%
\def\XINT_geq_yes { 1}%
```

6.17 \xintiiGt

```
\def\xintiiGt #1#2{\romannumeral0\xintiiifgt{#1}{#2}{1}{0}}%
```

6.18 \xintiiLt

```
\def\xintiiLt #1#2{\romannumeral0\xintiiiflt{#1}{#2}{1}{0}}%
```

6.19 \xintiiGtorEq

```
\def\xintiiGtorEq #1#2{\romannumeral0\xintiiiflt {#1}{#2}{0}{1}}%
```

6.20 \xintiiLtorEq

```
\def\xintiiLtorEq #1#2{\romannumeral0\xintiiifgt {#1}{#2}{0}{1}}%
```

6.21 \xintiiIsZero

1.09a. restyled in 1.09i. 1.1 adds \xintiiIsZero, etc... for optimization in \xintexpr

```
\def\xintiiIsZero {\romannumeral0\xintiiiszero }%
\def\xintiiiszero #1{\if0\xintiiSgn{#1}\xint_afterfi{ 1}\else\xint_afterfi{ 0}\fi}%
```

6.22 \xintiiIsNotZero

1.09a. restyled in 1.09i. 1.1 adds \xintiiIsZero, etc... for optimization in \xintexpr

```
\def\xintiiIsNotZero {\romannumeral0\xintiiisnotzero }%
\def\xintiiisnotzero
        #1{\if0\xintiiSgn{#1}\xint_afterfi{ 0}\else\xint_afterfi{ 1}\fi}%
```

6.23 \xintiiIsOne

Added in 1.03. 1.09a defines \xintIsOne. 1.1a adds \xintiiIsOne.

\XINT_isOne rewritten for 1.2g. Works with expanded strict integers, positive or negative.

```
\def\xintiiIsOne {\romannumeral0\xintiiisone }%
\def\xintiiisone #1{\expandafter\XINT_isone\romannumeral`&&@#1XY}%
\def\XINT_isone #1#2#3Y%
{%
    \unless\if#2X\xint_dothis{ 0}\fi
    \unless\if#11\xint_dothis{ 0}\fi
    \xint_orthat{ 1}%
}%
\def\XINT_isOne #1{\XINT_is_One#1XY}%
\def\XINT_is_One #1#2#3Y%
{%
    \unless\if#2X\xint_dothis0\fi
    \unless\if#11\xint_dothis0\fi
    \xint_orthat1%
}%
```

6.24 \xintiiOdd

\xintOdd is needed for the xintexpr-essions even() and odd() functions (and also by \xintNewExpr).

```
\def\xintiiOdd {\romannumeral0\xintiiodd }%
\def\xintiiodd #1%
{%
    \ifodd\xintLDg{#1} %<- intentional space
        \xint_afterfi{ 1}%
    \else
        \xint_afterfi{ 0}%
    \fi
}%
```

6.25 \xintiiEven

```
\def\xintiiEven {\romannumeral0\xintiieven }%
\def\xintiieven #1%
{%
    \ifodd\xintLDg{#1} %<- intentional space
        \xint_afterfi{ 0}%
    \else
        \xint_afterfi{ 1}%
    \fi
}%
```

6.26 \xintiiMON

MINUS ONE TO THE POWER N

```
\def\xintiiMON {\romannumeral0\xintiimon }%
\def\xintiimon #1%
{%
    \ifodd\xintLDg {#1} %<- intentional space
        \xint_afterfi{ -1}%
    \else
        \xint_afterfi{ 1}%
    \fi
}%
```

6.27 \xintiiMMON

MINUS ONE TO THE POWER N-1

```
\def\xintiiMMON {\romannumeral0\xintiimmon }%
\def\xintiimmon #1%
{%
    \ifodd\xintLDg {#1} %<- intentional space
        \xint_afterfi{ 1}%
    \else
        \xint_afterfi{ -1}%
    \fi
}%
```

6.28 \xintSgnFork

Expandable three-way fork added in 1.07. The argument #1 must expand to non-self-ending -1,0 or 1. 1.09i with _thenstop (now _stop_at...).

```
\def\xintSgnFork {\romannumeral0\xintsgnfork }%
\def\xintsgnfork #1%
{%
    \ifcase #1 \expandafter\xint_stop_atsecondofthree
            \or\expandafter\xint_stop_atthirdofthree
          \else\expandafter\xint_stop_atfirstofthree
    \fi
}%
```

6.29 \xintiiifSgn

Expandable three-way fork added in 1.09a. Branches expandably depending on whether <0, =0, >0. Choice of branch guaranteed in two steps.

1.09i has \xint_firstofthreeafterstop (now \xint_stop_atfirstofthree) etc for faster expansion.

1.1 adds \xintiiifSgn for optimization in xintexpr-essions. Should I move them to xintcore? (for bnumexpr)

```
\def\xintiiifSgn {\romannumeral0\xintiiifsgn }%
\def\xintiiifsgn #1%
{%
    \ifcase \xintiiSgn{#1}
               \expandafter\xint_stop_atsecondofthree
```

```
            \or\expandafter\xint_stop_atthirdofthree
          \else\expandafter\xint_stop_atfirstofthree
    \fi
}%
```

6.30 \xintiiifCmp

1.09e \xintifCmp {n}{m}{if n<m}{if n=m}{if n>m}. 1.1a adds ii variant

```
\def\xintiiifCmp {\romannumeral0\xintiiifcmp }%
\def\xintiiifcmp #1#2%
{%
    \ifcase\xintiiCmp {#1}{#2}
               \expandafter\xint_stop_atsecondofthree
            \or\expandafter\xint_stop_atthirdofthree
          \else\expandafter\xint_stop_atfirstofthree
    \fi
}%
```

6.31 \xintiiifEq

1.09a \xintifEq {n}{m}{YES if n=m}{NO if n<>m}. 1.1a adds ii variant

```
\def\xintiiifEq {\romannumeral0\xintiiifeq }%
\def\xintiiifeq #1#2%
{%
    \if0\xintiiCmp{#1}{#2}%
               \expandafter\xint_stop_atfirstoftwo
          \else\expandafter\xint_stop_atsecondoftwo
    \fi
}%
```

6.32 \xintiiifGt

1.09a \xintifGt {n}{m}{YES if n>m}{NO if n<=m}. 1.1a adds ii variant

```
\def\xintiiifGt {\romannumeral0\xintiiifgt }%
\def\xintiiifgt #1#2%
{%
    \if1\xintiiCmp{#1}{#2}%
               \expandafter\xint_stop_atfirstoftwo
          \else\expandafter\xint_stop_atsecondoftwo
    \fi
}%
```

6.33 \xintiiifLt

1.09a \xintifLt {n}{m}{YES if n<m}{NO if n>=m}. Restyled in 1.09i. 1.1a adds ii variant

```
\def\xintiiifLt {\romannumeral0\xintiiiflt }%
\def\xintiiiflt #1#2%
{%
    \ifnum\xintiiCmp{#1}{#2}<\xint_c_
          \expandafter\xint_stop_atfirstoftwo
    \else \expandafter\xint_stop_atsecondoftwo
    \fi
}%
```

6.34 \xintiiifZero

Expandable two-way fork added in 1.09a. Branches expandably depending on whether the argument is zero (branch A) or not (branch B). 1.09i restyling. By the way it appears (not thoroughly tested, though) that \if tests are faster than \ifnum tests. 1.1 adds ii versions.

```
\def\xintiiifZero {\romannumeral0\xintiiifzero }%
\def\xintiiifzero #1%
{%
    \if0\xintiiSgn{#1}%
       \expandafter\xint_stop_atfirstoftwo
    \else
       \expandafter\xint_stop_atsecondoftwo
    \fi
}%
```

6.35 \xintiiifNotZero

```
\def\xintiiifNotZero {\romannumeral0\xintiiifnotzero }%
\def\xintiiifnotzero #1%
{%
    \if0\xintiiSgn{#1}%
       \expandafter\xint_stop_atsecondoftwo
    \else
       \expandafter\xint_stop_atfirstoftwo
    \fi
}%
```

6.36 \xintiiifOne

added in 1.09i. 1.1a adds \xintiiifOne.

```
\def\xintiiifOne {\romannumeral0\xintiiifone }%
\def\xintiiifone #1%
{%
    \if1\xintiiIsOne{#1}%
       \expandafter\xint_stop_atfirstoftwo
    \else
       \expandafter\xint_stop_atsecondoftwo
    \fi
}%
```

6.37 \xintiiifOdd

1.09e. Restyled in 1.09i. 1.1a adds \xintiiifOdd.

```
\def\xintiiifOdd {\romannumeral0\xintiiifodd }%
\def\xintiiifodd #1%
{%
    \if\xintiiOdd{#1}1%
       \expandafter\xint_stop_atfirstoftwo
    \else
       \expandafter\xint_stop_atsecondoftwo
    \fi
}%
```

6.38 \xintifTrueAelseB, \xintifFalseAelseB

1.09i, with name changes at 1.2i.

1.2o uses \xintiiifNotZero, see comments to \xintAND etc... This will work fine with arguments being nested xintfrac.sty macros, without the overhead of \xintNum or \xintRaw parsing.

```
\def\xintifTrueAelseB {\romannumeral0\xintiiifnotzero}%
\def\xintifFalseAelseB{\romannumeral0\xintiiifzero}%
```

6.39 \xintIsTrue, \xintIsFalse

1.09c. Suppressed at 1.2o. They seem not to have been documented, fortunately.

```
%\let\xintIsTrue \xintIsNotZero
%\let\xintIsFalse\xintIsZero
```

6.40 \xintNOT

1.09c with name change at 1.2o. Besides, the macro is now defined as ii-type.

```
\def\xintNOT{\romannumeral0\xintiiiszero}%
```

6.41 \xintAND, \xintOR, \xintXOR

Added with 1.09a. But they used \xintSgn, etc... rather than \xintiiSgn. This brings \xintNum overhead which is not really desired, and which is not needed for use by xintexpr.sty. At 1.2o I modify them to use only ii macros. This is enough for sign or zeroness even for xintfrac format, as manipulated inside the \xintexpr. Big hesitation whether there should be however \xintiiAND outputting 1 or 0 versus an \xintAND outputting 1[0] versus 0[0] for example.

```
\def\xintAND {\romannumeral0\xintand }%
\def\xintand #1#2{\if0\xintiiSgn{#1}\expandafter\xint_firstoftwo
                             \else\expandafter\xint_secondoftwo\fi
                  { 0}{\xintiiisnotzero{#2}}}%
\def\xintOR {\romannumeral0\xintor }%
\def\xintor #1#2{\if0\xintiiSgn{#1}\expandafter\xint_firstoftwo
                            \else\expandafter\xint_secondoftwo\fi
                 {\xintiiisnotzero{#2}}{ 1}}%
\def\xintXOR {\romannumeral0\xintxor }%
\def\xintxor #1#2{\if\xintiiIsZero{#1}\xintiiIsZero{#2}%
                     \xint_afterfi{ 0}\else\xint_afterfi{ 1}\fi }%
```

6.42 \xintANDof

New with 1.09a. \xintANDof works also with an empty list. Empty items however are not accepted.

1.2l made \xintANDof robust against non terminated items.

1.2o's \xintifTrueAelseB is now an ii macro, actually.

1.4. This macro as well as ORof and XORof were formally not used by xintexpr, which uses comma separated items, but at 1.4 xintexpr uses braced items. And the macros here got slightly refactored and \XINT_ANDof added for usage by xintexpr and the NewExpr hook. For some random reason I decided to use ^ as delimiter this has to do that other macros in xintfrac in same family (such as \xintGCDof, \xintSum) also use \xint: internally and although not strictly needed having two separate ones clarifies.

```
\def\xintANDof  {\romannumeral0\xintandof }%
\def\xintandof  #1{\expandafter\XINT_andof\romannumeral`&&@#1^}%
\def\XINT_ANDof {\romannumeral0\XINT_andof}%
```

```
\def\XINT_andof #1%
{%
    \xint_gob_til_^ #1\XINT_andof_yes ^%
    \xintiiifNotZero{#1}\XINT_andof\XINT_andof_no
}%
\def\XINT_andof_no  #1^{ 0}%
\def\XINT_andof_yes ^#1\XINT_andof_no{ 1}%
```

6.43 \xintORof

New with 1.09a. Works also with an empty list. Empty items however are not accepted.

1.2l made \xintORof robust against non terminated items.

Refactored at 1.4.

```
\def\xintORof  {\romannumeral0\xintorof }%
\def\xintorof  #1{\expandafter\XINT_orof\romannumeral`&&@#1^}%
\def\XINT_ORof {\romannumeral0\XINT_orof}%
\def\XINT_orof #1%
{%
    \xint_gob_til_^ #1\XINT_orof_no ^%
    \xintiiifNotZero{#1}\XINT_orof_yes\XINT_orof
}%
\def\XINT_orof_yes#1^{ 1}%
\def\XINT_orof_no ^#1\XINT_orof{ 0}%
```

6.44 \xintXORof

New with 1.09a. Works with an empty list, too. Empty items however are not accepted. \XINT_xorof_c more efficient in 1.09i.

1.2l made \xintXORof robust against non terminated items.

Refactored at 1.4 to use \numexpr (or an \ifnum). I have not tested if more efficient or not or if one can do better without \the. \XINT_XORof for xintexpr matters.

```
\def\xintXORof  {\romannumeral0\xintxorof }%
\def\xintxorof  #1{\expandafter\XINT_xorof\romannumeral`&&@#1^}%
\def\XINT_XORof {\romannumeral0\XINT_xorof}%
\def\XINT_xorof {\if1\the\numexpr\XINT_xorof_a}%
\def\XINT_xorof_a #1%
{%
    \xint_gob_til_^ #1\XINT_xorof_e ^%
    \xintiiifNotZero{#1}{-}{}\XINT_xorof_a
}%
\def\XINT_xorof_e ^#1\XINT_xorof_a
   {1\relax\xint_afterfi{ 0}\else\xint_afterfi{ 1}\fi}%
```

6.45 \xintiiMax

At 1.2m, a long-standing bug was fixed: \xintiiMax had the overhead of applying \xintNum to its arguments due to use of a sub-macro of \xintGeq code to which this overhead was added at some point.

And on this occasion I reduced even more number of times input is grabbed.

```
\def\xintiiMax {\romannumeral0\xintiimax }%
\def\xintiimax #1%
{%
    \expandafter\xint_iimax \romannumeral`&&@#1\xint:
```

```
}%
\def\xint_iimax #1\xint:#2%
{%
    \expandafter\XINT_max_fork\romannumeral`&&@#2\xint:#1\xint:
}%
```

#3#4 vient du *premier*, #1#2 vient du *second*. I have renamed the sub-macros at 1.2m because the terminology was quite counter-intuitive; there was no bug, but still.

```
\def\XINT_max_fork #1#2\xint:#3#4\xint:
{%
    \xint_UDsignsfork
          #1#3\XINT_max_minusminus  % A < 0, B < 0
           #1-\XINT_max_plusminus   % B < 0, A >= 0
           #3-\XINT_max_minusplus   % A < 0, B >= 0
            --{\xint_UDzerosfork
                         #1#3\XINT_max_zerozero % A = B = 0
                          #10\XINT_max_pluszero % B = 0, A > 0
                          #30\XINT_max_zeroplus % A = 0, B > 0
                           00\XINT_max_plusplus % A, B > 0
                         \krof }%
    \krof
    #3#1#2\xint:#4\xint:
      \expandafter\xint_stop_atfirstoftwo
    \else
      \expandafter\xint_stop_atsecondoftwo
    \fi
    {#3#4}{#1#2}%
}%
```

Refactored at 1.2m for avoiding grabbing arguments. Position of inputs shared with iiCmp and iiGeq code.

```
\def\XINT_max_zerozero  #1\fi{\xint_stop_atfirstoftwo }%
\def\XINT_max_zeroplus  #1\fi{\xint_stop_atsecondoftwo }%
\def\XINT_max_pluszero  #1\fi{\xint_stop_atfirstoftwo }%
\def\XINT_max_minusplus #1\fi{\xint_stop_atsecondoftwo }%
\def\XINT_max_plusminus #1\fi{\xint_stop_atfirstoftwo }%
\def\XINT_max_plusplus
{%
    \if1\romannumeral0\XINT_geq_plusplus
}%
```

Premier des testés |A|=-A, second est |B|=-B. On veut le max(A,B), c'est donc A si |A|<|B| (ou |A|=|B|, mais peu importe alors). Donc on peut faire cela avec \unless. Simple.

```
\def\XINT_max_minusminus --%
{%
    \unless\if1\romannumeral0\XINT_geq_plusplus{}{}%
}%
```

6.46 \xintiiMin

New with 1.09a. I add \xintiiMin in 1.1 and \xintMin is an xintfrac macro.

At 1.2m, a long-standing bug was fixed: \xintiiMin had the overhead of applying \xintNum to its arguments due to use of a sub-macro of \xintGeq code to which this overhead was added at some point.

And on this occasion I reduced even more number of times input is grabbed.

```
\def\xintiiMin {\romannumeral0\xintiimin }%
\def\xintiimin #1%
{%
    \expandafter\xint_iimin \romannumeral`&&@#1\xint:
}%
\def\xint_iimin #1\xint:#2%
{%
    \expandafter\XINT_min_fork\romannumeral`&&@#2\xint:#1\xint:
}%
\def\XINT_min_fork #1#2\xint:#3#4\xint:
{%
    \xint_UDsignsfork
          #1#3\XINT_min_minusminus  % A < 0, B < 0
           #1-\XINT_min_plusminus   % B < 0, A >= 0
           #3-\XINT_min_minusplus   % A < 0, B >= 0
            --{\xint_UDzerosfork
                      #1#3\XINT_min_zerozero % A = B = 0
                       #10\XINT_min_pluszero % B = 0, A > 0
                       #30\XINT_min_zeroplus % A = 0, B > 0
                        00\XINT_min_plusplus % A, B > 0
                      \krof }%
    \krof
    #3#1#2\xint:#4\xint:
      \expandafter\xint_stop_atsecondoftwo
    \else
      \expandafter\xint_stop_atfirstoftwo
    \fi
    {#3#4}{#1#2}%
}%
\def\XINT_min_zerozero  #1\fi{\xint_stop_atfirstoftwo }%
\def\XINT_min_zeroplus  #1\fi{\xint_stop_atfirstoftwo }%
\def\XINT_min_pluszero  #1\fi{\xint_stop_atsecondoftwo }%
\def\XINT_min_minusplus #1\fi{\xint_stop_atfirstoftwo }%
\def\XINT_min_plusminus #1\fi{\xint_stop_atsecondoftwo }%
\def\XINT_min_plusplus
{%
    \if1\romannumeral0\XINT_geq_plusplus
}%
\def\XINT_min_minusminus --%
{%
    \unless\if1\romannumeral0\XINT_geq_plusplus{}{}%
}%
```

6.47 \xintiiMaxof

New with 1.09a. 1.2 has NO MORE \xintMaxof, requires \xintfracname. 1.2a adds \xintiiMaxof, as \xintiiMaxof:csv is not public.

NOT compatible with empty list.

1.2l made \xintiiMaxof robust against non terminated items.

1.4 refactors code to allow empty argument. For usage by \xintiiexpr. Slight deterioration, will come back.

```
\def\xintiiMaxof {\romannumeral0\xintiimaxof }%
```

```
\def\xintiimaxof #1{\expandafter\XINT_iimaxof\romannumeral`&&@#1^}%
\def\XINT_iiMaxof{\romannumeral0\XINT_iimaxof}%
\def\XINT_iimaxof#1%
{%
    \xint_gob_til_^ #1\XINT_iimaxof_empty ^%
    \expandafter\XINT_iimaxof_loop\romannumeral`&&@#1\xint:
}%
\def\XINT_iimaxof_empty ^#1\xint:{ 0}%
\def\XINT_iimaxof_loop #1\xint:#2%
{%
    \xint_gob_til_^ #2\XINT_iimaxof_e ^%
    \expandafter\XINT_iimaxof_loop\romannumeral0\xintiimax{#1}{#2}\xint:
}%
\def\XINT_iimaxof_e ^#1\xintiimax #2#3\xint:{ #2}%
```

6.48 \xintiiMinof

1.09a. 1.2a adds \xintiiMinof which was lacking.
1.4 refactoring for \xintiiexpr matters.

```
\def\xintiiMinof {\romannumeral0\xintiiminof }%
\def\xintiiminof #1{\expandafter\XINT_iiminof\romannumeral`&&@#1^}%
\def\XINT_iiMinof{\romannumeral0\XINT_iiminof}%
\def\XINT_iiminof#1%
{%
    \xint_gob_til_^ #1\XINT_iiminof_empty ^%
    \expandafter\XINT_iiminof_loop\romannumeral`&&@#1\xint:
}%
\def\XINT_iiminof_empty ^#1\xint:{ 0}%
\def\XINT_iiminof_loop #1\xint:#2%
{%
    \xint_gob_til_^ #2\XINT_iiminof_e ^%
    \expandafter\XINT_iiminof_loop\romannumeral0\xintiimin{#1}{#2}\xint:
}%
\def\XINT_iiminof_e ^#1\xintiimin #2#3\xint:{ #2}%
```

6.49 \xintiiSum

\xintiiSum {{a}{b}...{z}} Refactored at 1.4 for matters initially related to xintexpr delimiter choice.

```
\def\xintiiSum {\romannumeral0\xintiisum }%
\def\xintiisum #1{\expandafter\XINT_iisum\romannumeral`&&@#1^}%
\def\XINT_iiSum{\romannumeral0\XINT_iisum}%
\def\XINT_iisum #1%
{%
    \expandafter\XINT_iisum_a\romannumeral`&&@#1\xint:
}%
\def\XINT_iisum_a #1%
{%
    \xint_gob_til_^ #1\XINT_iisum_empty ^%
    \XINT_iisum_loop #1%
}%
\def\XINT_iisum_empty ^#1\xint:{ 0}%
```

bad coding as it depends on internal conventions of \XINT_add_nfork

```
\def\XINT_iisum_loop #1#2\xint:#3%
{%
    \expandafter\XINT_iisum_loop_a
    \expandafter#1\romannumeral`&&@#3\xint:#2\xint:\xint:
}%
\def\XINT_iisum_loop_a #1#2%
{%
    \xint_gob_til_^ #2\XINT_iisum_loop_end ^%
    \expandafter\XINT_iisum_loop\romannumeral0\XINT_add_nfork #1#2%
}%
```

see previous comment!

```
\def\XINT_iisum_loop_end ^#1\XINT_add_nfork #2#3\xint:#4\xint:\xint:{ #2#4}%
```

6.50 \xintiiPrd

\xintiiPrd {{a}...{z}}

Macros renamed and refactored (slightly more macros here to supposedly bring micro-gain) at 1.4 to match changes in xintfrac of delimiter, in sync with some usage in xintexpr.

Contrarily to the xintfrac version \xintPrd, this one aborts as soon as it hits a zero value.

```
\def\xintiiPrd {\romannumeral0\xintiiprd }%
\def\xintiiprd #1{\expandafter\XINT_iiprd\romannumeral`&&@#1^}%
\def\XINT_iiPrd{\romannumeral0\XINT_iiprd}%
```

The above romannumeral caused f-expansion of the list argument. We f-expand below the first item and each successive items because we do not use \xintiiMul but jump directly into \XINT_mul_nfork.

```
\def\XINT_iiprd #1%
{%
    \expandafter\XINT_iiprd_a\romannumeral`&&@#1\xint:
}%
\def\XINT_iiprd_a #1%
{%
    \xint_gob_til_^ #1\XINT_iiprd_empty ^%
    \xint_gob_til_zero #1\XINT_iiprd_zero 0%
    \XINT_iiprd_loop #1%
}%
\def\XINT_iiprd_empty ^#1\xint:{ 1}%
\def\XINT_iiprd_zero  0#1^{ 0}%
```

bad coding as it depends on internal conventions of \XINT_mul_nfork

```
\def\XINT_iiprd_loop #1#2\xint:#3%
{%
    \expandafter\XINT_iiprd_loop_a
    \expandafter#1\romannumeral`&&@#3\xint:#2\xint:\xint:
}%
\def\XINT_iiprd_loop_a #1#2%
{%
    \xint_gob_til_^    #2\XINT_iiprd_loop_end ^%
    \xint_gob_til_zero #2\XINT_iiprd_zero 0%
    \expandafter\XINT_iiprd_loop\romannumeral0\XINT_mul_nfork #1#2%
}%
```

see previous comment!

```
\def\XINT_iiprd_loop_end ^#1\XINT_mul_nfork #2#3\xint:#4\xint:\xint:{ #2#4}%
```

6.51 \xintiiSquareRoot

First done with 1.08.

1.1 added \xintiiSquareRoot.

1.1a added \xintiiSqrtR.

1.2f (2016/03/01-02-03) has rewritten the implementation, the underlying mathematics remaining about the same. The routine is much faster for inputs having up to 16 digits (because it does it all with \numexpr directly now), and also much faster for very long inputs (because it now fetches only the needed new digits after the first 16 (or 17) ones, via the geometric sequence 16, then 32, then 64, etc...; earlier version did the computations with all remaining digits after a suitable starting point with correct 4 or 5 leading digits). Note however that the fetching of tokens is via intrinsically O(N^2) macros, hence inevitably inputs with thousands of digits start being treated less well.

Actually there is some room for improvements, one could prepare better input X for the upcoming treatment of fetching its digits by 16, then 32, then 64, etc...

Incidently, as \xintiiSqrt uses subtraction and subtraction was broken from 1.2 to 1.2c, then for another reason from 1.2c to 1.2f, it could get wrong in certain (relatively rare) cases. There was also a bug that made it unneedlessly slow for odd number of digits on input.

1.2f also modifies \xintFloatSqrt in xintfrac.sty which now has more code in common with here and benefits from the same speed improvements.

1.2k belatedly corrects the output to {1}{1} and not 11 when input is zero. As braces are used in all other cases they should have been used here too.

Also, 1.2k adds an \xintiSqrtR macro, for coherence as \xintiSqrt is defined (and mentioned in user manual.)

```
\def\xintiiSquareRoot {\romannumeral0\xintiisquareroot }%
\def\xintiisquareroot #1{\expandafter\XINT_sqrt_checkin\romannumeral`&&@#1\xint:}%
\def\XINT_sqrt_checkin #1%
{%
    \xint_UDzerominusfork
     #1-\XINT_sqrt_iszero
     0#1\XINT_sqrt_isneg
      0-\XINT_sqrt
    \krof #1%
}%
\def\XINT_sqrt_iszero #1\xint:{{1}{1}}%
\def\XINT_sqrt_isneg  #1\xint:
   {\XINT_signalcondition{InvalidOperation}%
                          {Square root of negative: #1.}{}{{0}{0}}}%
\def\XINT_sqrt #1\xint:
{%
    \expandafter\XINT_sqrt_start\romannumeral0\xintlength {#1}.#1.%
}%
\def\XINT_sqrt_start #1.%
{%
    \ifnum #1<\xint_c_x\xint_dothis\XINT_sqrt_small_a\fi
    \xint_orthat\XINT_sqrt_big_a #1.%
}%
\def\XINT_sqrt_small_a #1.{\XINT_sqrt_a #1.\XINT_sqrt_small_d }%
\def\XINT_sqrt_big_a   #1.{\XINT_sqrt_a #1.\XINT_sqrt_big_d   }%
\def\XINT_sqrt_a #1.%
{%
   \ifodd #1
     \expandafter\XINT_sqrt_bO
```

```
  \else
    \expandafter\XINT_sqrt_bE
  \fi
  #1.%
}%
\def\XINT_sqrt_bE #1.#2#3#4%
{%
   \XINT_sqrt_c {#3#4}#2{#1}#3#4%
}%
\def\XINT_sqrt_bO #1.#2#3%
{%
   \XINT_sqrt_c #3#2{#1}#3%
}%
\def\XINT_sqrt_c #1#2%
{%
   \expandafter #2%
   \the\numexpr \ifnum #1>\xint_c_ii
                \ifnum #1>\xint_c_vi
                \ifnum #1>12 \ifnum #1>20 \ifnum #1>30
                \ifnum #1>42 \ifnum #1>56 \ifnum #1>72
                \ifnum #1>90
     10\else 9\fi \else 8\fi \else 7\fi \else 6\fi \else 5\fi
       \else 4\fi \else 3\fi \else 2\fi \else 1\fi .%
}%
\def\XINT_sqrt_small_d #1.#2%
{%
  \expandafter\XINT_sqrt_small_e
  \the\numexpr #1\ifcase \numexpr #2/\xint_c_ii-\xint_c_i\relax
                  \or 0\or 00\or 000\or 0000\fi .%
}%
\def\XINT_sqrt_small_e #1.#2.%
{%
  \expandafter\XINT_sqrt_small_ea\the\numexpr #1*#1-#2.#1.%
}%
\def\XINT_sqrt_small_ea #1%
{%
   \if0#1\xint_dothis\XINT_sqrt_small_ez\fi
   \if-#1\xint_dothis\XINT_sqrt_small_eb\fi
   \xint_orthat\XINT_sqrt_small_f #1%
}%
\def\XINT_sqrt_small_ez 0.#1.{\expandafter{\the\numexpr#1+\xint_c_i
        \expandafter}\expandafter{\the\numexpr #1*\xint_c_ii+\xint_c_i}}%
\def\XINT_sqrt_small_eb -#1.#2.%
{%
   \expandafter\XINT_sqrt_small_ec \the\numexpr
   (#1-\xint_c_i+#2)/(\xint_c_ii*#2).#1.#2.%
}%
\def\XINT_sqrt_small_ec #1.#2.#3.%
{%
   \expandafter\XINT_sqrt_small_f \the\numexpr
     -#2+\xint_c_ii*#3*#1+#1*#1\expandafter.\the\numexpr #3+#1.%
}%
```

```
\def\XINT_sqrt_small_f #1.#2.%
{%
   \expandafter\XINT_sqrt_small_g
   \the\numexpr (#1+#2)/(\xint_c_ii*#2)-\xint_c_i.#1.#2.%
}%
\def\XINT_sqrt_small_g #1#2.%
{%
    \if 0#1%
       \expandafter\XINT_sqrt_small_end
    \else
       \expandafter\XINT_sqrt_small_h
    \fi
    #1#2.%
}%
\def\XINT_sqrt_small_h #1.#2.#3.%
{%
    \expandafter\XINT_sqrt_small_f
    \the\numexpr #2-\xint_c_ii*#1*#3+#1*#1\expandafter.%
    \the\numexpr #3-#1.%
}%
\def\XINT_sqrt_small_end #1.#2.#3.{{#3}{#2}}%
\def\XINT_sqrt_big_d #1.#2%
{%
   \ifodd #2 \xint_dothis{\expandafter\XINT_sqrt_big_eO}\fi
   \xint_orthat{\expandafter\XINT_sqrt_big_eE}%
   \the\numexpr (#2-\xint_c_i)/\xint_c_ii.#1;%
}%
\def\XINT_sqrt_big_eE  #1;#2#3#4#5#6#7#8#9%
{%
    \XINT_sqrt_big_eE_a #1;{#2#3#4#5#6#7#8#9}%
}%
\def\XINT_sqrt_big_eE_a #1.#2;#3%
{%
    \expandafter\XINT_sqrt_bigormed_f
    \romannumeral0\XINT_sqrt_small_e #2000.#3.#1;%
}%
\def\XINT_sqrt_big_eO #1;#2#3#4#5#6#7#8#9%
{%
    \XINT_sqrt_big_eO_a #1;{#2#3#4#5#6#7#8#9}%
}%
\def\XINT_sqrt_big_eO_a #1.#2;#3#4%
{%
    \expandafter\XINT_sqrt_bigormed_f
    \romannumeral0\XINT_sqrt_small_e #20000.#3#4.#1;%
}%
\def\XINT_sqrt_bigormed_f #1#2#3;%
{%
    \ifnum#3<\xint_c_ix
          \xint_dothis {\csname XINT_sqrt_med_f\romannumeral#3\endcsname}%
    \fi
    \xint_orthat\XINT_sqrt_big_f #1.#2.#3;%
}%
```

```
\def\XINT_sqrt_med_fv   {\XINT_sqrt_med_fa .}%
\def\XINT_sqrt_med_fvi  {\XINT_sqrt_med_fa 0.}%
\def\XINT_sqrt_med_fvii {\XINT_sqrt_med_fa 00.}%
\def\XINT_sqrt_med_fviii{\XINT_sqrt_med_fa 000.}%
\def\XINT_sqrt_med_fa #1.#2.#3.#4;%
{%
    \expandafter\XINT_sqrt_med_fb
    \the\numexpr (#30#1-5#1)/(\xint_c_ii*#2).#1.#2.#3.%
}%
\def\XINT_sqrt_med_fb #1.#2.#3.#4.#5.%
{%
    \expandafter\XINT_sqrt_small_ea
    \the\numexpr (#40#2-\xint_c_ii*#3*#1)*10#2+(#1*#1-#5)\expandafter.%
    \the\numexpr #30#2-#1.%
}%
\def\XINT_sqrt_big_f #1;#2#3#4#5#6#7#8#9%
{%
    \XINT_sqrt_big_fa #1;{#2#3#4#5#6#7#8#9}%
}%
\def\XINT_sqrt_big_fa #1.#2.#3;#4%
{%
    \expandafter\XINT_sqrt_big_ga
    \the\numexpr #3-\xint_c_viii\expandafter.%
    \romannumeral0\XINT_sqrt_med_fa 000.#1.#2.;#4.%
}%

\def\XINT_sqrt_big_ga #1.#2#3%
{%
    \ifnum #1>\xint_c_viii
      \expandafter\XINT_sqrt_big_gb\else
      \expandafter\XINT_sqrt_big_ka
    \fi #1.#3.#2.%
}%
\def\XINT_sqrt_big_gb #1.#2.#3.%
{%
    \expandafter\XINT_sqrt_big_gc
    \the\numexpr (\xint_c_ii*#2-\xint_c_i)*\xint_c_x^viii/(\xint_c_iv*#3).%
    #3.#2.#1;%
}%
\def\XINT_sqrt_big_gc #1.#2.#3.%
{%
    \expandafter\XINT_sqrt_big_gd
    \romannumeral0\xintiiadd
        {\xintiiSub {#300000000}{\xintDouble{\xintiiMul{#2}{#1}}}00000000}%
        {\xintiiSqr {#1}}.%
    \romannumeral0\xintiisub{#200000000}{#1}.%
}%
\def\XINT_sqrt_big_gd #1.#2.%
{%
    \expandafter\XINT_sqrt_big_ge #2.#1.%
}%
\def\XINT_sqrt_big_ge #1;#2#3#4#5#6#7#8#9%
   {\XINT_sqrt_big_gf #1.#2#3#4#5#6#7#8#9;}%
```

```
\def\XINT_sqrt_big_gf #1;#2#3#4#5#6#7#8#9%
   {\XINT_sqrt_big_gg #1#2#3#4#5#6#7#8#9.}%
\def\XINT_sqrt_big_gg #1.#2.#3.#4.%
{%
    \expandafter\XINT_sqrt_big_gloop
    \expandafter\xint_c_xvi\expandafter.%
    \the\numexpr #3-\xint_c_viii\expandafter.%
    \romannumeral0\xintiisub {#2}{\xintiNum{#4}}.#1.%
}%
\def\XINT_sqrt_big_gloop #1.#2.%
{%
    \unless\ifnum #1<#2 \xint_dothis\XINT_sqrt_big_ka \fi
    \xint_orthat{\XINT_sqrt_big_gi #1.}#2.%
}%
\def\XINT_sqrt_big_gi #1.%
{%
    \expandafter\XINT_sqrt_big_gj\romannumeral\xintreplicate{#1}0.#1.%
}%
\def\XINT_sqrt_big_gj #1.#2.#3.#4.#5.%
{%
    \expandafter\XINT_sqrt_big_gk
    \romannumeral0\xintiidivision {#4#1}%
                  {\XINT_dbl #5\xint_bye2345678\xint_bye*\xint_c_ii\relax}.%
    #1.#5.#2.#3.%
}%
\def\XINT_sqrt_big_gk #1#2.#3.#4.%
{%
    \expandafter\XINT_sqrt_big_gl
    \romannumeral0\xintiiadd {#2#3}{\xintiiSqr{#1}}.%
    \romannumeral0\xintiisub {#4#3}{#1}.%
}%
\def\XINT_sqrt_big_gl #1.#2.%
{%
    \expandafter\XINT_sqrt_big_gm #2.#1.%
}%
\def\XINT_sqrt_big_gm #1.#2.#3.#4.#5.%
{%
    \expandafter\XINT_sqrt_big_gn
    \romannumeral0\XINT_split_fromleft\xint_c_ii*#3.#5\xint_bye2345678\xint_bye..%
    #1.#2.#3.#4.%
}%
\def\XINT_sqrt_big_gn #1.#2.#3.#4.#5.#6.%
{%
    \expandafter\XINT_sqrt_big_gloop
    \the\numexpr \xint_c_ii*#5\expandafter.%
    \the\numexpr #6-#5\expandafter.%
    \romannumeral0\xintiisub{#4}{\xintiNum{#1}}.#3.#2.%
}%
\def\XINT_sqrt_big_ka #1.#2.#3.#4.%
{%
    \expandafter\XINT_sqrt_big_kb
    \romannumeral0\XINT_dsx_addzeros {#1}#3;.%
```

```
    \romannumeral0\xintiisub
      {\XINT_dsx_addzerosnofuss {\xint_c_ii*#1}#2;}%
      {\xintiNum{#4}}.%
}%
\def\XINT_sqrt_big_kb #1.#2.%
{%
    \expandafter\XINT_sqrt_big_kc #2.#1.%
}%
\def\XINT_sqrt_big_kc #1%
{%
    \if0#1\xint_dothis\XINT_sqrt_big_kz\fi
    \xint_orthat\XINT_sqrt_big_kloop #1%
}%
\def\XINT_sqrt_big_kz 0.#1.%
{%
    \expandafter\XINT_sqrt_big_kend
    \romannumeral0%
    \xintinc{\XINT_dbl#1\xint_bye2345678\xint_bye*\xint_c_ii\relax}.#1.%
}%
\def\XINT_sqrt_big_kend #1.#2.%
{%
    \expandafter{\romannumeral0\xintinc{#2}}{#1}%
}%
\def\XINT_sqrt_big_kloop #1.#2.%
{%
    \expandafter\XINT_sqrt_big_ke
    \romannumeral0\xintiidivision{#1}%
     {\romannumeral0\XINT_dbl #2\xint_bye2345678\xint_bye*\xint_c_ii\relax}{#2}%
}%
\def\XINT_sqrt_big_ke #1%
{%
    \if0\XINT_Sgn #1\xint:
          \expandafter \XINT_sqrt_big_end
    \else \expandafter \XINT_sqrt_big_kf
    \fi {#1}%
}%
\def\XINT_sqrt_big_kf #1#2#3%
{%
    \expandafter\XINT_sqrt_big_kg
    \romannumeral0\xintiisub {#3}{#1}.%
    \romannumeral0\xintiiadd {#2}{\xintiiSqr {#1}}.%
}%
\def\XINT_sqrt_big_kg #1.#2.%
{%
   \expandafter\XINT_sqrt_big_kloop #2.#1.%
}%
\def\XINT_sqrt_big_end #1#2#3{{#3}{#2}}%
```

6.52 \xintiiSqrt, \xintiiSqrtR

```
\def\xintiiSqrt  {\romannumeral0\xintiisqrt  }%
\def\xintiisqrt  {\expandafter\XINT_sqrt_post\romannumeral0\xintiisquareroot  }%
\def\XINT_sqrt_post #1#2{\XINT_dec #1\XINT_dec_bye234567890\xint_bye}%
```

```
\def\xintiiSqrtR {\romannumeral0\xintiisqrtr }%
\def\xintiisqrtr {\expandafter\XINT_sqrtr_post\romannumeral0\xintiisquareroot }%
```

N = (#1)^2 - #2 avec #1 le plus petit possible et #2>0 (hence #2<2*#1). (#1-.5)^2=#1^2-#1+.25=N+#2-#1+.25. Si 0<#2<#1, <= N-0.75<N, donc rounded->#1 si #2>=#1, (#1-.5)^2>=N+.25>N, donc rounded->#1-1.

```
\def\XINT_sqrtr_post #1#2%
   {\xintiiifLt {#2}{#1}{ #1}{\XINT_dec #1\XINT_dec_bye234567890\xint_bye}}%
```

6.53 \xintiiBinomial

2015/11/28-29 for 1.2f.

2016/11/19 for 1.2h: I truly can't understand why I hard-coded last year an error-message for arguments outside of the range for binomial formula. Naturally there should be no error but a rather a 0 return value for binomial(x,y), if y<0 or x<y !

I really lack some kind of infinity or NaN value.

```
\def\xintiiBinomial {\romannumeral0\xintiibinomial }%
\def\xintiibinomial #1#2%
{%
    \expandafter\XINT_binom_pre\the\numexpr #1\expandafter.\the\numexpr #2.%
}%
\def\XINT_binom_pre #1.#2.%
{%
    \expandafter\XINT_binom_fork \the\numexpr#1-#2.#2.#1.%
}%
```

k.x-k.x. I hesitated to restrict maximal allowed value of x to 10000. Finally I don't. But due to using small multiplication and small division, x must have at most eight digits. If x>=2^31 an arithmetic overflow error will have happened already.

```
\def\XINT_binom_fork #1#2.#3#4.#5#6.%
{%
    \if-#5\xint_dothis{\XINT_signalcondition{InvalidOperation}%
                       {Binomial with negative first argument: #5#6.}{}{ 0}}\fi
    \if-#1\xint_dothis{ 0}\fi
    \if-#3\xint_dothis{ 0}\fi
    \if0#1\xint_dothis{ 1}\fi
    \if0#3\xint_dothis{ 1}\fi
    \ifnum #5#6>\xint_c_x^viii_mone\xint_dothis
       {\XINT_signalcondition{InvalidOperation}%
            {Binomial with too large argument: #5#6 >= 10^8.}{}{ 0}}\fi
    \ifnum #1#2>#3#4  \xint_dothis{\XINT_binom_a #1#2.#3#4.}\fi
                      \xint_orthat{\XINT_binom_a #3#4.#1#2.}%
}%
```

x-k.k. avec 0<k<x, k<=x-k. Les divisions produiront en extra après le quotient un terminateur 1!\Z!0!. On va procéder par petite multiplication suivie par petite division. Donc ici on met le 1!\Z!0! pour amorcer.

Le \xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax est le terminateur pour le \XINT_unsep_cuzsmall final.

```
\def\XINT_binom_a #1.#2.%
{%
    \expandafter\XINT_binom_b\the\numexpr \xint_c_i+#1.1.#2.100000001!1!;!0!%
}%
```

y=x-k+1.j=1.k. On va évaluer par y/1*(y+1)/2*(y+2)/3 etc... On essaie de regrouper de manière à utiliser au mieux \numexpr. On peut aller jusqu'à x=10000 car 9999*10000<10^8. 463*464*465=99896880, 98*99*100*101=97990200. On va vérifier à chaque étape si on dépasse un seuil. Le style de l'implémentation diffère de celui que j'avais utilisé pour \xintiiFac. On pourrait tout-à-fait avoir une verybigloop, mais bon. Je rajoute aussi un verysmall. Le traitement est un peu différent pour elle afin d'aller jusqu'à x=29 (et pas seulement 26 si je suivais le modèle des autres, mais je veux pouvoir faire binomial(29,1), binomial(29,2), ... en vsmall).

```
\def\XINT_binom_b #1.%
{%
    \ifnum #1>9999 \xint_dothis\XINT_binom_vbigloop \fi
    \ifnum #1>463  \xint_dothis\XINT_binom_bigloop   \fi
    \ifnum #1>98   \xint_dothis\XINT_binom_medloop   \fi
    \ifnum #1>29   \xint_dothis\XINT_binom_smallloop \fi
                   \xint_orthat\XINT_binom_vsmallloop #1.%
}%
```

y.j.k. Au départ on avait x-k+1.1.k. Ensuite on a des blocs 1<8d>! donnant le résultat intermédiaire, dans l'ordre, et à la fin on a 1!1;!0!. Dans smallloop on peut prendre 4 par 4.

```
\def\XINT_binom_smallloop #1.#2.#3.%
{%
    \ifcase\numexpr #3-#2\relax
        \expandafter\XINT_binom_end_
    \or \expandafter\XINT_binom_end_i
    \or \expandafter\XINT_binom_end_ii
    \or \expandafter\XINT_binom_end_iii
    \else\expandafter\XINT_binom_smallloop_a
    \fi #1.#2.#3.%
}%
```

Ça m'ennuie un peu de reprendre les #1, #2, #3 ici. On a besoin de \numexpr pour \XINT_binom_div, mais de \romannumeral0 pour le unsep après \XINT_binom_mul.

```
\def\XINT_binom_smallloop_a #1.#2.#3.%
{%
    \expandafter\XINT_binom_smallloop_b
    \the\numexpr #1+\xint_c_iv\expandafter.%
    \the\numexpr #2+\xint_c_iv\expandafter.%
    \the\numexpr #3\expandafter.%
    \the\numexpr\expandafter\XINT_binom_div
    \the\numexpr #2*(#2+\xint_c_i)*(#2+\xint_c_ii)*(#2+\xint_c_iii)\expandafter
    !\romannumeral0\expandafter\XINT_binom_mul
    \the\numexpr #1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_binom_smallloop_b #1.%
{%
    \ifnum #1>98  \expandafter\XINT_binom_medloop   \else
                  \expandafter\XINT_binom_smallloop \fi #1.%
}%
```

Ici on prend trois par trois.

```
\def\XINT_binom_medloop #1.#2.#3.%
{%
    \ifcase\numexpr #3-#2\relax
        \expandafter\XINT_binom_end_
    \or \expandafter\XINT_binom_end_i
```

```
    \or \expandafter\XINT_binom_end_ii
    \else\expandafter\XINT_binom_medloop_a
    \fi #1.#2.#3.%
}%
\def\XINT_binom_medloop_a #1.#2.#3.%
{%
    \expandafter\XINT_binom_medloop_b
    \the\numexpr #1+\xint_c_iii\expandafter.%
    \the\numexpr #2+\xint_c_iii\expandafter.%
    \the\numexpr #3\expandafter.%
    \the\numexpr\expandafter\XINT_binom_div
        \the\numexpr #2*(#2+\xint_c_i)*(#2+\xint_c_ii)\expandafter
    !\romannumeral0\expandafter\XINT_binom_mul
        \the\numexpr #1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_binom_medloop_b #1.%
{%
    \ifnum #1>463 \expandafter\XINT_binom_bigloop   \else
                  \expandafter\XINT_binom_medloop   \fi #1.%
}%
```

Ici on prend deux par deux.

```
\def\XINT_binom_bigloop #1.#2.#3.%
{%
    \ifcase\numexpr #3-#2\relax
        \expandafter\XINT_binom_end_
    \or \expandafter\XINT_binom_end_i
    \else\expandafter\XINT_binom_bigloop_a
    \fi #1.#2.#3.%
}%
\def\XINT_binom_bigloop_a #1.#2.#3.%
{%
    \expandafter\XINT_binom_bigloop_b
    \the\numexpr #1+\xint_c_ii\expandafter.%
    \the\numexpr #2+\xint_c_ii\expandafter.%
    \the\numexpr #3\expandafter.%
    \the\numexpr\expandafter\XINT_binom_div
        \the\numexpr #2*(#2+\xint_c_i)\expandafter
    !\romannumeral0\expandafter\XINT_binom_mul
        \the\numexpr #1*(#1+\xint_c_i)!%
}%
\def\XINT_binom_bigloop_b #1.%
{%
    \ifnum #1>9999 \expandafter\XINT_binom_vbigloop  \else
                   \expandafter\XINT_binom_bigloop   \fi #1.%
}%
```

Et finalement un par un.

```
\def\XINT_binom_vbigloop #1.#2.#3.%
{%
    \ifnum #3=#2
         \expandafter\XINT_binom_end_
    \else\expandafter\XINT_binom_vbigloop_a
    \fi #1.#2.#3.%
```

```
}%
\def\XINT_binom_vbigloop_a #1.#2.#3.%
{%
    \expandafter\XINT_binom_vbigloop
    \the\numexpr #1+\xint_c_i\expandafter.%
    \the\numexpr #2+\xint_c_i\expandafter.%
    \the\numexpr #3\expandafter.%
    \the\numexpr\expandafter\XINT_binom_div\the\numexpr #2\expandafter
    !\romannumeral0\XINT_binom_mul #1!%
}%
```

y.j.k. La partie very small. y est au plus 26 (non 29 mais retesté dans \XINT_binom_vsmallloop_a), et tous les binomial(29,n) sont <10^8. On peut donc faire y(y+1)(y+2)(y+3) et aussi il y a le fait que etex fait a*b/c en double precision. Pour ne pas bifurquer à la fin sur smallloop, si n=27, 27, ou 29 on procède un peu différemment des autres boucles. Si je testais aussi #1 après #3-#2 pour les autres il faudrait des terminaisons différentes.

```
\def\XINT_binom_vsmallloop #1.#2.#3.%
{%
    \ifcase\numexpr #3-#2\relax
        \expandafter\XINT_binom_vsmallend_
    \or \expandafter\XINT_binom_vsmallend_i
    \or \expandafter\XINT_binom_vsmallend_ii
    \or \expandafter\XINT_binom_vsmallend_iii
    \else\expandafter\XINT_binom_vsmallloop_a
    \fi #1.#2.#3.%
}%
\def\XINT_binom_vsmallloop_a #1.%
{%
    \ifnum #1>26  \expandafter\XINT_binom_smallloop_a  \else
                  \expandafter\XINT_binom_vsmallloop_b \fi #1.%
}%
\def\XINT_binom_vsmallloop_b #1.#2.#3.%
{%
    \expandafter\XINT_binom_vsmallloop
    \the\numexpr #1+\xint_c_iv\expandafter.%
    \the\numexpr #2+\xint_c_iv\expandafter.%
    \the\numexpr #3\expandafter.%
    \the\numexpr \expandafter\XINT_binom_vsmallmuldiv
    \the\numexpr  #2*(#2+\xint_c_i)*(#2+\xint_c_ii)*(#2+\xint_c_iii)\expandafter
    !\the\numexpr #1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_binom_mul #1!#21!;!0!%
{%
    \expandafter\XINT_rev_nounsep\expandafter{\expandafter}%
    \the\numexpr\expandafter\XINT_smallmul
    \the\numexpr\xint_c_x^viii+#1\expandafter
    !\romannumeral0\XINT_rev_nounsep {}1;!#2%
    \R!\R!\R!\R!\R!\R!\R!\R!\W
    \R!\R!\R!\R!\R!\R!\R!\R!\W
    1;!%
}%
\def\XINT_binom_div #1!1;!%
{%
```

```
    \expandafter\XINT_smalldivx_a
    \the\numexpr #1/\xint_c_ii\expandafter\xint:
    \the\numexpr \xint_c_x^viii+#1!%
}%
```

Vaguement envisagé d'éviter le 10^8+ mais bon.

```
\def\XINT_binom_vsmallmuldiv #1!#2!1#3!{\xint_c_x^viii+#2*#3/#1!}%
```

On a des terminaisons communes aux trois situations small, med, big, et on est sûr de pouvoir faire les multiplications dans \numexpr, car on vient ici *après* avoir comparé à 9999 ou 463 ou 98.

```
\def\XINT_binom_end_iii #1.#2.#3.%
{%
    \expandafter\XINT_binom_finish
    \the\numexpr\expandafter\XINT_binom_div
        \the\numexpr #2*(#2+\xint_c_i)*(#2+\xint_c_ii)*(#2+\xint_c_iii)\expandafter
    !\romannumeral0\expandafter\XINT_binom_mul
        \the\numexpr #1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_binom_end_ii #1.#2.#3.%
{%
    \expandafter\XINT_binom_finish
    \the\numexpr\expandafter\XINT_binom_div
        \the\numexpr #2*(#2+\xint_c_i)*(#2+\xint_c_ii)\expandafter
    !\romannumeral0\expandafter\XINT_binom_mul
        \the\numexpr #1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_binom_end_i #1.#2.#3.%
{%
    \expandafter\XINT_binom_finish
    \the\numexpr\expandafter\XINT_binom_div
        \the\numexpr #2*(#2+\xint_c_i)\expandafter
    !\romannumeral0\expandafter\XINT_binom_mul
        \the\numexpr #1*(#1+\xint_c_i)!%
}%
\def\XINT_binom_end_ #1.#2.#3.%
{%
    \expandafter\XINT_binom_finish
    \the\numexpr\expandafter\XINT_binom_div\the\numexpr #2\expandafter
    !\romannumeral0\XINT_binom_mul #1!%
}%
\def\XINT_binom_finish #1;!0!%
   {\XINT_unsep_cuzsmall #1\xint_bye!2!3!4!5!6!7!8!9!\xint_bye\xint_c_i\relax}%
```

Duplication de code seulement pour la boucle avec très petits coeffs, mais en plus on fait au maximum des possibilités. (on pourrait tester plus le résultat déjà obtenu).

```
\def\XINT_binom_vsmallend_iii #1.%
{%
    \ifnum #1>26  \expandafter\XINT_binom_end_iii \else
                  \expandafter\XINT_binom_vsmallend_iiib \fi #1.%
}%
\def\XINT_binom_vsmallend_iiib #1.#2.#3.%
{%
    \expandafter\XINT_binom_vsmallfinish
    \the\numexpr \expandafter\XINT_binom_vsmallmuldiv
```

```
    \the\numexpr  #2*(#2+\xint_c_i)*(#2+\xint_c_ii)*(#2+\xint_c_iii)\expandafter
    !\the\numexpr #1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_binom_vsmallend_ii #1.%
{%
    \ifnum #1>27  \expandafter\XINT_binom_end_ii \else
                  \expandafter\XINT_binom_vsmallend_iib \fi #1.%
}%
\def\XINT_binom_vsmallend_iib #1.#2.#3.%
{%
    \expandafter\XINT_binom_vsmallfinish
    \the\numexpr \expandafter\XINT_binom_vsmallmuldiv
    \the\numexpr  #2*(#2+\xint_c_i)*(#2+\xint_c_ii)\expandafter
    !\the\numexpr #1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_binom_vsmallend_i #1.%
{%
    \ifnum #1>28  \expandafter\XINT_binom_end_i \else
                  \expandafter\XINT_binom_vsmallend_ib \fi #1.%
}%
\def\XINT_binom_vsmallend_ib #1.#2.#3.%
{%
    \expandafter\XINT_binom_vsmallfinish
    \the\numexpr \expandafter\XINT_binom_vsmallmuldiv
    \the\numexpr  #2*(#2+\xint_c_i)\expandafter
    !\the\numexpr #1*(#1+\xint_c_i)!%
}%
\def\XINT_binom_vsmallend_ #1.%
{%
    \ifnum #1>29  \expandafter\XINT_binom_end_ \else
                  \expandafter\XINT_binom_vsmallend_b \fi #1.%
}%
\def\XINT_binom_vsmallend_b #1.#2.#3.%
{%
    \expandafter\XINT_binom_vsmallfinish
    \the\numexpr\XINT_binom_vsmallmuldiv #2!#1!%
}%
\def\XINT_binom_vsmallfinish#1{%
\def\XINT_binom_vsmallfinish1##1!1!;!0!{\expandafter#1\the\numexpr##1\relax}%
}\XINT_binom_vsmallfinish{ }%
```

6.54 \xintiiPFactorial

2015/11/29 for 1.2f. Partial factorial pfac(a,b)=(a+1)...b, only for non-negative integers with a<=b<10^8.

1.2h (2016/11/20) removes the non-negativity condition. It was a bit unfortunate that the code raised \xintError:OutOfRangePFac if 0<=a<=b<10^8 was violated. The rule now applied is to interpret pfac(a,b) as the product for a<j<=b (not as a ratio of Gamma function), hence if a>=b, return 1 because of an empty product. If a<b: if a<0, return 0 for b>=0 and (-1)^(b-a) times |b|...(|a|-1) for b<0. But only for the range 0<= a <= b < 10^8 is the macro result to be considered as stable.

```
\def\xintiiPFactorial {\romannumeral0\xintiipfactorial }%
\def\xintiipfactorial #1#2%
```

```
{%
    \expandafter\XINT_pfac_fork\the\numexpr#1\expandafter.\the\numexpr #2.%
}%
\def\xintPFactorial{\romannumeral0\xintpfactorial}%
\let\xintpfactorial\xintiipfactorial
```

Code is a simplified version of the one for \xintiiBinomial, with no attempt at implementing a "very small" branch.

```
\def\XINT_pfac_fork #1#2.#3#4.%
{%
    \unless\ifnum #1#2<#3#4 \xint_dothis\XINT_pfac_one\fi
    \if-#3\xint_dothis\XINT_pfac_neg\fi
    \if-#1\xint_dothis\XINT_pfac_zero\fi
    \ifnum #3#4>\xint_c_x^viii_mone\xint_dothis\XINT_pfac_outofrange\fi
    \xint_orthat \XINT_pfac_a #1#2.#3#4.%
}%
\def\XINT_pfac_outofrange #1.#2.%
   {\XINT_signalcondition{InvalidOperation}%
         {pFactorial with too large argument: #2 >= 10^8.}{}{ 0}}%
\def\XINT_pfac_one        #1.#2.{ 1}%
\def\XINT_pfac_zero       #1.#2.{ 0}%
\def\XINT_pfac_neg -#1.-#2.%
{%
    \ifnum #1>\xint_c_x^viii\xint_dothis\XINT_pfac_outofrange\fi
    \xint_orthat
   {\ifodd\numexpr#2-#1\relax\xint_afterfi{\expandafter-\romannumeral`&&@}\fi
    \expandafter\XINT_pfac_a }%
    \the\numexpr #2-\xint_c_i\expandafter.\the\numexpr#1-\xint_c_i.%
}%
\def\XINT_pfac_a #1.#2.%
{%
    \expandafter\XINT_pfac_b\the\numexpr \xint_c_i+#1.#2.100000001!1;!%
    1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!1\R!\W
}%
\def\XINT_pfac_b #1.%
{%
    \ifnum #1>9999 \xint_dothis\XINT_pfac_vbigloop \fi
    \ifnum #1>463  \xint_dothis\XINT_pfac_bigloop   \fi
    \ifnum #1>98   \xint_dothis\XINT_pfac_medloop   \fi
                   \xint_orthat\XINT_pfac_smallloop #1.%
}%
\def\XINT_pfac_smallloop #1.#2.%
{%
    \ifcase\numexpr #2-#1\relax
        \expandafter\XINT_pfac_end_
    \or \expandafter\XINT_pfac_end_i
    \or \expandafter\XINT_pfac_end_ii
    \or \expandafter\XINT_pfac_end_iii
    \else\expandafter\XINT_pfac_smallloop_a
    \fi #1.#2.%
}%
\def\XINT_pfac_smallloop_a #1.#2.%
{%
```

```
    \expandafter\XINT_pfac_smallloop_b
    \the\numexpr #1+\xint_c_iv\expandafter.%
    \the\numexpr #2\expandafter.%
    \the\numexpr\expandafter\XINT_smallmul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_pfac_smallloop_b #1.%
{%
    \ifnum #1>98  \expandafter\XINT_pfac_medloop   \else
                  \expandafter\XINT_pfac_smallloop \fi #1.%
}%
\def\XINT_pfac_medloop #1.#2.%
{%
    \ifcase\numexpr #2-#1\relax
        \expandafter\XINT_pfac_end_
    \or \expandafter\XINT_pfac_end_i
    \or \expandafter\XINT_pfac_end_ii
    \else\expandafter\XINT_pfac_medloop_a
    \fi #1.#2.%
}%
\def\XINT_pfac_medloop_a #1.#2.%
{%
    \expandafter\XINT_pfac_medloop_b
    \the\numexpr #1+\xint_c_iii\expandafter.%
    \the\numexpr #2\expandafter.%
    \the\numexpr\expandafter\XINT_smallmul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_pfac_medloop_b #1.%
{%
    \ifnum #1>463 \expandafter\XINT_pfac_bigloop   \else
                  \expandafter\XINT_pfac_medloop   \fi #1.%
}%
\def\XINT_pfac_bigloop #1.#2.%
{%
    \ifcase\numexpr #2-#1\relax
        \expandafter\XINT_pfac_end_
    \or \expandafter\XINT_pfac_end_i
    \else\expandafter\XINT_pfac_bigloop_a
    \fi #1.#2.%
}%
\def\XINT_pfac_bigloop_a #1.#2.%
{%
    \expandafter\XINT_pfac_bigloop_b
    \the\numexpr #1+\xint_c_ii\expandafter.%
    \the\numexpr #2\expandafter.%
    \the\numexpr\expandafter
    \XINT_smallmul\the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)!%
}%
\def\XINT_pfac_bigloop_b #1.%
{%
    \ifnum #1>9999 \expandafter\XINT_pfac_vbigloop  \else
```

```
                    \expandafter\XINT_pfac_bigloop   \fi #1.%
}%
\def\XINT_pfac_vbigloop #1.#2.%
{%
    \ifnum #2=#1
         \expandafter\XINT_pfac_end_
    \else\expandafter\XINT_pfac_vbigloop_a
    \fi #1.#2.%
}%
\def\XINT_pfac_vbigloop_a #1.#2.%
{%
    \expandafter\XINT_pfac_vbigloop
    \the\numexpr #1+\xint_c_i\expandafter.%
    \the\numexpr #2\expandafter.%
    \the\numexpr\expandafter\XINT_smallmul\the\numexpr\xint_c_x^viii+#1!%
}%
\def\XINT_pfac_end_iii #1.#2.%
{%
    \expandafter\XINT_mul_out
    \the\numexpr\expandafter\XINT_smallmul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_pfac_end_ii #1.#2.%
{%
    \expandafter\XINT_mul_out
    \the\numexpr\expandafter\XINT_smallmul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_pfac_end_i #1.#2.%
{%
    \expandafter\XINT_mul_out
    \the\numexpr\expandafter\XINT_smallmul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)!%
}%
\def\XINT_pfac_end_ #1.#2.%
{%
    \expandafter\XINT_mul_out
    \the\numexpr\expandafter\XINT_smallmul\the\numexpr \xint_c_x^viii+#1!%
}%
```

6.55 \xintBool, \xintToggle

1.09c

```
\def\xintBool #1{\romannumeral`&&@%
                  \csname if#1\endcsname\expandafter1\else\expandafter0\fi }%
\def\xintToggle #1{\romannumeral`&&@\iftoggle{#1}{1}{0}}%
```

6.56 \xintiiGCD

1.3d: \xintiiGCD code from xintgcd is copied here to support gcd() function in \xintiiexpr.
1.4: removed from xintgcd the original caode as now xintgcd loads xint.

Modified at 1.4d (2021/03/29). Damn'ed! Since 1.3d (2019/01/06) the code was broken if one of the arguments vanished due to a typo in macro names: "AisZero" at one location and "Aiszero" at next, and same for B...

How could this not be detected by my tests !?!

This caused \xintiiGCDof hence the gcd() function in \xintiiexpr to break as soon as one argument was zero.

```
\def\xintiiGCD {\romannumeral0\xintiigcd }%
\def\xintiigcd #1{\expandafter\XINT_iigcd\romannumeral0\xintiiabs#1\xint:}%
\def\XINT_iigcd #1#2\xint:#3%
{%
    \expandafter\XINT_gcd_fork\expandafter#1%
                \romannumeral0\xintiiabs#3\xint:#1#2\xint:
}%
\def\XINT_gcd_fork #1#2%
{%
    \xint_UDzerofork
      #1\XINT_gcd_Aiszero
      #2\XINT_gcd_Biszero
       0\XINT_gcd_loop
    \krof
    #2%
}%
\def\XINT_gcd_Aiszero #1\xint:#2\xint:{ #1}%
\def\XINT_gcd_Biszero #1\xint:#2\xint:{ #2}%
\def\XINT_gcd_loop #1\xint:#2\xint:
{%
    \expandafter\expandafter\expandafter\XINT_gcd_CheckRem
    \expandafter\xint_secondoftwo
    \romannumeral0\XINT_div_prepare {#1}{#2}\xint:#1\xint:
}%
\def\XINT_gcd_CheckRem #1%
{%
    \xint_gob_til_zero #1\XINT_gcd_end0\XINT_gcd_loop #1%
}%
\def\XINT_gcd_end0\XINT_gcd_loop #1\xint:#2\xint:{ #2}%
```

6.57 \xintiiGCDof

New with 1.09a (was located in xintgcd.sty).

1.21 adds protection against items being non-terminated \the\numexpr.

1.4 renames the macro into \xintiiGCDof and moves it here. Terminator modified to ^ for direct call by \xintiiexpr function.

1.4d fixes breakage inherited since 1.3d rom \xintiiGCD, in case any argument vanished.

Currently does not support empty list of arguments.

```
\def\xintiiGCDof    {\romannumeral0\xintiigcdof }%
\def\xintiigcdof    #1{\expandafter\XINT_iigcdof_a\romannumeral`&&@#1^}%
\def\XINT_iiGCDof   {\romannumeral0\XINT_iigcdof_a}%
\def\XINT_iigcdof_a #1{\expandafter\XINT_iigcdof_b\romannumeral`&&@#1!}%
\def\XINT_iigcdof_b #1!#2{\expandafter\XINT_iigcdof_c\romannumeral`&&@#2!{#1}!}%
\def\XINT_iigcdof_c #1{\xint_gob_til_^ #1\XINT_iigcdof_e ^\XINT_iigcdof_d #1}%
\def\XINT_iigcdof_d #1!{\expandafter\XINT_iigcdof_b\romannumeral0\xintiigcd {#1}}%
\def\XINT_iigcdof_e #1!#2!{ #2}%
```

6.58 \xintiiLCM

Copied over \xintiiLCM code from xintgcd at 1.3d in order to support lcm() function in \xintiiexpr.
At 1.4 original code removed from xintgcd as the latter now requires xint.

```
\def\xintiiLCM {\romannumeral0\xintiilcm}%
\def\xintiilcm #1{\expandafter\XINT_iilcm\romannumeral0\xintiiabs#1\xint:}%
\def\XINT_iilcm #1#2\xint:#3%
{%
    \expandafter\XINT_lcm_fork\expandafter#1%
                \romannumeral0\xintiiabs#3\xint:#1#2\xint:
}%
\def\XINT_lcm_fork #1#2%
{%
    \xint_UDzerofork
      #1\XINT_lcm_iszero
      #2\XINT_lcm_iszero
       0\XINT_lcm_notzero
    \krof
    #2%
}%
\def\XINT_lcm_iszero #1\xint:#2\xint:{ 0}%
\def\XINT_lcm_notzero #1\xint:#2\xint:
{%
    \expandafter\XINT_lcm_end\romannumeral0%
      \expandafter\expandafter\expandafter\XINT_gcd_CheckRem
      \expandafter\xint_secondoftwo
      \romannumeral0\XINT_div_prepare {#1}{#2}\xint:#1\xint:
    \xint:#1\xint:#2\xint:
}%
\def\XINT_lcm_end #1\xint:#2\xint:#3\xint:{\xintiimul {#2}{\xintiiQuo{#3}{#1}}}%
```

6.59 \xintiiLCMof

See comments of \xintiiGCDof.

```
\def\xintiiLCMof      {\romannumeral0\xintiilcmof }%
\def\xintiilcmof    #1{\expandafter\XINT_iilcmof_a\romannumeral`&&@#1^}%
\def\XINT_iiLCMof   {\romannumeral0\XINT_iilcmof_a}%
\def\XINT_iilcmof_a #1{\expandafter\XINT_iilcmof_b\romannumeral`&&@#1!}%
\def\XINT_iilcmof_b #1!#2{\expandafter\XINT_iilcmof_c\romannumeral`&&@#2!{#1}!}%
\def\XINT_iilcmof_c #1{\xint_gob_til_^ #1\XINT_iilcmof_e ^\XINT_iilcmof_d #1}%
\def\XINT_iilcmof_d #1!{\expandafter\XINT_iilcmof_b\romannumeral0\xintiilcm {#1}}%
\def\XINT_iilcmof_e #1!#2!{ #2}%
```

6.60 (WIP) \xintRandomDigits

1.3b. See user manual. Whether this will be part of xintkernel, xintcore, or xint is yet to be decided.

```
\def\xintRandomDigits{\romannumeral0\xintrandomdigits}%
\def\xintrandomdigits#1%
{%
    \csname xint_gob_andstop_\expandafter\XINT_randomdigits\the\numexpr#1\xint:
}%
```

```
\def\XINT_randomdigits#1\xint:
{%
    \expandafter\XINT_randomdigits_a
    \the\numexpr(#1+\xint_c_iii)/\xint_c_viii\xint:#1\xint:
}%
\def\XINT_randomdigits_a#1\xint:#2\xint:
{%
    \romannumeral\numexpr\xint_c_viii*#1-#2\csname XINT_%
      \romannumeral\XINT_replicate #1\endcsname \csname
    XINT_rdg\endcsname
}%
\def\XINT_rdg
{%
    \expandafter\XINT_rdg_aux\the\numexpr%
                \xint_c_nine_x^viii%
                               -\xint_texuniformdeviate\xint_c_ii^vii%
                -\xint_c_ii^vii*\xint_texuniformdeviate\xint_c_ii^vii%
                -\xint_c_ii^xiv*\xint_texuniformdeviate\xint_c_ii^vii%
                -\xint_c_ii^xxi*\xint_texuniformdeviate\xint_c_ii^vii%
                +\xint_texuniformdeviate\xint_c_x^viii%
                \relax%
}%
\def\XINT_rdg_aux#1{XINT_rdg\endcsname}%
\let\XINT_XINT_rdg\endcsname
```

6.61 (WIP) \XINT_eightrandomdigits, \xintEightRandomDigits

1.3b. 1.4 adds some public alias...

```
\def\XINT_eightrandomdigits
{%
     \expandafter\xint_gobble_i\the\numexpr%
                \xint_c_nine_x^viii%
                               -\xint_texuniformdeviate\xint_c_ii^vii%
                -\xint_c_ii^vii*\xint_texuniformdeviate\xint_c_ii^vii%
                -\xint_c_ii^xiv*\xint_texuniformdeviate\xint_c_ii^vii%
                -\xint_c_ii^xxi*\xint_texuniformdeviate\xint_c_ii^vii%
                +\xint_texuniformdeviate\xint_c_x^viii%
                \relax%
}%
\let\xintEightRandomDigits\XINT_eightrandomdigits
\def\xintRandBit{\xint_texuniformdeviate\xint_c_ii}%
```

6.62 (WIP) \xintRandBit

1.4 And let's add also \xintRandBit while we are at it.

```
\def\xintRandBit{\xint_texuniformdeviate\xint_c_ii}%
```

6.63 (WIP) \xintXRandomDigits

1.3b.

```
\def\xintXRandomDigits#1%
{%
```

```
    \csname xint_gobble_\expandafter\XINT_xrandomdigits\the\numexpr#1\xint:
}%
\def\XINT_xrandomdigits#1\xint:
{%
    \expandafter\XINT_xrandomdigits_a
    \the\numexpr(#1+\xint_c_iii)/\xint_c_viii\xint:#1\xint:
}%
\def\XINT_xrandomdigits_a#1\xint:#2\xint:
{%
    \romannumeral\numexpr\xint_c_viii*#1-#2\expandafter\endcsname
    \romannumeral`&&@\romannumeral
                     \XINT_replicate #1\endcsname\XINT_eightrandomdigits
}%
```

6.64 (WIP) \xintiiRandRangeAtoB

1.3b. Support for randrange() function.

We do it f-expandably for matters of \xintNewExpr etc... The \xintexpr will add \xintNum wrapper to possible fractional input. But \xintiiexpr will call as is.

TODO: ? implement third argument (STEP) TODO: \xintNum wrapper (which truncates) not so good in floatexpr. Use round?

It is an error if b<=a, as in Python.

```
\def\xintiiRandRangeAtoB{\romannumeral`&&@\xintiirandrangeAtoB}%
\def\xintiirandrangeAtoB#1%
{%
    \expandafter\XINT_randrangeAtoB_a\romannumeral`&&@#1\xint:
}%
\def\XINT_randrangeAtoB_a#1\xint:#2%
{%
    \xintiiadd{\expandafter\XINT_randrange
               \romannumeral0\xintiisub{#2}{#1}\xint:}%
              {#1}%
}%
```

6.65 (WIP) \xintiiRandRange

1.3b. Support for randrange().

```
\def\xintiiRandRange{\romannumeral`&&@\xintiirandrange}%
\def\xintiirandrange#1%
{%
    \expandafter\XINT_randrange\romannumeral`&&@#1\xint:
}%
\def\XINT_randrange #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_randrange_err:empty
      0#1\XINT_randrange_err:empty
       0-\XINT_randrange_a
    \krof #1%
}%
\def\XINT_randrange_err:empty#1\xint:
{%
```

```
    \XINT_expandableerror{Empty range for randrange.} 0%
}%
\def\XINT_randrange_a #1\xint:
{%
    \expandafter\XINT_randrange_b\romannumeral0\xintlength{#1}.#1\xint:
}%
\def\XINT_randrange_b #1.%
{%
    \ifnum#1<\xint_c_x\xint_dothis{\the\numexpr\XINT_uniformdeviate{}}\fi
    \xint_orthat{\XINT_randrange_c #1.}%
}%
\def\XINT_randrange_c #1.#2#3#4#5#6#7#8#9%
{%
    \expandafter\XINT_randrange_d
    \the\numexpr\expandafter\XINT_uniformdeviate\expandafter
       {\expandafter}\the\numexpr\xint_c_i+#2#3#4#5#6#7#8#9\xint:\xint:
    #2#3#4#5#6#7#8#9\xint:#1\xint:
}%
```

This raises following annex question: immediately after setting the seed is it possible for \xintUniformDeviate{N} where N>0 has exactly eight digits to return either 0 or N-1 ? It could be that this is never the case, then there is a bias in randrange(). Of course there are anyhow only 2^28 seeds so randrange(10^X) is by necessity biased when executed immediately after setting the seed, if X is at least 9.

```
\def\XINT_randrange_d #1\xint:#2\xint:
{%
    \ifnum#1=\xint_c_\xint_dothis\XINT_randrange_Z\fi
    \ifnum#1=#2 \xint_dothis\XINT_randrange_A\fi
    \xint_orthat\XINT_randrange_e #1\xint:
}%
\def\XINT_randrange_e #1\xint:#2\xint:#3\xint:
{%
    \the\numexpr#1\expandafter\relax
    \romannumeral0\xintrandomdigits{#2-\xint_c_viii}%
}%
```

This is quite unlikely to get executed but if it does it must pay attention to leading zeros, hence the \xintinum. We don't have to be overly obstinate about removing overheads...

```
\def\XINT_randrange_Z 0\xint:#1\xint:#2\xint:
{%
    \xintinum{\xintRandomDigits{#1-\xint_c_viii}}%
}%
```

Here too, overhead is not such a problem. The idea is that we got by extraordinary same first 8 digits as upper range bound so we pick at random the remaining needed digits in one go and compare with the upper bound. If too big, we start again with another random 8 leading digits in given range. No need to aim at any kind of efficiency for the check and loop back.

```
\def\XINT_randrange_A #1\xint:#2\xint:#3\xint:
{%
    \expandafter\XINT_randrange_B
    \romannumeral0\xintrandomdigits{#2-\xint_c_viii}\xint:
    #3\xint:#2.#1\xint:
}%
\def\XINT_randrange_B #1\xint:#2\xint:#3.#4\xint:
```

```
{%
    \xintiiifLt{#1}{#2}{\XINT_randrange_E}{\XINT_randrange_again}%
    #4#1\xint:#3.#4#2\xint:
}%
\def\XINT_randrange_E #1\xint:#2\xint:{ #1}%
\def\XINT_randrange_again #1\xint:{\XINT_randrange_c}%
```

6.66 (WIP) Adjustments for engines without uniformdeviate primitive

1.3b.

```
\ifdefined\xint_texuniformdeviate
\else
  \def\xintrandomdigits#1%
  {%
      \XINT_expandableerror
      {No uniformdeviate at engine level.} 0%
  }%
  \let\xintXRandomDigits\xintRandomDigits
  \def\XINT_randrange#1\xint:
  {%
      \XINT_expandableerror
      {No uniformdeviate at engine level.} 0%
  }%
\fi
\XINTrestorecatcodesendinput%
```

7 Package xintbinhex implementation

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The commenting is currently (2022/06/11) very sparse.

The macros from 1.08 (2013/06/07) remained unchanged until their complete rewrite at 1.2m (2017/07/31).

At 1.2n dependencies on xintcore were removed, so now the package loads only xintkernel (this could have been done earlier).

Also at 1.2n, macros evolved again, the main improvements being in the increased allowable sizes of the input for \xintDecToHex, \xintDecToBin, \xintBinToHex. Use of \csname governed expansion at some places rather than \numexpr with some clean-up after it.

7.1 Catcodes, ε-TEX and reload detection

The code for reload detection was initially copied from Heiko Oberdiek's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5    % ^^M
  \endlinechar=13 %
  \catcode123=1   % {
  \catcode125=2   % }
  \catcode64=11   % @
  \catcode44=12   % ,
  \catcode46=12   % .
  \catcode58=12   % :
  \catcode94=7    % ^
  \def\empty{}\def\space{ }\newlinechar10
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xintbinhex.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xintkernel.sty\endcsname
  \expandafter\ifx\csname numexpr\endcsname\relax
    \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
      \immediate\write128{^^JPackage xintbinhex Warning:^^J%
                          \space\space\space\space
                          \numexpr not available, aborting input.^^J}%
    \else
      \PackageWarningNoLine{xintbinhex}{\numexpr not available, aborting input}%
    \fi
    \def\z{\endgroup\endinput}%
  \else
    \ifx\x\relax   % plain-TeX, first loading of xintbinhex.sty
      \ifx\w\relax % but xintkernel.sty not yet loaded.
         \def\z{\endgroup\input xintkernel.sty\relax}%
      \fi
    \else
      \ifx\x\empty % LaTeX, first loading,
```

```
      % variable is initialized, but \ProvidesPackage not yet seen
          \ifx\w\relax % xintkernel.sty not yet loaded.
            \def\z{\endgroup\RequirePackage{xintkernel}}%
          \fi
      \else
        \def\z{\endgroup\endinput}% xintbinhex already loaded.
      \fi
    \fi
  \fi
\z%
\XINTsetupcatcodes% defined in xintkernel.sty
```

7.2 Package identification

```
\XINT_providespackage
\ProvidesPackage{xintbinhex}%
  [2022/06/10 v1.4m Expandable binary and hexadecimal conversions (JFB)]%
```

7.3 Constants, etc...

1.2n switches to \csname-governed expansion at various places.

```
\newcount\xint_c_ii^xv  \xint_c_ii^xv   32768
\newcount\xint_c_ii^xvi \xint_c_ii^xvi  65536
\def\XINT_tmpa #1{\ifx\relax#1\else
  \expandafter\edef\csname XINT_csdth_#1\endcsname
  {\endcsname\ifcase #1 0\or 1\or 2\or 3\or 4\or 5\or 6\or 7\or
              8\or 9\or A\or B\or C\or D\or E\or F\fi}%
  \expandafter\XINT_tmpa\fi }%
\XINT_tmpa {0}{1}{2}{3}{4}{5}{6}{7}{8}{9}{10}{11}{12}{13}{14}{15}\relax
\def\XINT_tmpa #1{\ifx\relax#1\else
  \expandafter\edef\csname XINT_csdtb_#1\endcsname
  {\endcsname\ifcase #1
   0000\or 0001\or 0010\or 0011\or 0100\or 0101\or 0110\or 0111\or
   1000\or 1001\or 1010\or 1011\or 1100\or 1101\or 1110\or 1111\fi}%
  \expandafter\XINT_tmpa\fi }%
\XINT_tmpa {0}{1}{2}{3}{4}{5}{6}{7}{8}{9}{10}{11}{12}{13}{14}{15}\relax
\let\XINT_tmpa\relax
\expandafter\def\csname XINT_csbth_0000\endcsname {\endcsname0}%
\expandafter\def\csname XINT_csbth_0001\endcsname {\endcsname1}%
\expandafter\def\csname XINT_csbth_0010\endcsname {\endcsname2}%
\expandafter\def\csname XINT_csbth_0011\endcsname {\endcsname3}%
\expandafter\def\csname XINT_csbth_0100\endcsname {\endcsname4}%
\expandafter\def\csname XINT_csbth_0101\endcsname {\endcsname5}%
\expandafter\def\csname XINT_csbth_0110\endcsname {\endcsname6}%
\expandafter\def\csname XINT_csbth_0111\endcsname {\endcsname7}%
\expandafter\def\csname XINT_csbth_1000\endcsname {\endcsname8}%
\expandafter\def\csname XINT_csbth_1001\endcsname {\endcsname9}%
\expandafter\def\csname XINT_csbth_1010\endcsname {\endcsname A}%
\expandafter\def\csname XINT_csbth_1011\endcsname {\endcsname B}%
\expandafter\def\csname XINT_csbth_1100\endcsname {\endcsname C}%
\expandafter\def\csname XINT_csbth_1101\endcsname {\endcsname D}%
\expandafter\def\csname XINT_csbth_1110\endcsname {\endcsname E}%
```

```
\expandafter\def\csname XINT_csbth_1111\endcsname {\endcsname F}%
\let\XINT_csbth_none \endcsname
\expandafter\def\csname XINT_cshtb_0\endcsname {\endcsname0000}%
\expandafter\def\csname XINT_cshtb_1\endcsname {\endcsname0001}%
\expandafter\def\csname XINT_cshtb_2\endcsname {\endcsname0010}%
\expandafter\def\csname XINT_cshtb_3\endcsname {\endcsname0011}%
\expandafter\def\csname XINT_cshtb_4\endcsname {\endcsname0100}%
\expandafter\def\csname XINT_cshtb_5\endcsname {\endcsname0101}%
\expandafter\def\csname XINT_cshtb_6\endcsname {\endcsname0110}%
\expandafter\def\csname XINT_cshtb_7\endcsname {\endcsname0111}%
\expandafter\def\csname XINT_cshtb_8\endcsname {\endcsname1000}%
\expandafter\def\csname XINT_cshtb_9\endcsname {\endcsname1001}%
\def\XINT_cshtb_A {\endcsname1010}%
\def\XINT_cshtb_B {\endcsname1011}%
\def\XINT_cshtb_C {\endcsname1100}%
\def\XINT_cshtb_D {\endcsname1101}%
\def\XINT_cshtb_E {\endcsname1110}%
\def\XINT_cshtb_F {\endcsname1111}%
\let\XINT_cshtb_none \endcsname
```

7.4 Helper macros

7.4.1 \XINT_zeroes_foriv

```
\romannumeral0\XINT_zeroes_foriv #1\R{0\R}{00\R}{000\R}%
                                     \R{0\R}{00\R}{000\R}\R\W
```

expands to the <empty> or 0 or 00 or 000 needed which when adjoined to #1 extend it to length 4N.

```
\def\XINT_zeroes_foriv #1#2#3#4#5#6#7#8%
{%
    \xint_gob_til_R #8\XINT_zeroes_foriv_end\R\XINT_zeroes_foriv
}%
\def\XINT_zeroes_foriv_end\R\XINT_zeroes_foriv #1#2\W
   {\XINT_zeroes_foriv_done #1}%
\def\XINT_zeroes_foriv_done #1\R{ #1}%
```

7.5 \xintDecToHex

Complete rewrite at 1.2m in the 1.2 style. Also, 1.2m is robust against non terminated inputs.

Improvements of coding at 1.2n, increased maximal size. Again some coding improvement at 1.2o, about 6% speed gain.

An input without leading zeroes gives an output without leading zeroes.

```
\def\xintDecToHex {\romannumeral0\xintdectohex }%
\def\xintdectohex #1%
{%
    \expandafter\XINT_dth_checkin\romannumeral`&&@#1\xint:
}%
\def\XINT_dth_checkin #1%
{%
    \xint_UDsignfork
       #1\XINT_dth_neg
        -{\XINT_dth_main #1}%
     \krof
```

```
}%
\def\XINT_dth_neg {\expandafter-\romannumeral0\XINT_dth_main}%
\def\XINT_dth_main #1\xint:
{%
    \expandafter\XINT_dth_finish
    \romannumeral`&&@\expandafter\XINT_dthb_start
    \romannumeral0\XINT_zeroes_foriv
       #1\R{0\R}{00\R}{000\R}\R{0\R}{00\R}{000\R}\R\W
    #1\xint_bye\XINT_dth_tohex
}%
\def\XINT_dthb_start #1#2#3#4#5%
{%
    \xint_bye#5\XINT_dthb_small\xint_bye\XINT_dthb_start_a #1#2#3#4#5%
}%
\def\XINT_dthb_small\xint_bye\XINT_dthb_start_a #1\xint_bye#2{#2#1!}%
\def\XINT_dthb_start_a #1#2#3#4#5#6#7#8#9%
{%
    \expandafter\XINT_dthb_again\the\numexpr\expandafter\XINT_dthb_update
    \the\numexpr#1#2#3#4%
    \xint_bye#9\XINT_dthb_lastpass\xint_bye
    #5#6#7#8!\XINT_dthb_exclam\relax\XINT_dthb_nextfour #9%
}%
```

The 1.2n inserted exclamations marks, which when bumping back from \XINT_dthb_again gave rise to a \numexpr-loop which gathered the ! delimited arguments and inserted \expandafter\XINT_dthb_update\the\numexpr dynamically. The 1.2o trick is to insert it here immediately. Then at \XINT_dthb_again the \numexpr will trigger an already prepared chain.

The crux of the thing is handling of #3 at \XINT_dthb_update_a.

```
\def\XINT_dthb_exclam {!\XINT_dthb_exclam\relax
                         \expandafter\XINT_dthb_update\the\numexpr}%
\def\XINT_dthb_update #1!%
{%
    \expandafter\XINT_dthb_update_a
    \the\numexpr (#1+\xint_c_ii^xv)/\xint_c_ii^xvi-\xint_c_i\xint:
    #1\xint:%
}%
\def\XINT_dthb_update_a #1\xint:#2\xint:#3%
{%
    0000+#1\expandafter#3\the\numexpr#2-#1*\xint_c_ii^xvi
}%
```

1.2m and 1.2n had some unduly complicated ending pattern for \XINT_dthb_nextfour as inheritance of a loop needing ! separators which was pruned out at 1.2o (see previous comment).

```
\def\XINT_dthb_nextfour #1#2#3#4#5%
{%
    \xint_bye#5\XINT_dthb_lastpass\xint_bye
    #1#2#3#4!\XINT_dthb_exclam\relax\XINT_dthb_nextfour#5%
}%
\def\XINT_dthb_lastpass\xint_bye #1!#2\xint_bye#3{#1!#3!}%
\def\XINT_dth_tohex
{%
    \expandafter\expandafter\expandafter\XINT_dth_tohex_a\csname\XINT_tofourhex
}%
```

```
\def\XINT_dth_tohex_a\endcsname{!\XINT_dth_tohex!}%
\def\XINT_dthb_again #1!#2#3%
{%
    \ifx#3\relax
          \expandafter\xint_firstoftwo
      \else
          \expandafter\xint_secondoftwo
    \fi
    {\expandafter\XINT_dthb_again
     \the\numexpr
     \ifnum #1>\xint_c_
        \xint_afterfi{\expandafter\XINT_dthb_update\the\numexpr#1}%
     \fi}%
    {\ifnum #1>\xint_c_ \xint_dothis{#2#1!}\fi\xint_orthat{!#2!}}%
}%
\def\XINT_tofourhex #1!%
{%
    \expandafter\XINT_tofourhex_a
    \the\numexpr (#1+\xint_c_ii^vii)/\xint_c_ii^viii-\xint_c_i\xint:
    #1\xint:
}%
\def\XINT_tofourhex_a #1\xint:#2\xint:
{%
    \expandafter\XINT_tofourhex_c
    \the\numexpr (#1+\xint_c_viii)/\xint_c_xvi-\xint_c_i\xint:
    #1\xint:
    \the\numexpr #2-\xint_c_ii^viii*#1!%
}%
\def\XINT_tofourhex_c #1\xint:#2\xint:
{%
    XINT_csdth_#1%
    \csname XINT_csdth_\the\numexpr #2-\xint_c_xvi*#1\relax
    \csname \expandafter\XINT_tofourhex_d
}%
\def\XINT_tofourhex_d #1!%
{%
    \expandafter\XINT_tofourhex_e
    \the\numexpr (#1+\xint_c_viii)/\xint_c_xvi-\xint_c_i\xint:
    #1\xint:
}%
\def\XINT_tofourhex_e #1\xint:#2\xint:
{%
    XINT_csdth_#1%
    \csname XINT_csdth_\the\numexpr #2-\xint_c_xvi*#1\endcsname
}%
```

We only clean-up up to 3 zero hexadecimal digits, as output was produced in chunks of 4 hex digits. If input had no leading zero, output will have none either. If input had many leading zeroes, output will have some number (unspecified, but a recipe can be given...) of leading zeroes...

The coding is for varying a bit, I did not check if efficient, it does not matter.

```
\def\XINT_dth_finish !\XINT_dth_tohex!#1#2#3%
{%
    \unless\if#10\xint_dothis{ #1#2#3}\fi
```

```
    \unless\if#20\xint_dothis{ #2#3}\fi
    \unless\if#30\xint_dothis{ #3}\fi
    \xint_orthat{ }%
}%
```

7.6 \xintDecToBin

Complete rewrite at 1.2m in the 1.2 style. Also, 1.2m is robust against non terminated inputs.
Revisited at 1.2n like in \xintDecToHex: increased maximal size.
An input without leading zeroes gives an output without leading zeroes.
Most of the code canvas is shared with \xintDecToHex.

```
\def\xintDecToBin {\romannumeral0\xintdectobin }%
\def\xintdectobin #1%
{%
    \expandafter\XINT_dtb_checkin\romannumeral`&&@#1\xint:
}%
\def\XINT_dtb_checkin #1%
{%
    \xint_UDsignfork
       #1\XINT_dtb_neg
        -{\XINT_dtb_main #1}%
     \krof
}%
\def\XINT_dtb_neg {\expandafter-\romannumeral0\XINT_dtb_main}%
\def\XINT_dtb_main #1\xint:
{%
    \expandafter\XINT_dtb_finish
    \romannumeral`&&@\expandafter\XINT_dthb_start
    \romannumeral0\XINT_zeroes_foriv
       #1\R{0\R}{00\R}{000\R}\R{0\R}{00\R}{000\R}\R\W
    #1\xint_bye\XINT_dtb_tobin
}%
\def\XINT_dtb_tobin
{%
    \expandafter\expandafter\expandafter\XINT_dtb_tobin_a\csname\XINT_tosixteenbits
}%
\def\XINT_dtb_tobin_a\endcsname{!\XINT_dtb_tobin!}%
\def\XINT_tosixteenbits #1!%
{%
    \expandafter\XINT_tosixteenbits_a
    \the\numexpr (#1+\xint_c_ii^vii)/\xint_c_ii^viii-\xint_c_i\xint:
    #1\xint:
}%
\def\XINT_tosixteenbits_a #1\xint:#2\xint:
{%
    \expandafter\XINT_tosixteenbits_c
    \the\numexpr (#1+\xint_c_viii)/\xint_c_xvi-\xint_c_i\xint:
    #1\xint:
    \the\numexpr #2-\xint_c_ii^viii*#1!%
}%
\def\XINT_tosixteenbits_c #1\xint:#2\xint:
{%
```

```
    XINT_csdtb_#1%
    \csname XINT_csdtb_\the\numexpr #2-\xint_c_xvi*#1\relax
    \csname \expandafter\XINT_tosixteenbits_d
}%
\def\XINT_tosixteenbits_d #1!%
{%
    \expandafter\XINT_tosixteenbits_e
    \the\numexpr (#1+\xint_c_viii)/\xint_c_xvi-\xint_c_i\xint:
    #1\xint:
}%
\def\XINT_tosixteenbits_e #1\xint:#2\xint:
{%
    XINT_csdtb_#1%
    \csname XINT_csdtb_\the\numexpr #2-\xint_c_xvi*#1\endcsname
}%
\def\XINT_dtb_finish !\XINT_dtb_tobin!#1#2#3#4#5#6#7#8%
{%
    \expandafter\XINT_dtb_finish_a\the\numexpr #1#2#3#4#5#6#7#8\relax
}%
\def\XINT_dtb_finish_a #1{%
\def\XINT_dtb_finish_a ##1##2##3##4##5##6##7##8##9%
{%
    \expandafter#1\the\numexpr ##1##2##3##4##5##6##7##8##9\relax
}}\XINT_dtb_finish_a { }%
```

7.7 \xintHexToDec

Completely (and belatedly) rewritten at 1.2m in the 1.2 style.

1.2m version robust against non terminated inputs, but there is no primitive from TeX which may generate hexadecimal digits and provoke expansion ahead, afaik, except of course if decimal digits are treated as hexadecimal. This robustness is not on purpose but from need to expand argument and then grab it again. So we do it safely.

Increased maximal size at 1.2n.

1.2m version robust against non terminated inputs.

An input without leading zeroes gives an output without leading zeroes.

```
\def\xintHexToDec {\romannumeral0\xinthextodec }%
\def\xinthextodec #1%
{%
    \expandafter\XINT_htd_checkin\romannumeral`&&@#1\xint:
}%
\def\XINT_htd_checkin #1%
{%
    \xint_UDsignfork
       #1\XINT_htd_neg
        -{\XINT_htd_main #1}%
     \krof
}%
\def\XINT_htd_neg {\expandafter-\romannumeral0\XINT_htd_main}%
\def\XINT_htd_main #1\xint:
{%
    \expandafter\XINT_htd_startb
    \the\numexpr\expandafter\XINT_htd_starta
```

```
    \romannumeral0\XINT_zeroes_foriv
       #1\R{0\R}{00\R}{000\R}\R{0\R}{00\R}{000\R}\R\W
    #1\xint_bye!2!3!4!5!6!7!8!9!\xint_bye\relax
}%
\def\XINT_htd_starta #1#2#3#4{"#1#2#3#4+100000!}%
\def\XINT_htd_startb 1#1%
{%
    \if#10\expandafter\XINT_htd_startba\else
          \expandafter\XINT_htd_startbb
    \fi 1#1%
}%
\def\XINT_htd_startba 10#1!{\XINT_htd_again #1%
    \xint_bye!2!3!4!5!6!7!8!9!\xint_bye\XINT_htd_nextfour}%
\def\XINT_htd_startbb 1#1#2!{\XINT_htd_again #1!#2%
    \xint_bye!2!3!4!5!6!7!8!9!\xint_bye\XINT_htd_nextfour}%
```

It is a bit annoying to grab all to the end here. I have a version, modeled on the 1.2n variant of \xintDecToHex which solved that problem there, but it did not prove enough if at all faster in my brief testing and it had the defect of a reduced maximal allowed size of the input.

```
\def\XINT_htd_again #1\XINT_htd_nextfour #2%
{%
    \xint_bye #2\XINT_htd_finish\xint_bye
    \expandafter\XINT_htd_A\the\numexpr
    \XINT_htd_a #1\XINT_htd_nextfour #2%
}%
\def\XINT_htd_a #1!#2!#3!#4!#5!#6!#7!#8!#9!%
{%
    #1\expandafter\XINT_htd_update
    \the\numexpr #2\expandafter\XINT_htd_update
    \the\numexpr #3\expandafter\XINT_htd_update
    \the\numexpr #4\expandafter\XINT_htd_update
    \the\numexpr #5\expandafter\XINT_htd_update
    \the\numexpr #6\expandafter\XINT_htd_update
    \the\numexpr #7\expandafter\XINT_htd_update
    \the\numexpr #8\expandafter\XINT_htd_update
    \the\numexpr #9\expandafter\XINT_htd_update
    \the\numexpr \XINT_htd_a
}%
\def\XINT_htd_nextfour #1#2#3#4%
{%
    *\xint_c_ii^xvi+"#1#2#3#4+1000000000\relax\xint_bye!%
    2!3!4!5!6!7!8!9!\xint_bye\XINT_htd_nextfour
}%
```

If the innocent looking commented out #6 is left in the pattern as was the case at 1.2m, the maximal size becomes limited at 5538 digits, not 8298! (with parameter stack size = 10000.)

```
\def\XINT_htd_update 1#1#2#3#4#5%#6!%
{%
    *\xint_c_ii^xvi+10000#1#2#3#4#5!%#6!%
}%
\def\XINT_htd_A 1#1%
{%
    \if#10\expandafter\XINT_htd_Aa\else
```

```
          \expandafter\XINT_htd_Ab
    \fi 1#1%
}%
\def\XINT_htd_Aa 10#1#2#3#4{\XINT_htd_again #1#2#3#4!}%
\def\XINT_htd_Ab 1#1#2#3#4#5{\XINT_htd_again #1!#2#3#4#5!}%
\def\XINT_htd_finish\xint_bye
    \expandafter\XINT_htd_A\the\numexpr \XINT_htd_a #1\XINT_htd_nextfour
{%
    \expandafter\XINT_htd_finish_cuz\the\numexpr0\XINT_htd_unsep_loop #1%
}%
\def\XINT_htd_unsep_loop #1!#2!#3!#4!#5!#6!#7!#8!#9!%
{%
    \expandafter\XINT_unsep_clean
    \the\numexpr 1#1#2\expandafter\XINT_unsep_clean
    \the\numexpr 1#3#4\expandafter\XINT_unsep_clean
    \the\numexpr 1#5#6\expandafter\XINT_unsep_clean
    \the\numexpr 1#7#8\expandafter\XINT_unsep_clean
    \the\numexpr 1#9\XINT_htd_unsep_loop_a
}%
\def\XINT_htd_unsep_loop_a #1!#2!#3!#4!#5!#6!#7!#8!#9!%
{%
    #1\expandafter\XINT_unsep_clean
    \the\numexpr 1#2#3\expandafter\XINT_unsep_clean
    \the\numexpr 1#4#5\expandafter\XINT_unsep_clean
    \the\numexpr 1#6#7\expandafter\XINT_unsep_clean
    \the\numexpr 1#8#9\XINT_htd_unsep_loop
}%
\def\XINT_unsep_clean 1{\relax}% also in xintcore
\def\XINT_htd_finish_cuz #1{%
\def\XINT_htd_finish_cuz ##1##2##3##4##5%
   {\expandafter#1\the\numexpr ##1##2##3##4##5\relax}%
}\XINT_htd_finish_cuz{ }%
```

7.8 \xintBinToDec

Redone entirely for 1.2m. Starts by converting to hexadecimal first.
Increased maximal size at 1.2n.
An input without leading zeroes gives an output without leading zeroes.
Robust against non-terminated input.

```
\def\xintBinToDec {\romannumeral0\xintbintodec }%
\def\xintbintodec #1%
{%
    \expandafter\XINT_btd_checkin\romannumeral`&&@#1\xint:
}%
\def\XINT_btd_checkin #1%
{%
    \xint_UDsignfork
       #1\XINT_btd_N
        -{\XINT_btd_main #1}%
     \krof
}%
\def\XINT_btd_N {\expandafter-\romannumeral0\XINT_btd_main }%
```

```
\def\XINT_btd_main #1\xint:
{%
    \csname XINT_btd_htd\csname\expandafter\XINT_bth_loop
    \romannumeral0\XINT_zeroes_foriv
       #1\R{0\R}{00\R}{000\R}\R{0\R}{00\R}{000\R}\R\W
    #1\xint_bye2345678\xint_bye none\endcsname\xint:
}%
\def\XINT_btd_htd #1\xint:
{%
    \expandafter\XINT_htd_startb
    \the\numexpr\expandafter\XINT_htd_starta
    \romannumeral0\XINT_zeroes_foriv
       #1\R{0\R}{00\R}{000\R}\R{0\R}{00\R}{000\R}\R\W
    #1\xint_bye!2!3!4!5!6!7!8!9!\xint_bye\relax
}%
```

7.9 \xintBinToHex

Complete rewrite for 1.2m. But input for 1.2m version limited to about 13320 binary digits (expansion depth=10000).

Again redone for 1.2n for \csname governed expansion: increased maximal size.

Size of output is ceil(size(input)/4), leading zeroes in output (inherited from the input) are not trimmed.

An input without leading zeroes gives an output without leading zeroes.

Robust against non-terminated input.

```
\def\xintBinToHex {\romannumeral0\xintbintohex }%
\def\xintbintohex #1%
{%
    \expandafter\XINT_bth_checkin\romannumeral`&&@#1\xint:
}%
\def\XINT_bth_checkin #1%
{%
    \xint_UDsignfork
       #1\XINT_bth_N
        -{\XINT_bth_main #1}%
     \krof
}%
\def\XINT_bth_N {\expandafter-\romannumeral0\XINT_bth_main }%
\def\XINT_bth_main #1\xint:
{%
    \csname space\csname\expandafter\XINT_bth_loop
    \romannumeral0\XINT_zeroes_foriv
       #1\R{0\R}{00\R}{000\R}\R{0\R}{00\R}{000\R}\R\W
    #1\xint_bye2345678\xint_bye none\endcsname
}%
\def\XINT_bth_loop #1#2#3#4#5#6#7#8%
{%
            XINT_csbth_#1#2#3#4%
    \csname XINT_csbth_#5#6#7#8%
    \csname\XINT_bth_loop
}%
```

7.10 \xintHexToBin

Completely rewritten for 1.2m.

Attention this macro is not robust against arguments expanding after themselves.

Only up to three zeros are removed on front of output: if the input had a leading zero, there will be a leading zero (and then possibly 4n of them if inputs had more leading zeroes) on output.

Rewritten again at 1.2n for \csname governed expansion.

```
\def\xintHexToBin {\romannumeral0\xinthextobin }%
\def\xinthextobin #1%
{%
    \expandafter\XINT_htb_checkin\romannumeral`&&@#1%
    \xint_bye 23456789\xint_bye none\endcsname
}%
\def\XINT_htb_checkin #1%
{%
    \xint_UDsignfork
       #1\XINT_htb_N
        -{\XINT_htb_main #1}%
     \krof
}%
\def\XINT_htb_N {\expandafter-\romannumeral0\XINT_htb_main }%
\def\XINT_htb_main {\csname XINT_htb_cuz\csname\XINT_htb_loop}%
\def\XINT_htb_loop #1#2#3#4#5#6#7#8#9%
{%
             XINT_cshtb_#1%
     \csname XINT_cshtb_#2%
     \csname XINT_cshtb_#3%
     \csname XINT_cshtb_#4%
     \csname XINT_cshtb_#5%
     \csname XINT_cshtb_#6%
     \csname XINT_cshtb_#7%
     \csname XINT_cshtb_#8%
     \csname XINT_cshtb_#9%
     \csname \XINT_htb_loop
}%
\def\XINT_htb_cuz #1{%
\def\XINT_htb_cuz ##1##2##3##4%
   {\expandafter#1\the\numexpr##1##2##3##4\relax}%
}\XINT_htb_cuz { }%
```

7.11 \xintCHexToBin

The 1.08 macro had same functionality as \xintHexToBin, and slightly different code, the 1.2m version has the same code as \xintHexToBin except that it does not remove leading zeros from output: if the input had N hexadecimal digits, the output will have exactly 4N binary digits.

Rewritten again at 1.2n for \csname governed expansion.

```
\def\xintCHexToBin {\romannumeral0\xintchextobin }%
\def\xintchextobin #1%
{%
    \expandafter\XINT_chtb_checkin\romannumeral`&&@#1%
    \xint_bye 23456789\xint_bye none\endcsname
}%
```

```
\def\XINT_chtb_checkin #1%
{%
    \xint_UDsignfork
       #1\XINT_chtb_N
        -{\XINT_chtb_main #1}%
     \krof
}%
\def\XINT_chtb_N {\expandafter-\romannumeral0\XINT_chtb_main }%
\def\XINT_chtb_main {\csname space\csname\XINT_htb_loop}%
\XINTrestorecatcodesendinput%
```

8 Package xintgcd implementation

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The commenting is currently (2022/06/11) very sparse.

Release 1.09h has modified a bit the \xintTypesetEuclideAlgorithm and \xintTypesetBezoutAlgorithm layout with respect to line indentation in particular. And they use the xinttools \xintloop rather than the Plain TEX or LATEX's \loop.

Breaking change at 1.2p: \xintBezout{A}{B} formerly had output {A}{B}{U}{V}{D} with AU-BV=D, now it is {U}{V}{D} with AU+BV=D.

From 1.1 to 1.3f the package loaded only xintcore. At 1.4 it now automatically loads both of xint and xinttools (the latter being in fact a requirement of \xintTypesetEuclideAlgorithm and \xintTypesetBezoutAlgorithm since 1.09h).

Changed at 1.4!

At 1.4 \xintGCD, \xintLCM, \xintGCDof, and \xintLCMof are *removed* from the package: they are provided only by xintfrac and they handle general fractions, not only integers.

The original integer-only macros have been renamed into respectively \xintiiGCD, \xintiiLCM, \xintiiGCDof, and \xintiiLCMof and got relocated into xint package.

8.1 Catcodes, ε-TEX and reload detection

The code for reload detection was initially copied from Heiko Oberdiek's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5     % ^^M
  \endlinechar=13 %
  \catcode123=1    % {
  \catcode125=2    % }
  \catcode64=11    % @
  \catcode44=12    % ,
  \catcode46=12    % .
  \catcode58=12    % :
  \catcode94=7     % ^
  \def\empty{}\def\space{ }\newlinechar10
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xintgcd.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xint.sty\endcsname
  \expandafter\let\expandafter\t\csname ver@xinttools.sty\endcsname
  \expandafter\ifx\csname numexpr\endcsname\relax
    \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
      \immediate\write128{^^JPackage xintgcd Warning:^^J%
                          \space\space\space\space
                          \numexpr not available, aborting input.^^J}%
    \else
      \PackageWarningNoLine{xintgcd}{\numexpr not available, aborting input}%
    \fi
    \def\z{\endgroup\endinput}%
  \else
```

```
    \ifx\x\relax   % plain-TeX, first loading of xintgcd.sty
      \ifx\w\relax % but xint.sty not yet loaded.
         \expandafter\def\expandafter\z\expandafter{\z\input xint.sty\relax}%
      \fi
      \ifx\t\relax % but xinttools.sty not yet loaded.
         \expandafter\def\expandafter\z\expandafter{\z\input xinttools.sty\relax}%
      \fi
    \else
      \ifx\x\empty % LaTeX, first loading,
      % variable is initialized, but \ProvidesPackage not yet seen
          \ifx\w\relax % xint.sty not yet loaded.
            \expandafter\def\expandafter\z\expandafter{\z\RequirePackage{xint}}%
          \fi
          \ifx\t\relax % xinttools.sty not yet loaded.
            \expandafter\def\expandafter\z\expandafter{\z\RequirePackage{xinttools}}%
          \fi
      \else
        \def\z{\endgroup\endinput}% xintgcd already loaded.
      \fi
    \fi
  \fi
\z%
\XINTsetupcatcodes% defined in xintkernel.sty
```

8.2 Package identification

```
\XINT_providespackage
\ProvidesPackage{xintgcd}%
  [2022/06/10 v1.4m Euclide algorithm with xint package (JFB)]%
```

8.3 \xintBezout

\xintBezout{#1}{#2} produces {U}{V}{D} with UA+VB=D, D = PGCD(A,B) (non-positive), where #1 and #2 f-expand to big integers A and B.

I had not checked this macro for about three years when I realized in January 2017 that \xintBezout{A}{B} was buggy for the cases A = 0 or B = 0. I fixed that blemish in 1.2l but overlooked the other blemish that \xintBezout{A}{B} with A multiple of B produced a coefficient U as -0 in place of 0.

Hence I rewrote again for 1.2p. On this occasion I modified the output of the macro to be {U}{V}{D} with AU+BV=D, formerly it was {A}{B}{U}{V}{D} with AU - BV = D. This is quite breaking change!

Note in particular change of sign of V.

I don't know why I had designed this macro to contain {A}{B} in its output. Perhaps I initially intended to output {A//D}{B//D} (but forgot), as this is actually possible from outcome of the last iteration, with no need of actually dividing. Current code however arranges to skip this last update, as U and V are already furnished by the iteration prior to realizing that the last non-zero remainder was found.

Also 1.2l raised InvalidOperation if both A and B vanished, but I removed this behaviour at 1.2p.

```
\def\xintBezout {\romannumeral0\xintbezout }%
\def\xintbezout #1%
{%
    \expandafter\XINT_bezout\expandafter {\romannumeral0\xintnum{#1}}%
```

```
}%
\def\XINT_bezout #1#2%
{%
    \expandafter\XINT_bezout_fork \romannumeral0\xintnum{#2}\Z #1\Z
}%
```

#3#4 = A, #1#2=B. Micro improvement for 1.2l.

```
\def\XINT_bezout_fork #1#2\Z #3#4\Z
{%
    \xint_UDzerosfork
     #1#3\XINT_bezout_botharezero
      #10\XINT_bezout_secondiszero
      #30\XINT_bezout_firstiszero
       00\xint_UDsignsfork
    \krof
          #1#3\XINT_bezout_minusminus % A < 0, B < 0
           #1-\XINT_bezout_minusplus  % A > 0, B < 0
           #3-\XINT_bezout_plusminus  % A < 0, B > 0
            --\XINT_bezout_plusplus   % A > 0, B > 0
    \krof
    {#2}{#4}#1#3% #1#2=B, #3#4=A
}%
\def\XINT_bezout_botharezero #1\krof#2#300{{0}{0}{0}}%
\def\XINT_bezout_firstiszero #1\krof#2#3#4#5%
{%
    \xint_UDsignfork
      #4{{0}{-1}{#2}}%
       -{{0}{1}{#4#2}}%
    \krof
}%
\def\XINT_bezout_secondiszero #1\krof#2#3#4#5%
{%
    \xint_UDsignfork
       #5{{-1}{0}{#3}}%
        -{{1}{0}{#5#3}}%
    \krof
}%
```

#4#2= A < 0, #3#1 = B < 0

```
\def\XINT_bezout_minusminus #1#2#3#4%
{%
    \expandafter\XINT_bezout_mm_post
    \romannumeral0\expandafter\XINT_bezout_preloop_a
    \romannumeral0\XINT_div_prepare {#1}{#2}{#1}%
}%
\def\XINT_bezout_mm_post #1#2%
{%
    \expandafter\XINT_bezout_mm_postb\expandafter
    {\romannumeral0\xintiiopp{#2}}{\romannumeral0\xintiiopp{#1}}%
}%
\def\XINT_bezout_mm_postb #1#2{\expandafter{#2}{#1}}%
```

minusplus #4#2= A > 0, B < 0

```
\def\XINT_bezout_minusplus #1#2#3#4%
```

```
{%
    \expandafter\XINT_bezout_mp_post
    \romannumeral0\expandafter\XINT_bezout_preloop_a
    \romannumeral0\XINT_div_prepare {#1}{#4#2}{#1}%
}%
\def\XINT_bezout_mp_post #1#2%
{%
    \expandafter\xint_exchangetwo_keepbraces\expandafter
    {\romannumeral0\xintiiopp {#2}}{#1}%
}%
```

plusminus A < 0, B > 0

```
\def\XINT_bezout_plusminus #1#2#3#4%
{%
    \expandafter\XINT_bezout_pm_post
    \romannumeral0\expandafter\XINT_bezout_preloop_a
    \romannumeral0\XINT_div_prepare {#3#1}{#2}{#3#1}%
}%
\def\XINT_bezout_pm_post #1{\expandafter{\romannumeral0\xintiiopp{#1}}}%
```

plusplus, B = #3#1 > 0, A = #4#2 > 0

```
\def\XINT_bezout_plusplus #1#2#3#4%
{%
    \expandafter\XINT_bezout_preloop_a
    \romannumeral0\XINT_div_prepare {#3#1}{#4#2}{#3#1}%
}%
```

```
n = 0: BA1001 (B, A, e=1, vv, uu, v, u)
r(1)=B, r(0)=A, après n étapes {r(n+1)}{r(n)}{vv}{uu}{v}{u}
q(n) quotient de r(n-1) par r(n)
si reste nul, exit et renvoie U = -e*uu, V = e*vv, A*U+B*V=D
sinon mise à jour
  vv, v = q * vv + v, vv
  uu, u = q * uu + u, uu
  e = -e
puis calcul quotient reste et itération
```

We arrange for \xintiiMul sub-routine to be called only with positive arguments, thus skipping some un-needed sign parsing there. For that though we have to screen out the special cases A divides B, or B divides A. And we first want to exchange A and B if A < B. These special cases are the only one possibly leading to U or V zero (for A and B positive which is the case here.) Thus the general case always leads to non-zero U and V's and assigning a final sign is done simply adding a - to one of them, with no fear of producing -0.

```
\def\XINT_bezout_preloop_a #1#2#3%
{%
    \if0#1\xint_dothis\XINT_bezout_preloop_exchange\fi
    \if0#2\xint_dothis\XINT_bezout_preloop_exit\fi
    \xint_orthat{\expandafter\XINT_bezout_loop_B}%
    \romannumeral0\XINT_div_prepare {#2}{#3}{#2}{#1}110%
}%
\def\XINT_bezout_preloop_exit
    \romannumeral0\XINT_div_prepare #1#2#3#4#5#6#7%
{%
    {0}{1}{#2}%
```

```
}%
\def\XINT_bezout_preloop_exchange
{%
    \expandafter\xint_exchangetwo_keepbraces
    \romannumeral0\expandafter\XINT_bezout_preloop_A
}%
\def\XINT_bezout_preloop_A #1#2#3#4%
{%
    \if0#2\xint_dothis\XINT_bezout_preloop_exit\fi
    \xint_orthat{\expandafter\XINT_bezout_loop_B}%
    \romannumeral0\XINT_div_prepare {#2}{#3}{#2}{#1}%
}%
\def\XINT_bezout_loop_B #1#2%
{%
    \if0#2\expandafter\XINT_bezout_exitA
     \else\expandafter\XINT_bezout_loop_C
    \fi {#1}{#2}%
}%
```

We use the fact that the \romannumeral-`0 (or equivalent) done by \xintiiadd will absorb the initial space token left by \XINT_mul_plusplus in its output.

We arranged for operands here to be always positive which is needed for \XINT_mul_plusplus entry point (last time I checked...). Admittedly this kind of optimization is not good for maintenance of code, but I can't resist temptation of limiting the shuffling around of tokens...

```
\def\XINT_bezout_loop_C #1#2#3#4#5#6#7%
{%
    \expandafter\XINT_bezout_loop_D\expandafter
        {\romannumeral0\xintiiadd{\XINT_mul_plusplus{}{}#1\xint:#4\xint:}{#6}}%
        {\romannumeral0\xintiiadd{\XINT_mul_plusplus{}{}#1\xint:#5\xint:}{#7}}%
    {#2}{#3}{#4}{#5}%
}%
\def\XINT_bezout_loop_D #1#2%
{%
    \expandafter\XINT_bezout_loop_E\expandafter{#2}{#1}%
}%
\def\XINT_bezout_loop_E #1#2#3#4%
{%
    \expandafter\XINT_bezout_loop_b
    \romannumeral0\XINT_div_prepare {#3}{#4}{#3}{#2}{#1}%
}%
\def\XINT_bezout_loop_b #1#2%
{%
    \if0#2\expandafter\XINT_bezout_exita
     \else\expandafter\XINT_bezout_loop_c
    \fi {#1}{#2}%
}%
\def\XINT_bezout_loop_c #1#2#3#4#5#6#7%
{%
    \expandafter\XINT_bezout_loop_d\expandafter
        {\romannumeral0\xintiiadd{\XINT_mul_plusplus{}{}#1\xint:#4\xint:}{#6}}%
        {\romannumeral0\xintiiadd{\XINT_mul_plusplus{}{}#1\xint:#5\xint:}{#7}}%
    {#2}{#3}{#4}{#5}%
}%
```

```
\def\XINT_bezout_loop_d #1#2%
{%
    \expandafter\XINT_bezout_loop_e\expandafter{#2}{#1}%
}%
\def\XINT_bezout_loop_e #1#2#3#4%
{%
    \expandafter\XINT_bezout_loop_B
    \romannumeral0\XINT_div_prepare {#3}{#4}{#3}{#2}{#1}%
}%
```

sortir U, V, D mais on a travaillé avec vv, uu, v, u dans cet ordre.
The code is structured so that #4 and #5 are guaranteed non-zero if we exit here, hence we can not create a -0 in output.

```
\def\XINT_bezout_exita #1#2#3#4#5#6#7{{-#5}{#4}{#3}}%
\def\XINT_bezout_exitA #1#2#3#4#5#6#7{{#5}{-#4}{#3}}%
```

8.4 \xintEuclideAlgorithm

Pour Euclide: {N}{A}{D=r(n)}{B}{q1}{r1}{q2}{r2}{q3}{r3}....{qN}{rN=0}
u<2n> = u<2n+3>u<2n+2> + u<2n+4> à la n ième étape.

Formerly, used \xintiabs, but got deprecated at 1.2o.

```
\def\xintEuclideAlgorithm {\romannumeral0\xinteuclidealgorithm }%
\def\xinteuclidealgorithm #1%
{%
    \expandafter\XINT_euc\expandafter{\romannumeral0\xintiiabs{\xintNum{#1}}}%
}%
\def\XINT_euc #1#2%
{%
    \expandafter\XINT_euc_fork\romannumeral0\xintiiabs{\xintNum{#2}}\Z #1\Z
}%
```

Ici #3#4=A, #1#2=B

```
\def\XINT_euc_fork #1#2\Z #3#4\Z
{%
    \xint_UDzerofork
      #1\XINT_euc_BisZero
      #3\XINT_euc_AisZero
       0\XINT_euc_a
    \krof
    {0}{#1#2}{#3#4}{{#3#4}{#1#2}}{}\Z
}%
```

Le {} pour protéger {{A}{B}} si on s'arrête après une étape (B divise A). On va renvoyer:
{N}{A}{D=r(n)}{B}{q1}{r1}{q2}{r2}{q3}{r3}....{qN}{rN=0}

```
\def\XINT_euc_AisZero #1#2#3#4#5#6{{1}{0}{#2}{#2}{0}{0}}%
\def\XINT_euc_BisZero #1#2#3#4#5#6{{1}{0}{#3}{#3}{0}{0}}%
```

{n}{rn}{an}{{qn}{rn}}...{{A}{B}}{}\Z
a(n) = r(n-1). Pour n=0 on a juste {0}{B}{A}{{A}{B}}{}\Z
\XINT_div_prepare {u}{v} divise v par u

```
\def\XINT_euc_a #1#2#3%
{%
    \expandafter\XINT_euc_b\the\numexpr #1+\xint_c_i\expandafter.%
```

```
    \romannumeral0\XINT_div_prepare {#2}{#3}{#2}%
}%
```

{n+1}{q(n+1)}{r(n+1)}{rn}{{qn}{rn}}...

```
\def\XINT_euc_b #1.#2#3#4%
{%
    \XINT_euc_c #3\Z {#1}{#3}{#4}{{#2}{#3}}%
}%
```

r(n+1)\Z {n+1}{r(n+1)}{r(n)}{{q(n+1)}{r(n+1)}}{{qn}{rn}}...
Test si r(n+1) est nul.

```
\def\XINT_euc_c #1#2\Z
{%
    \xint_gob_til_zero #1\XINT_euc_end0\XINT_euc_a
}%
```

{n+1}{r(n+1)}{r(n)}{{q(n+1)}{r(n+1)}}...{}\Z Ici r(n+1) = 0. On arrête on se prépare à inverser {n+1}{0}{r(n)}{{q(n+1)}{r(n+1)}}.....{{q1}{r1}}{{A}{B}}{}\Z
On veut renvoyer: {N=n+1}{A}{D=r(n)}{B}{q1}{r1}{q2}{r2}{q3}{r3}....{qN}{rN=0}

```
\def\XINT_euc_end0\XINT_euc_a #1#2#3#4\Z%
{%
    \expandafter\XINT_euc_end_a
    \romannumeral0%
    \XINT_rord_main {}#4{{#1}{#3}}%
    \xint:
      \xint_bye\xint_bye\xint_bye\xint_bye
      \xint_bye\xint_bye\xint_bye\xint_bye
    \xint:
}%
\def\XINT_euc_end_a #1#2#3{{#1}{#3}{#2}}%
```

8.5 \xintBezoutAlgorithm

Pour Bezout: objectif, renvoyer
{N}{A}{0}{1}{D=r(n)}{B}{1}{0}{q1}{r1}{alpha1=q1}{beta1=1}
{q2}{r2}{alpha2}{beta2}....{qN}{rN=0}{alphaN=A/D}{betaN=B/D}
alpha0=1, beta0=0, alpha(-1)=0, beta(-1)=1

```
\def\xintBezoutAlgorithm {\romannumeral0\xintbezoutalgorithm }%
\def\xintbezoutalgorithm #1%
{%
    \expandafter \XINT_bezalg
    \expandafter{\romannumeral0\xintiiabs{\xintNum{#1}}}%
}%
\def\XINT_bezalg #1#2%
{%
    \expandafter\XINT_bezalg_fork\romannumeral0\xintiiabs{\xintNum{#2}}\Z #1\Z
}%
```

Ici #3#4=A, #1#2=B

```
\def\XINT_bezalg_fork #1#2\Z #3#4\Z
{%
    \xint_UDzerofork
      #1\XINT_bezalg_BisZero
```

```
     #3\XINT_bezalg_AisZero
      0\XINT_bezalg_a
   \krof
   0{#1#2}{#3#4}1001{{#3#4}{#1#2}}{}\Z
}%
\def\XINT_bezalg_AisZero #1#2#3\Z{{1}{0}{0}{1}{#2}{#2}{1}{0}{0}{0}{0}{1}}%
\def\XINT_bezalg_BisZero #1#2#3#4\Z{{1}{0}{0}{1}{#3}{#3}{1}{0}{0}{0}{0}{1}}%
```

pour préparer l'étape n+1 il faut {n}{r(n)}{r(n-1)}{alpha(n)}{beta(n)}{alpha(n-1)}{beta(n-1)} {{q(n)}{r(n)}{alpha(n)}{beta(n)}}... division de #3 par #2

```
\def\XINT_bezalg_a #1#2#3%
{%
   \expandafter\XINT_bezalg_b\the\numexpr #1+\xint_c_i\expandafter.%
   \romannumeral0\XINT_div_prepare {#2}{#3}{#2}%
}%
```

{n+1}{q(n+1)}{r(n+1)}{r(n)}{alpha(n)}{beta(n)}{alpha(n-1)}{beta(n-1)}...

```
\def\XINT_bezalg_b #1.#2#3#4#5#6#7#8%
{%
   \expandafter\XINT_bezalg_c\expandafter
    {\romannumeral0\xintiiadd {\xintiiMul {#6}{#2}}{#8}}%
    {\romannumeral0\xintiiadd {\xintiiMul {#5}{#2}}{#7}}%
    {#1}{#2}{#3}{#4}{#5}{#6}%
}%
```

{beta(n+1)}{alpha(n+1)}{n+1}{q(n+1)}{r(n+1)}{r(n)}{alpha(n)}{beta(n}

```
\def\XINT_bezalg_c #1#2#3#4#5#6%
{%
   \expandafter\XINT_bezalg_d\expandafter {#2}{#3}{#4}{#5}{#6}{#1}%
}%
```

{alpha(n+1)}{n+1}{q(n+1)}{r(n+1)}{r(n)}{beta(n+1)}

```
\def\XINT_bezalg_d #1#2#3#4#5#6#7#8%
{%
   \XINT_bezalg_e #4\Z {#2}{#4}{#5}{#1}{#6}{#7}{#8}{{#3}{#4}{#1}{#6}}%
}%
```

r(n+1)\Z {n+1}{r(n+1)}{r(n)}{alpha(n+1)}{beta(n+1)}
{alpha(n)}{beta(n)}{q,r,alpha,beta(n+1)}
Test si r(n+1) est nul.

```
\def\XINT_bezalg_e #1#2\Z
{%
   \xint_gob_til_zero #1\XINT_bezalg_end0\XINT_bezalg_a
}%
```

Ici r(n+1) = 0. On arrête on se prépare à inverser.
{n+1}{r(n+1)}{r(n)}{alpha(n+1)}{beta(n+1)}{alpha(n)}{beta(n)}
{q,r,alpha,beta(n+1)}...{{A}{B}}{}\Z
On veut renvoyer
{N}{A}{0}{1}{D=r(n)}{B}{1}{0}{q1}{r1}{alpha1=q1}{beta1=1}
{q2}{r2}{alpha2}{beta2}....{qN}{rN=0}{alphaN=A/D}{betaN=B/D}

```
\def\XINT_bezalg_end0\XINT_bezalg_a #1#2#3#4#5#6#7#8\Z
{%
   \expandafter\XINT_bezalg_end_a
```

```
    \romannumeral0%
    \XINT_rord_main {}#8{{#1}{#3}}%
    \xint:
      \xint_bye\xint_bye\xint_bye\xint_bye
      \xint_bye\xint_bye\xint_bye\xint_bye
    \xint:
}%
```

```
  {N}{D}{A}{B}{q1}{r1}{alpha1=q1}{beta1=1}{q2}{r2}{alpha2}{beta2}
....{qN}{rN=0}{alphaN=A/D}{betaN=B/D}
On veut renvoyer
{N}{A}{0}{1}{D=r(n)}{B}{1}{0}{q1}{r1}{alpha1=q1}{beta1=1}
{q2}{r2}{alpha2}{beta2}....{qN}{rN=0}{alphaN=A/D}{betaN=B/D}
```

```
\def\XINT_bezalg_end_a #1#2#3#4{{#1}{#3}{0}{1}{#2}{#4}{1}{0}}%
```

8.6 \xintTypesetEuclideAlgorithm

```
TYPESETTING
  Organisation:
  {N}{A}{D}{B}{q1}{r1}{q2}{r2}{q3}{r3}....{qN}{rN=0}
\U1 = N = nombre d'étapes, \U3 = PGCD, \U2 = A, \U4=B q1 = \U5, q2 = \U7 --> qn = \U<2n+3>, rn =
\U<2n+4> bn = rn. B = r0. A=r(-1)
  r(n-2) = q(n)r(n-1)+r(n) (n e étape)
  \U{2n} = \U{2n+3} \times \U{2n+2} + \U{2n+4}, n e étape. (avec n entre 1 et N)
  1.09h uses \xintloop, and \par rather than \endgraf; and \par rather than \hfill\break
```

```
\def\xintTypesetEuclideAlgorithm {%
    \unless\ifdefined\xintAssignArray
       \errmessage
        {xintgcd: package xinttools is required for \string\xintTypesetEuclideAlgorithm}%
       \expandafter\xint_gobble_iii
    \fi
    \XINT_TypesetEuclideAlgorithm
}%
\def\XINT_TypesetEuclideAlgorithm #1#2%
{% l'algo remplace #1 et #2 par |#1| et |#2|
  \par
  \begingroup
    \xintAssignArray\xintEuclideAlgorithm {#1}{#2}\to\U
    \edef\A{\U2}\edef\B{\U4}\edef\N{\U1}%
    \setbox 0 \vbox{\halign {$##$\cr \A\cr \B \cr}}%
    \count 255 1
    \xintloop
      \indent\hbox to \wd 0 {\hfil$\U{\numexpr 2*\count255\relax}$}%
      ${} =  \U{\numexpr 2*\count255 + 3\relax}
      \times \U{\numexpr 2*\count255 + 2\relax}
          +  \U{\numexpr 2*\count255 + 4\relax}$%
    \ifnum \count255 < \N
      \par
      \advance \count255 1
    \repeat
  \endgroup
}%
```

8.7 `\xintTypesetBezoutAlgorithm`

Pour Bezout on a: {N}{A}{0}{1}{D=r(n)}{B}{1}{0}{q1}{r1}{alpha1=q1}{beta1=1}
{q2}{r2}{alpha2}{beta2}....{qN}{rN=0}{alphaN=A/D}{betaN=B/D}

Donc 4N+8 termes: U1 = N, U2= A, U5=D, U6=B, q1 = U9, qn = U{4n+5}, n au moins 1
rn = U{4n+6}, n au moins -1
alpha(n) = U{4n+7}, n au moins -1
beta(n) = U{4n+8}, n au moins -1

1.09h uses `\xintloop`, and `\par` rather than `\endgraf`; and no more `\parindent0pt`

```
\def\xintTypesetBezoutAlgorithm {%
    \unless\ifdefined\xintAssignArray
       \errmessage
        {xintgcd: package xinttools is required for \string\xintTypesetBezoutAlgorithm}%
       \expandafter\xint_gobble_iii
    \fi
    \XINT_TypesetBezoutAlgorithm
}%
\def\XINT_TypesetBezoutAlgorithm #1#2%
{%
  \par
  \begingroup
    \xintAssignArray\xintBezoutAlgorithm {#1}{#2}\to\BEZ
    \edef\A{\BEZ2}\edef\B{\BEZ6}\edef\N{\BEZ1}% A = |#1|, B = |#2|
    \setbox 0 \vbox{\halign {$##$\cr \A\cr \B \cr}}%
    \count255 1
    \xintloop
      \indent\hbox to \wd 0 {\hfil$\BEZ{4*\count255 - 2}$}%
      ${} =  \BEZ{4*\count255 + 5}
      \times \BEZ{4*\count255 + 2}
          +  \BEZ{4*\count255 + 6}$\hfill\break
      \hbox to \wd 0 {\hfil$\BEZ{4*\count255 +7}$}%
      ${} = \BEZ{4*\count255 + 5}
      \times \BEZ{4*\count255 + 3}
          +  \BEZ{4*\count255 - 1}$\hfill\break
      \hbox to \wd 0 {\hfil$\BEZ{4*\count255 +8}$}%
      ${} =  \BEZ{4*\count255 + 5}
      \times \BEZ{4*\count255 + 4}
          +  \BEZ{4*\count255 }$
      \par
    \ifnum \count255 < \N
    \advance \count255 1
  \repeat
    \edef\U{\BEZ{4*\N + 4}}%
    \edef\V{\BEZ{4*\N + 3}}%
    \edef\D{\BEZ5}%
    \ifodd\N
       $\U\times\A  - \V\times \B = -\D$%
    \else
       $\U\times\A - \V\times\B = \D$%
    \fi
    \par
  \endgroup
}%
```

```
\XINTrestorecatcodesendinput%
```

9 Package xintfrac implementation

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.52 \xintDivFloor 233
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.56 \xintDivMod 235
.57 \xintMod 236
.58 \xintIsOne 237
.59 \xintGeq 237
.60 \xintMax 238
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.62 \xintMin 239
.63 \xintMinof 240
.64 \xintCmp 240
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The commenting is currently (2022/06/11) very sparse.

9.1 Catcodes, ε-TEX and reload detection

The code for reload detection was initially copied from Heiko Oberdiek's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5    % ^^M
  \endlinechar=13 %
  \catcode123=1   % {
  \catcode125=2   % }
  \catcode64=11   % @
  \catcode44=12   % ,
  \catcode46=12   % .
  \catcode58=12   % :
  \catcode94=7    % ^
  \def\empty{}\def\space{ }\newlinechar10
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xintfrac.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xint.sty\endcsname
  \expandafter\ifx\csname numexpr\endcsname\relax
    \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
      \immediate\write128{^^JPackage xintfrac Warning:^^J%
                          \space\space\space\space
                          \numexpr not available, aborting input.^^J}%
    \else
      \PackageWarningNoLine{xintfrac}{\numexpr not available, aborting input}%
    \fi
    \def\z{\endgroup\endinput}%
  \else
    \ifx\x\relax   % plain-TeX, first loading of xintfrac.sty
      \ifx\w\relax % but xint.sty not yet loaded.
         \def\z{\endgroup\input xint.sty\relax}%
      \fi
    \else
      \ifx\x\empty % LaTeX, first loading,
      % variable is initialized, but \ProvidesPackage not yet seen
          \ifx\w\relax % xint.sty not yet loaded.
            \def\z{\endgroup\RequirePackage{xint}}%
          \fi
      \else
        \def\z{\endgroup\endinput}% xintfrac already loaded.
      \fi
    \fi
  \fi
\z%
```

```
\XINTsetupcatcodes% defined in xintkernel.sty
```

9.2 Package identification

```
\XINT_providespackage
\ProvidesPackage{xintfrac}%
  [2022/06/10 v1.4m Expandable operations on fractions (JFB)]%
```

9.3 \XINT_cntSgnFork

1.09i. Used internally, #1 must expand to \m@ne, \z@, or \@ne or equivalent. \XINT_cntSgnFork does not insert a romannumeral stopper.

```
\def\XINT_cntSgnFork #1%
{%
    \ifcase #1\expandafter\xint_secondofthree
            \or\expandafter\xint_thirdofthree
          \else\expandafter\xint_firstofthree
    \fi
}%
```

9.4 \xintLen

The used formula is disputable, the idea is that A/1 and A should have same length. Venerable code rewritten for 1.2i, following updates to \xintLength in xintkernel.sty. And sadly, I forgot on this occasion that this macro is not supposed to count the sign... Fixed in 1.2k.

```
\def\xintLen {\romannumeral0\xintlen }%
\def\xintlen #1%
{%
    \expandafter\XINT_flen\romannumeral0\XINT_infrac {#1}%
}%
\def\XINT_flen#1{\def\XINT_flen ##1##2##3%
{%
    \expandafter#1%
    \the\numexpr \XINT_abs##1+%
    \XINT_len_fork ##2##3\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye-\xint_c_i
    \relax
}}\XINT_flen{ }%
```

9.5 \XINT_outfrac

Modified at 1.06b (2013/05/14). 1.06b version now outputs 0/1[0] and not 0[0] in case of zero. More generally all macros have been checked in xintfrac, xintseries, xintcfrac, to make sure the output format for fractions was always A/B[n]. (except \xintIrr, \xintJrr, \xintRawWithZeros).

Months later (2014/10/22): perhaps I should document what this macro does before I forget? from {e}{N}{D} it outputs N/D[e], checking in passing if D=0 or if N=0. It also makes sure D is not < 0. I am not sure but I don't think there is any place in the code which could call \XINT_outfrac with a D < 0, but I should check.

```
\def\XINT_outfrac #1#2#3%
{%
    \ifcase\XINT_cntSgn #3\xint:
```

```
        \expandafter \XINT_outfrac_divisionbyzero
    \or
        \expandafter \XINT_outfrac_P
    \else
        \expandafter \XINT_outfrac_N
    \fi
    {#2}{#3}[#1]%
}%
\def\XINT_outfrac_divisionbyzero #1#2[#3]%
{%
    \XINT_signalcondition{DivisionByZero}{Division by zero: #1/#2.}{}{ 0/1[0]}%
}%
\def\XINT_outfrac_P#1{%
\def\XINT_outfrac_P ##1##2%
   {\if0\XINT_Sgn ##1\xint:\expandafter\XINT_outfrac_Zero\fi#1##1/##2}%
}\XINT_outfrac_P{ }%
\def\XINT_outfrac_Zero #1[#2]{ 0/1[0]}%
\def\XINT_outfrac_N #1#2%
{%
    \expandafter\XINT_outfrac_N_a\expandafter
    {\romannumeral0\XINT_opp #2}{\romannumeral0\XINT_opp #1}%
}%
\def\XINT_outfrac_N_a #1#2%
{%
    \expandafter\XINT_outfrac_P\expandafter {#2}{#1}%
}%
```

9.6 \XINT_infrac

Added at 1.03 (2013/04/14). Parses fraction, scientific notation, etc... and produces {n}{A}{B} corresponding to A/B times 10^n. No reduction to smallest terms.

Modified at 1.07 (2013/05/25). Extended in 1.07 to accept scientific notation on input. With lowercase e only. The \xintexpr parser does accept uppercase E also. Ah, by the way, perhaps I should at least say what this macro does? (belated addition 2014/10/22...), before I forget! It prepares the fraction in the internal format {exponent}{Numerator}{Denominator} where Denominator is at least 1.

Modified at 1.2 (2015/10/10). This venerable macro from the very early days has gotten a lifting for release 1.2. There were two kinds of issues:

1) use of \W, \Z, \T delimiters was very poor choice as this could clash with user input,

2) the new \XINT_frac_gen handles macros (possibly empty) in the input as general as \A.\Be\C/\D.\Ee\F. The earlier version would not have expanded the \B or \E: digits after decimal mark were constrained to arise from expansion of the first token. Thus the 1.03 original code would have expanded only \A, \D, \C, and \F for this input.

This reminded me think I should revisit the remaining earlier portions of code, as I was still learning TeX coding when I wrote them.

Also I thought about parsing even faster the A/B[N] input, not expanding B, but this turned out to clash with some established uses in the documentation such as 1/\xintiiSqr{...}[0]. For the implementation, careful here about potential brace removals with parameter patterns such as like #1/#2#3[#4]for example.

While I was at it 1.2 added \numexpr parsing of the N, which earlier was restricted to be only explicit digits. I allowed [] with empty N, but the way I did it in 1.2 with \the\numexpr 0#1 was buggy, as it did not allow #1 to be a \count for example or itself a \numexpr (although such inputs were not previously allowed, I later turned out to use them in the code itself, e.g. the float factorial of version 1.2f). The better way would be \the\numexpr#1+\xint_c_ but 1.2f finally does only \the\numexpr #1 and #1 is not allowed to be empty.

The 1.2 \XINT_frac_gen had two locations with such a problematic \numexpr 0#1 which I replaced for 1.2f with \numexpr#1+\xint_c_.

Regarding calling the macro with an argument A[<expression>], a / inthe expression must be suitably hidden for example in \firstofone type constructs.

Note: when the numerator is found to be zero \XINT_infrac *always* returns {0}{0}{1}. This behaviour must not change because 1.2g \xintFloat and XINTinFloat (for example) rely upon it: if the denominator on output is not 1, then \xintFloat assumes that the numerator is not zero.

As described in the manual, if the input contains a (final) [N] part, it is assumed that it is in the shape A[N] or A/B[N] with A (and B) not containing neither decimal mark nor scientific part, moreover B must be positive and A have at most one minus sign (and no plus sign). Else there will be errors, for example -0/2[0] would not be recognized as being zero at this stage and this could cause issues afterwards. When there is no ending [N] part, both numerator and denominator will be parsed for the more general format allowing decimal digits and scientific part and possibly multiple leading signs.

Modified at 1.2l (2017/07/26). 1.2l fixes frailty of \XINT_infrac (hence basically of all xintfrac macros) respective to non terminated \numexpr input: \xintRaw{\the\numexpr1} for example. The issue was that \numexpr sees the / and expands what's next. But even \numexpr 1// for example creates an error, and to my mind this is a defect of \numexpr. It should be able to trace back and see that / was used as delimiter not as operator. Anyway, I thus fixed this problem belatedly here regarding \XINT_infrac.

Modified at 1.4l (2022/05/29). The venerable \XINT_inFrac is used nowhere, only \XINT_infrac is. It is deprecated and I will remove it at next major release. See \xintRawBraced.

```
\def\XINT_inFrac {\XINT_expandableerror{\XINT_inFrac is deprecated, use \xintRawBraced}%
                 \romannumeral0\XINT_infrac }%
\def\XINT_infrac #1% this one is core xintfrac macro
{%
    \expandafter\XINT_infrac_fork\romannumeral`&&@#1\xint:/\XINT_W[\XINT_W\XINT_T
}%
\def\XINT_infrac_fork #1[#2%
{%
    \xint_UDXINTWfork
      #2\XINT_frac_gen          % input has no brackets [N]
      \XINT_W\XINT_infrac_res_a % there is some [N], must be strict A[N] or A/B[N] input
    \krof
    #1[#2%
}%
\def\XINT_infrac_res_a #1%
{%
    \xint_gob_til_zero #1\XINT_infrac_res_zero 0\XINT_infrac_res_b #1%
}%
```

Note that input exponent is here ignored and forced to be zero.

```
\def\XINT_infrac_res_zero 0\XINT_infrac_res_b #1\XINT_T {{0}{0}{1}}%
\def\XINT_infrac_res_b #1/#2%
{%
    \xint_UDXINTWfork
     #2\XINT_infrac_res_ca      % it was A[N] input
     \XINT_W\XINT_infrac_res_cb % it was A/B[N] input
    \krof
```

```
    #1/#2%
}%
```

An empty [] is not allowed. (this was authorized in 1.2, removed in 1.2f).

```
\def\XINT_infrac_res_ca #1[#2]\xint:/\XINT_W[\XINT_W\XINT_T
   {\expandafter{\the\numexpr #2}{#1}{1}}%
\def\XINT_infrac_res_cb #1/#2[%
   {\expandafter\XINT_infrac_res_cc\romannumeral`&&@#2~#1[}%
\def\XINT_infrac_res_cc #1~#2[#3]\xint:/\XINT_W[\XINT_W\XINT_T
   {\expandafter{\the\numexpr #3}{#2}{#1}}%
```

9.7 \XINT_frac_gen

Modified at 1.07 (2013/05/25). Extended at to recognize and accept scientific notation both at the numerator and (possible) denominator. Only a lowercase e will do here, but uppercase E is possible within an \xintexpr..\relax

Modified at 1.2 (2015/10/10). Completely rewritten. The parsing handles inputs such as \A.\Be\C/\D.\Ee\F where each of \A, \B, \D, and \E may need f-expansion and \C and \F will end up in \numexpr.

Modified at 1.2f (2016/03/12). 1.2f corrects an issue to allow \C and \F to be \count variable (or expressions with \numexpr): 1.2 did a bad \numexpr0#1 which allowed only explicit digits for expanded #1.

```
\def\XINT_frac_gen #1/#2%
{%
    \xint_UDXINTWfork
      #2\XINT_frac_gen_A      % there was no /
      \XINT_W\XINT_frac_gen_B % there was a /
    \krof
    #1/#2%
}%
```

Note that #1 is only expanded so far up to decimal mark or "e".

```
\def\XINT_frac_gen_A #1\xint:/\XINT_W [\XINT_W {\XINT_frac_gen_C 0~1!#1ee.\XINT_W }%
\def\XINT_frac_gen_B #1/#2\xint:/\XINT_W[%\XINT_W
{%
    \expandafter\XINT_frac_gen_Ba
    \romannumeral`&&@#2ee.\XINT_W\XINT_Z #1ee.%\XINT_W
}%
\def\XINT_frac_gen_Ba #1.#2%
{%
    \xint_UDXINTWfork
      #2\XINT_frac_gen_Bb
      \XINT_W\XINT_frac_gen_Bc
    \krof
    #1.#2%
}%
\def\XINT_frac_gen_Bb #1e#2e#3\XINT_Z
                 {\expandafter\XINT_frac_gen_C\the\numexpr #2+\xint_c_~#1!}%
\def\XINT_frac_gen_Bc #1.#2e%
{%
    \expandafter\XINT_frac_gen_Bd\romannumeral`&&@#2.#1e%
}%
\def\XINT_frac_gen_Bd #1.#2e#3e#4\XINT_Z
```

```
{%
    \expandafter\XINT_frac_gen_C\the\numexpr #3-%
    \numexpr\XINT_length_loop
    #1\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    ~#2#1!%
}%
\def\XINT_frac_gen_C #1!#2.#3%
{%
    \xint_UDXINTWfork
      #3\XINT_frac_gen_Ca
      \XINT_W\XINT_frac_gen_Cb
    \krof
    #1!#2.#3%
}%
\def\XINT_frac_gen_Ca #1~#2!#3e#4e#5\XINT_T
{%
    \expandafter\XINT_frac_gen_F\the\numexpr #4-#1\expandafter
    ~\romannumeral0\expandafter\XINT_num_cleanup\the\numexpr\XINT_num_loop
     #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\Z~#3~%
}%
\def\XINT_frac_gen_Cb #1.#2e%
{%
    \expandafter\XINT_frac_gen_Cc\romannumeral`&&@#2.#1e%
}%
\def\XINT_frac_gen_Cc #1.#2~#3!#4e#5e#6\XINT_T
{%
    \expandafter\XINT_frac_gen_F\the\numexpr #5-#2-%
    \numexpr\XINT_length_loop
    #1\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    \relax\expandafter~%
    \romannumeral0\expandafter\XINT_num_cleanup\the\numexpr\XINT_num_loop
    #3\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\Z
    ~#4#1~%
}%
\def\XINT_frac_gen_F #1~#2%
{%
    \xint_UDzerominusfork
      #2-\XINT_frac_gen_Gdivbyzero
      0#2{\XINT_frac_gen_G  -{}}%
       0-{\XINT_frac_gen_G {}#2}%
    \krof  #1~%
}%
\def\XINT_frac_gen_Gdivbyzero #1~~#2~%
{%
   \expandafter\XINT_frac_gen_Gdivbyzero_a
   \romannumeral0\expandafter\XINT_num_cleanup\the\numexpr\XINT_num_loop
   #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\Z~#1~%
}%
```

```
\def\XINT_frac_gen_Gdivbyzero_a #1~#2~%
{%
    \XINT_signalcondition{DivisionByZero}{Division by zero: #1/0.}{}{{#2}{#1}{0}}%
}%
\def\XINT_frac_gen_G #1#2#3~#4~#5~%
{%
    \expandafter\XINT_frac_gen_Ga
    \romannumeral0\expandafter\XINT_num_cleanup\the\numexpr\XINT_num_loop
    #1#5\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\Z~#3~{#2#4}%
}%
\def\XINT_frac_gen_Ga #1#2~#3~%
{%
    \xint_gob_til_zero #1\XINT_frac_gen_zero 0%
    {#3}{#1#2}%
}%
\def\XINT_frac_gen_zero 0#1#2#3{{0}{0}{1}}%
```

9.8 \XINT_factortens

This is the core macro for \xintREZ. To be used as \romannumeral0\XINT_factortens{...}. Output is A.N. (formerly {A}{N}) where A is the integer stripped from trailing zeroes and N is the number of removed zeroes. Only for positive strict integers!

Modified at 1.3a (2018/03/07). Completely rewritten at 1.3a to replace a double \xintReverseOrder by a direct \numexpr governed expansion to the end and back, à la 1.2. I should comment more... and perhaps improve again in future.
Testing shows significant gain at 100 digits or more.

```
\def\XINT_factortens #1{\expandafter\XINT_factortens_z
                        \romannumeral0\XINT_factortens_a#1%
                        \XINT_factortens_b123456789.}%
\def\XINT_factortens_z.\XINT_factortens_y{ }%
\def\XINT_factortens_a #1#2#3#4#5#6#7#8#9%
   {\expandafter\XINT_factortens_x
    \the\numexpr 1#1#2#3#4#5#6#7#8#9\XINT_factortens_a}%
\def\XINT_factortens_b#1\XINT_factortens_a#2#3.%
   {.\XINT_factortens_cc 000000000-#2.}%
\def\XINT_factortens_x1#1.#2{#2#1}%
\def\XINT_factortens_y{.\XINT_factortens_y}%
\def\XINT_factortens_cc #1#2#3#4#5#6#7#8#9%
   {\if#90\xint_dothis
     {\expandafter\XINT_factortens_d\the\numexpr #8#7#6#5#4#3#2#1\relax
      \xint_c_i 2345678.}\fi
    \xint_orthat{\XINT_factortens_yy{#1#2#3#4#5#6#7#8#9}}}%
\def\XINT_factortens_yy #1#2.{.\XINT_factortens_y#1.0.}%
\def\XINT_factortens_c #1#2#3#4#5#6#7#8#9%
   {\if#90\xint_dothis
     {\expandafter\XINT_factortens_d\the\numexpr #8#7#6#5#4#3#2#1\relax
      \xint_c_i 2345678.}\fi
    \xint_orthat{.\XINT_factortens_y #1#2#3#4#5#6#7#8#9.}}%
\def\XINT_factortens_d #1#2#3#4#5#6#7#8#9%
   {\if#10\expandafter\XINT_factortens_e\fi
    \XINT_factortens_f #9#9#8#7#6#5#4#3#2#1.}%
\def\XINT_factortens_f #1#2\xint_c_i#3.#4.#5.%
```

```
   {\expandafter\XINT_factortens_g\the\numexpr#1+#5.#3.}%
\def\XINT_factortens_g #1.#2.{.\XINT_factortens_y#2.#1.}%
\def\XINT_factortens_e #1..#2.%
   {\expandafter.\expandafter\XINT_factortens_c
    \the\numexpr\xint_c_ix+#2.}%
```

9.9 \xintEq, \xintNotEq, \xintGt, \xintLt, \xintGtorEq, \xintLtorEq, \xintIsZero, \xintIsNotZero, \xintOdd, \xintEven, \xintifSgn, \xintifCmp, \xintifEq, \xintifGt, \xintifLt, \xintifZero, \xintifNotZero, \xintifOne, \xintifOdd

Moved here at 1.3. Formerly these macros were already defined in xint.sty or even xintcore.sty. They are slim wrappers of macros defined elsewhere in xintfrac.

```
\def\xintEq    {\romannumeral0\xinteq }%
\def\xinteq    #1#2{\xintifeq{#1}{#2}{1}{0}}%
\def\xintNotEq#1#2{\romannumeral0\xintifeq {#1}{#2}{0}{1}}%
\def\xintGt {\romannumeral0\xintgt }%
\def\xintgt #1#2{\xintifgt{#1}{#2}{1}{0}}%
\def\xintLt    {\romannumeral0\xintlt }%
\def\xintlt #1#2{\xintiflt{#1}{#2}{1}{0}}%
\def\xintGtorEq #1#2{\romannumeral0\xintiflt {#1}{#2}{0}{1}}%
\def\xintLtorEq #1#2{\romannumeral0\xintifgt {#1}{#2}{0}{1}}%
\def\xintIsZero    {\romannumeral0\xintiszero }%
\def\xintiszero #1{\if0\xintSgn{#1}\xint_afterfi{ 1}\else\xint_afterfi{ 0}\fi}%
\def\xintIsNotZero{\romannumeral0\xintisnotzero }%
\def\xintisnotzero
          #1{\if0\xintSgn{#1}\xint_afterfi{ 0}\else\xint_afterfi{ 1}\fi}%
\def\xintOdd      {\romannumeral0\xintodd }%
\def\xintodd #1%
{%
    \ifodd\xintLDg{\xintNum{#1}} %<- intentional space
        \xint_afterfi{ 1}%
    \else
        \xint_afterfi{ 0}%
    \fi
}%
\def\xintEven     {\romannumeral0\xinteven }%
\def\xinteven #1%
{%
    \ifodd\xintLDg{\xintNum{#1}} %<- intentional space
        \xint_afterfi{ 0}%
    \else
        \xint_afterfi{ 1}%
    \fi
}%
\def\xintifSgn{\romannumeral0\xintifsgn }%
\def\xintifsgn #1%
{%
    \ifcase \xintSgn{#1}
               \expandafter\xint_stop_atsecondofthree
            \or\expandafter\xint_stop_atthirdofthree
          \else\expandafter\xint_stop_atfirstofthree
    \fi
```

```
}%
\def\xintifCmp{\romannumeral0\xintifcmp }%
\def\xintifcmp #1#2%
{%
    \ifcase\xintCmp {#1}{#2}
               \expandafter\xint_stop_atsecondofthree
            \or\expandafter\xint_stop_atthirdofthree
          \else\expandafter\xint_stop_atfirstofthree
    \fi
}%
\def\xintifEq {\romannumeral0\xintifeq }%
\def\xintifeq #1#2%
{%
    \if0\xintCmp{#1}{#2}%
               \expandafter\xint_stop_atfirstoftwo
          \else\expandafter\xint_stop_atsecondoftwo
    \fi
}%
\def\xintifGt {\romannumeral0\xintifgt }%
\def\xintifgt #1#2%
{%
    \if1\xintCmp{#1}{#2}%
               \expandafter\xint_stop_atfirstoftwo
          \else\expandafter\xint_stop_atsecondoftwo
    \fi
}%
\def\xintifLt {\romannumeral0\xintiflt }%
\def\xintiflt #1#2%
{%
    \ifnum\xintCmp{#1}{#2}<\xint_c_
          \expandafter\xint_stop_atfirstoftwo
    \else \expandafter\xint_stop_atsecondoftwo
    \fi
}%
\def\xintifZero    {\romannumeral0\xintifzero }%
\def\xintifzero #1%
{%
    \if0\xintSgn{#1}%
       \expandafter\xint_stop_atfirstoftwo
    \else
       \expandafter\xint_stop_atsecondoftwo
    \fi
}%
\def\xintifNotZero{\romannumeral0\xintifnotzero }%
\def\xintifnotzero #1%
{%
    \if0\xintSgn{#1}%
       \expandafter\xint_stop_atsecondoftwo
    \else
       \expandafter\xint_stop_atfirstoftwo
    \fi
}%
```

```
\def\xintifOne {\romannumeral0\xintifone }%
\def\xintifone #1%
{%
    \if1\xintIsOne{#1}%
       \expandafter\xint_stop_atfirstoftwo
    \else
       \expandafter\xint_stop_atsecondoftwo
    \fi
}%
\def\xintifOdd {\romannumeral0\xintifodd }%
\def\xintifodd #1%
{%
    \if\xintOdd{#1}1%
       \expandafter\xint_stop_atfirstoftwo
    \else
       \expandafter\xint_stop_atsecondoftwo
    \fi
}%
```

9.10 \xintRaw

Added at 1.07 (2013/05/25). 1.07: this macro simply prints in a user readable form the fraction after its initial scanning. Useful when put inside braces in an \xintexpr, when the input is not yet in the A/B[n] form.

```
\def\xintRaw {\romannumeral0\xintraw }%
\def\xintraw
{%
    \expandafter\XINT_raw\romannumeral0\XINT_infrac
}%
\def\XINT_raw #1#2#3{ #2/#3[#1]}%
```

9.11 \xintRawBraced

Added at 1.4l (2022/05/29). User level interface to core \romannumeral0\XINT_infrac. Replaces \XINT_inFrac which was defined but nowhere used by the xint packages.

```
\def\xintRawBraced {\romannumeral0\xintrawbraced }%
\let\xintrawbraced \XINT_infrac
```

9.12 \xintiLogTen

Added at 1.3e (2019/04/05). The exponent a, such that 10^a<= abs(x) < 10^(a+1). No rounding done on x, handled as an exact fraction.

```
\def\xintiLogTen {\the\numexpr\xintilogten}%
\def\xintilogten
{%
    \expandafter\XINT_ilogten\romannumeral0\xintraw
}%
\def\XINT_ilogten #1%
{%
    \xint_UDzerominusfork
      0#1\XINT_ilogten_p
      #1-\XINT_ilogten_z
```

```
      0-{\XINT_ilogten_p#1}%
    \krof
}%
\def\XINT_ilogten_z #1[#2]{-"7FFF8000\relax}%
\def\XINT_ilogten_p #1/#2[#3]%
{%
    #3+\expandafter\XINT_ilogten_a
       \the\numexpr\xintLength{#1}\expandafter.\the\numexpr\xintLength{#2}.#1.#2.%
}%
\def\XINT_ilogten_a #1.#2.%
{%
    #1-#2\ifnum#1>#2
      \expandafter\XINT_ilogten_aa
    \else
      \expandafter\XINT_ilogten_ab
    \fi #1.#2.%
}%
\def\XINT_ilogten_aa #1.#2.#3.#4.%
{%
    \xintiiifLt{#3}{\XINT_dsx_addzerosnofuss{#1-#2}#4;}{-1}{}\relax
}%
\def\XINT_ilogten_ab #1.#2.#3.#4.%
{%
    \xintiiifLt{\XINT_dsx_addzerosnofuss{#2-#1}#3;}{#4}{-1}{}\relax
}%
```

9.13 \xintPRaw

Added at 1.09b (2013/10/03).

```
\def\xintPRaw {\romannumeral0\xintpraw }%
\def\xintpraw
{%
    \expandafter\XINT_praw\romannumeral0\XINT_infrac
}%
\def\XINT_praw #1%
{%
    \ifnum #1=\xint_c_ \expandafter\XINT_praw_a\fi \XINT_praw_A {#1}%
}%
\def\XINT_praw_A #1#2#3%
{%
    \if\XINT_isOne{#3}1\expandafter\xint_firstoftwo
                 \else\expandafter\xint_secondoftwo
    \fi { #2[#1]}{ #2/#3[#1]}%
}%
\def\XINT_praw_a\XINT_praw_A #1#2#3%
{%
    \if\XINT_isOne{#3}1\expandafter\xint_firstoftwo
                 \else\expandafter\xint_secondoftwo
    \fi { #2}{ #2/#3}%
}%
```

9.14 \xintSPRaw

This private macro was for internal usage by \xinttheexpr. It got moved here at 1.4 and is not used anymore by the package.

It checks if input has a [N] part, if yes uses \xintPRaw, else simply lets the input pass through as is.

```
\def\xintSPRaw    {\romannumeral0\xintspraw }%
\def\xintspraw  #1{\expandafter\XINT_spraw\romannumeral`&&@#1[\W]}%
\def\XINT_spraw #1[#2#3]{\xint_gob_til_W #2\XINT_spraw_a\W\XINT_spraw_p #1[#2#3]}%
\def\XINT_spraw_a\W\XINT_spraw_p #1[\W]{ #1}%
\def\XINT_spraw_p #1[\W]{\xintpraw {#1}}%
```

9.15 \xintFracToSci

Added at 1.4l (2022/05/29). The macro with this name which was added here at 1.4 then had various changes and finally was moved to xintexpr at 1.4k is now called there \xint_FracToSci_x and is private. The present macro is public and behaves like the other xintfrac macros: f-expandable and accepts general input. Its output is exactly the same as \xint_FracToSci_x for same inputs, with the exception of the empty input which \xintFracToSci will output as 0 but \xint_FracToSci_x as empty. But the latter is not used by \xinteval for an empty leaf as it employs then \xintexprEmptyItem.

```
\def\xintFracToSci{\romannumeral0\xintfractosci}%
\def\xintfractosci#1{\expandafter\XINT_fractosci\romannumeral0\xintraw{#1}}%
\def\XINT_fractosci#1#2/#3[#4]{\expanded{ %
    \ifnum#4=\xint_c_ #1#2\else
      \romannumeral0\expandafter\XINT_pfloat_a_fork\romannumeral0\xintrez{#1#2[#4]}%
    \fi
    \if\XINT_isOne{#3}1\else\if#10\else/#3\fi\fi}%
}%
```

9.16 \xintFracToDecimal

Added at 1.4l (2022/05/29). The macro with this name which was added at 1.4k to xintexpr has been removed. The public variant here behaves like the other xintfrac macros: f-expandable and accepts general input.

```
\def\xintFracToDecimal{\romannumeral0\xintfractodecimal}%
\def\xintfractodecimal#1{\expandafter\XINT_fractodecimal\romannumeral0\xintraw{#1}}%
\def\XINT_fractodecimal #1#2/#3[#4]{\expanded{ %
    \ifnum#4=\xint_c_ #1#2\else
      \romannumeral0\expandafter\XINT_dectostr\romannumeral0\xintrez{#1#2[#4]}%
    \fi
    \if\XINT_isOne{#3}1\else\if#10\else/#3\fi\fi}%
}%
```

9.17 \xintRawWithZeros

This was called \xintRaw in versions earlier than 1.07

```
\def\xintRawWithZeros {\romannumeral0\xintrawwithzeros }%
\def\xintrawwithzeros
{%
    \expandafter\XINT_rawz_fork\romannumeral0\XINT_infrac
}%
```

```
\def\XINT_rawz_fork #1%
{%
    \ifnum#1<\xint_c_
      \expandafter\XINT_rawz_Ba
    \else
      \expandafter\XINT_rawz_A
    \fi
    #1.%
}%
\def\XINT_rawz_A  #1.#2#3{\XINT_dsx_addzeros{#1}#2;/#3}%
\def\XINT_rawz_Ba -#1.#2#3{\expandafter\XINT_rawz_Bb
    \expandafter{\romannumeral0\XINT_dsx_addzeros{#1}#3;}{#2}}%
\def\XINT_rawz_Bb #1#2{ #2/#1}%
```

9.18 \xintDecToString

Added at 1.3 (2018/03/01). This is a backport from polexpr 0.4. It is definitely not in final form, consider it to be an unstable macro.

```
\def\xintDecToString{\romannumeral0\xintdectostring}%
\def\xintdectostring#1{\expandafter\XINT_dectostr\romannumeral0\xintraw{#1}}%
\def\XINT_dectostr #1/#2[#3]{\xintiiifZero {#1}%
       \XINT_dectostr_z
       {\if1\XINT_isOne{#2}\expandafter\XINT_dectostr_a
                      \else\expandafter\XINT_dectostr_b
        \fi}%
  #1/#2[#3]%
}%
\def\XINT_dectostr_z#1[#2]{ 0}%
\def\XINT_dectostr_a#1/#2[#3]{%
    \ifnum#3<\xint_c_\xint_dothis{\xinttrunc{-#3}{#1[#3]}}\fi
    \xint_orthat{\xintiie{#1}{#3}}%
}%
\def\XINT_dectostr_b#1/#2[#3]{% just to handle this somehow
    \ifnum#3<\xint_c_\xint_dothis{\xinttrunc{-#3}{#1[#3]}/#2}\fi
    \xint_orthat{\xintiie{#1}{#3}/#2}%
}%
```

9.19 \xintDecToStringREZ

Added at 1.4e (2021/05/05). And I took this opportunity to improve documentation in manual.

```
\def\xintDecToStringREZ{\romannumeral0\xintdectostringrez}%
\def\xintdectostringrez#1{\expandafter\XINT_dectostr\romannumeral0\xintrez{#1}}%
```

9.20 \xintFloor, \xintiFloor

Added at 1.09a (2013/09/24). 1.1 for \xintiFloor/\xintFloor. Not efficient if big negative decimal exponent. Also sub-efficient if big positive decimal exponent.

```
\def\xintFloor {\romannumeral0\xintfloor }%
\def\xintfloor #1% devrais-je faire \xintREZ?
    {\expandafter\XINT_ifloor \romannumeral0\xintrawwithzeros {#1}./1[0]}%
\def\xintiFloor {\romannumeral0\xintifloor }%
\def\xintifloor #1%
```

```
    {\expandafter\XINT_ifloor \romannumeral0\xintrawwithzeros {#1}.}%
\def\XINT_ifloor #1/#2.{\xintiiquo {#1}{#2}}%
```

9.21 \xintCeil, \xintiCeil

Added at 1.09a (2013/09/24).

```
\def\xintCeil {\romannumeral0\xintceil }%
\def\xintceil #1{\xintiiopp {\xintFloor {\xintOpp{#1}}}}%
\def\xintiCeil {\romannumeral0\xinticeil }%
\def\xinticeil #1{\xintiiopp {\xintiFloor {\xintOpp{#1}}}}%
```

9.22 \xintNumerator

```
\def\xintNumerator {\romannumeral0\xintnumerator }%
\def\xintnumerator
{%
    \expandafter\XINT_numer\romannumeral0\XINT_infrac
}%
\def\XINT_numer #1%
{%
    \ifcase\XINT_cntSgn #1\xint:
      \expandafter\XINT_numer_B
    \or
      \expandafter\XINT_numer_A
    \else
      \expandafter\XINT_numer_B
    \fi
    {#1}%
}%
\def\XINT_numer_A #1#2#3{\XINT_dsx_addzeros{#1}#2;}%
\def\XINT_numer_B #1#2#3{ #2}%
```

9.23 \xintDenominator

```
\def\xintDenominator {\romannumeral0\xintdenominator }%
\def\xintdenominator
{%
    \expandafter\XINT_denom_fork\romannumeral0\XINT_infrac
}%
\def\XINT_denom_fork #1%
{%
    \ifnum#1<\xint_c_
      \expandafter\XINT_denom_B
    \else
      \expandafter\XINT_denom_A
    \fi
    #1.%
}%
\def\XINT_denom_A #1.#2#3{ #3}%
\def\XINT_denom_B -#1.#2#3{\XINT_dsx_addzeros{#1}#3;}%
```

9.24 \xintTeXFrac

Added at 1.03 (2013/04/14). Useless typesetting macro.

Modified at 1.4g (2021/05/25). Renamed from \xintFrac.

Modified at 1.4m (2022/06/10). The old name now raises an error, not a warning.

```
\ifdefined\PackageWarning
\def\xintfracTeXDeprecation#1#2{%
\PackageWarning{xintfrac}{\string#1 is deprecated. Use \string#2\MessageBreak
                          to suppress this warning}#2%
}%
\else
\edef\xintfracTeXDeprecation#1#2{{\newlinechar10
\immediate\noexpand\write128{&&JPackage xintfrac Warning: \noexpand\string#1 is
  deprecated. Use \noexpand\string#2&&J%
(xintfrac)\xintReplicate{16}{ }to suppress this warning
on input line \noexpand\the\inputlineno.&&J}}#2%
}%
\fi
\ifdefined\PackageError
\def\xintfracTeXError#1#2{%
\PackageError{xintfrac}{\string#1 has been removed.\MessageBreak
    Use \string#2 to suppress this error}%
    {I will fix it for now if you hit the `Return' key.}#2%
}%
\else
\edef\xintfracTeXError#1#2{{\newlinechar10
\errhelp{I will fix it for now if you hit the `Return' key.}%
\errmessage{Package xintfrac Error: \noexpand\string#1 has been removed.&&J%
(xintfrac)\xintReplicate{16}{ }Use \noexpand\string#2 to suppress this error}}#2%
}%
\fi
\def\xintFrac   {\xintfracTeXError\xintFrac\xintTeXFrac}%
\def\xintTeXFrac{\romannumeral0\xintfrac }%
\def\xintfrac #1%
{%
    \expandafter\XINT_fracfrac_A\romannumeral0\XINT_infrac {#1}%
}%
\def\XINT_fracfrac_A #1{\XINT_fracfrac_B #1\Z }%
\catcode`^=7
\def\XINT_fracfrac_B #1#2\Z
{%
    \xint_gob_til_zero #1\XINT_fracfrac_C 0\XINT_fracfrac_D {10^{#1#2}}%
}%
\def\XINT_fracfrac_C 0\XINT_fracfrac_D #1#2#3%
{%
    \if1\XINT_isOne {#3}%
        \xint_afterfi {\expandafter\xint_stop_atfirstoftwo\xint_gobble_ii }%
    \fi
    \space
    \frac {#2}{#3}%
}%
\def\XINT_fracfrac_D #1#2#3%
```

```
{%
    \if1\XINT_isOne {#3}\XINT_fracfrac_E\fi
    \space
    \frac {#2}{#3}#1%
}%
\def\XINT_fracfrac_E \fi\space\frac #1#2{\fi \space #1\cdot }%
```

9.25 \xintTeXsignedFrac

Modified at 1.4g (2021/05/25). Renamed from \xintSignedFrac.

Modified at 1.4m (2022/06/10). The old name now raises an error, not a warning.

```
\def\xintSignedFrac   {\xintfracTeXError\xintSignedFrac\xintTeXsignedFrac}%
\def\xintTeXsignedFrac{\romannumeral0\xintsignedfrac }%
\def\xintsignedfrac #1%
{%
    \expandafter\XINT_sgnfrac_a\romannumeral0\XINT_infrac {#1}%
}%
\def\XINT_sgnfrac_a #1#2%
{%
    \XINT_sgnfrac_b #2\Z {#1}%
}%
\def\XINT_sgnfrac_b #1%
{%
    \xint_UDsignfork
      #1\XINT_sgnfrac_N
       -{\XINT_sgnfrac_P #1}%
    \krof
}%
\def\XINT_sgnfrac_P #1\Z #2%
{%
    \XINT_fracfrac_A {#2}{#1}%
}%
\def\XINT_sgnfrac_N
{%
    \expandafter-\romannumeral0\XINT_sgnfrac_P
}%
```

9.26 \xintTeXFromSci

Added at 1.4g (2021/05/25). The main problem is how to name this and related macros.

I use \expanded here, as \xintFracToSci is not f-expandable.

Some complications as I want this to be usable on output of \xintFracToSci hence need to handle the case of a /B. After some hesitations I ended with the following which looks reasonable:

- if no scientific part, use \frac (or \over) for A/B
- if scientific part, postfix /B as \cdot B^{-1}

Modified at 1.4l (2022/05/29). Suppress external \expanded. Keep internal one.

Rename \xintTeXFromSci from \xintTeXfromSci. Keep deprecated old name for the moment.

Add \xintTeXFromScifracmacro. Make it \protected.

Nota bene: catcode of ^ is normal one here (else nothing would work).

```
\def\xintTeXfromSci{\xintfracTeXDeprecated\xintTeXfromSci\xintTeXFromSci}%
\def\xintTeXFromSci#1%
```

```
{%
    \expandafter\XINT_texfromsci\expanded{#1}/\relax/\xint:
}%
\def\XINT_texfromsci #1/#2#3/#4\xint:
{%
    \XINT_texfromsci_a #1e\relax e\xint:
    {\ifx\relax#2\xint_dothis\xint_firstofone\fi
     \xint_orthat{\xintTeXFromScifracmacro{#2#3}}}%
    {\unless\ifx\relax#2\cdot{#2#3}^{-1}\fi}%
}%
\def\XINT_texfromsci_a #1e#2#3e#4\xint:#5#6%
{%
    \ifx\relax#2#5{#1}\else#1\cdot10^{#2#3}#6\fi
}%
\ifdefined\frac
  \protected\def\xintTeXFromScifracmacro#1#2{\frac{#2}{#1}}%
\else
  \protected\def\xintTeXFromScifracmacro#1#2{{#2\over#1}}%
\fi
```

9.27 \xintTeXOver

Modified at 1.4g (2021/05/25). Renamed from \xintFwOver.

Modified at 1.4m (2022/06/10). The old name now raises an error, not a warning.

```
\def\xintFwOver {\xintfracTeXError\xintFwOver\xintTeXOver}%
\def\xintTeXOver{\romannumeral0\xintfwover }%
\def\xintfwover #1%
{%
    \expandafter\XINT_fwover_A\romannumeral0\XINT_infrac {#1}%
}%
\def\XINT_fwover_A #1{\XINT_fwover_B #1\Z }%
\def\XINT_fwover_B #1#2\Z
{%
    \xint_gob_til_zero #1\XINT_fwover_C 0\XINT_fwover_D {10^{#1#2}}%
}%
\catcode`^=11
\def\XINT_fwover_C #1#2#3#4#5%
{%
    \if0\XINT_isOne {#5}\xint_afterfi { {#4\over #5}}%
                    \else\xint_afterfi { #4}%
    \fi
}%
\def\XINT_fwover_D #1#2#3%
{%
    \if0\XINT_isOne {#3}\xint_afterfi { {#2\over #3}}%
                    \else\xint_afterfi { #2\cdot }%
    \fi
    #1%
}%
```

9.28 \xintTeXsignedOver

Modified at 1.4g (2021/05/25). Renamed from \xintSignedFwOver.

Modified at 1.4m (2022/06/10). The old name now raises an error, not a warning.

```
\def\xintSignedFwOver {\xintfracTeXError\xintSignedFwOver\xintTeXsignedOver}%
\def\xintTeXsignedOver{\romannumeral0\xintsignedfwover }%
\def\xintsignedfwover #1%
{%
    \expandafter\XINT_sgnfwover_a\romannumeral0\XINT_infrac {#1}%
}%
\def\XINT_sgnfwover_a #1#2%
{%
    \XINT_sgnfwover_b #2\Z {#1}%
}%
\def\XINT_sgnfwover_b #1%
{%
    \xint_UDsignfork
      #1\XINT_sgnfwover_N
       -{\XINT_sgnfwover_P #1}%
    \krof
}%
\def\XINT_sgnfwover_P #1\Z #2%
{%
    \XINT_fwover_A {#2}{#1}%
}%
\def\XINT_sgnfwover_N
{%
    \expandafter-\romannumeral0\XINT_sgnfwover_P
}%
```

9.29 \xintREZ

Removes trailing zeros from A and B and adjust the N in A/B[N].

The macro really doing the job \XINT_factortens was redone at 1.3a. But speed gain really noticeable only beyond about 100 digits.

```
\def\xintREZ {\romannumeral0\xintrez }%
\def\xintrez
{%
    \expandafter\XINT_rez_A\romannumeral0\XINT_infrac
}%
\def\XINT_rez_A #1#2%
{%
    \XINT_rez_AB #2\Z {#1}%
}%
\def\XINT_rez_AB #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_rez_zero
      0#1\XINT_rez_neg
       0-{\XINT_rez_B #1}%
    \krof
}%
```

```
\def\XINT_rez_zero #1\Z #2#3{ 0/1[0]}%
\def\XINT_rez_neg {\expandafter-\romannumeral0\XINT_rez_B }%
\def\XINT_rez_B #1\Z
{%
    \expandafter\XINT_rez_C\romannumeral0\XINT_factortens {#1}%
}%
\def\XINT_rez_C #1.#2.#3#4%
{%
    \expandafter\XINT_rez_D\romannumeral0\XINT_factortens {#4}#3+#2.#1.%
}%
\def\XINT_rez_D #1.#2.#3.%
{%
    \expandafter\XINT_rez_E\the\numexpr #3-#2.#1.%
}%
\def\XINT_rez_E #1.#2.#3.{ #3/#2[#1]}%
```

9.30 \xintE

Added at 1.07 (2013/05/25). The fraction is the first argument contrarily to \xintTrunc and \xintRound.

Modified at 1.1 (2014/10/28). 1.1 modifies and moves \xintiiE to xint.sty.

```
\def\xintE {\romannumeral0\xinte }%
\def\xinte #1%
{%
    \expandafter\XINT_e \romannumeral0\XINT_infrac {#1}%
}%
\def\XINT_e #1#2#3#4%
{%
    \expandafter\XINT_e_end\the\numexpr #1+#4.{#2}{#3}%
}%
\def\XINT_e_end #1.#2#3{ #2/#3[#1]}%
```

9.31 \xintIrr, \xintPIrr

Modified at 1.04 (2013/04/25). fixes a buggy \xintIrr {0}.

Modified at 1.05 (2013/05/01). modifies the initial parsing and post-processing to use \xintrawwithzeros and to more quickly deal with an input denominator equal to 1.

Modified at 1.08 (2013/06/07). this version does not remove a /1 denominator.

Modified at 1.3 (2018/03/01). added \xintPIrr (partial Irr, which ignores the decimal part).

```
\def\xintIrr {\romannumeral0\xintirr }%
\def\xintPIrr{\romannumeral0\xintpirr }%
\def\xintirr #1%
{%
    \expandafter\XINT_irr_start\romannumeral0\xintrawwithzeros {#1}\Z
}%
\def\xintpirr #1%
{%
    \expandafter\XINT_pirr_start\romannumeral0\xintraw{#1}%
}%
\def\XINT_irr_start #1#2/#3\Z
{%
```

```
    \if0\XINT_isOne {#3}%
      \xint_afterfi
          {\xint_UDsignfork
               #1\XINT_irr_negative
                -{\XINT_irr_nonneg #1}%
           \krof}%
    \else
      \xint_afterfi{\XINT_irr_denomisone #1}%
    \fi
    #2\Z {#3}%
}%
\def\XINT_pirr_start #1#2/#3[%
{%
    \if0\XINT_isOne {#3}%
      \xint_afterfi
          {\xint_UDsignfork
               #1\XINT_irr_negative
                -{\XINT_irr_nonneg #1}%
           \krof}%
    \else
      \xint_afterfi{\XINT_irr_denomisone #1}%
    \fi
    #2\Z {#3}[%
}%
\def\XINT_irr_denomisone #1\Z #2{ #1/1}% changed in 1.08
\def\XINT_irr_negative   #1\Z #2{\XINT_irr_D #1\Z #2\Z -}%
\def\XINT_irr_nonneg     #1\Z #2{\XINT_irr_D #1\Z #2\Z \space}%
\def\XINT_irr_D #1#2\Z #3#4\Z
{%
    \xint_UDzerosfork
       #3#1\XINT_irr_indeterminate
       #30\XINT_irr_divisionbyzero
       #10\XINT_irr_zero
        00\XINT_irr_loop_a
    \krof
    {#3#4}{#1#2}{#3#4}{#1#2}%
}%
\def\XINT_irr_indeterminate #1#2#3#4#5%
{%
    \XINT_signalcondition{DivisionUndefined}{0/0 indeterminate fraction.}{}{ 0/1}%
}%
\def\XINT_irr_divisionbyzero #1#2#3#4#5%
{%
    \XINT_signalcondition{DivisionByZero}{Division by zero: #5#2/0.}{}{ 0/1}%
}%
\def\XINT_irr_zero #1#2#3#4#5{ 0/1}% changed in 1.08
\def\XINT_irr_loop_a #1#2%
{%
    \expandafter\XINT_irr_loop_d
    \romannumeral0\XINT_div_prepare {#1}{#2}{#1}%
}%
\def\XINT_irr_loop_d #1#2%
```

```
{%
    \XINT_irr_loop_e #2\Z
}%
\def\XINT_irr_loop_e #1#2\Z
{%
    \xint_gob_til_zero #1\XINT_irr_loop_exit0\XINT_irr_loop_a {#1#2}%
}%
\def\XINT_irr_loop_exit0\XINT_irr_loop_a #1#2#3#4%
{%
    \expandafter\XINT_irr_loop_exitb\expandafter
    {\romannumeral0\xintiiquo {#3}{#2}}%
    {\romannumeral0\xintiiquo {#4}{#2}}%
}%
\def\XINT_irr_loop_exitb #1#2%
{%
   \expandafter\XINT_irr_finish\expandafter {#2}{#1}%
}%
\def\XINT_irr_finish #1#2#3{#3#1/#2}% changed in 1.08
```

9.32 \xintifInt

```
\def\xintifInt   {\romannumeral0\xintifint }%
\def\xintifint #1{\expandafter\XINT_ifint\romannumeral0\xintrawwithzeros {#1}.}%
\def\XINT_ifint #1/#2.%
{%
    \if 0\xintiiRem {#1}{#2}%
     \expandafter\xint_stop_atfirstoftwo
    \else
     \expandafter\xint_stop_atsecondoftwo
    \fi
}%
```

9.33 \xintIsInt

Added at 1.3d only, for isint() xintexpr function.

```
\def\xintIsInt   {\romannumeral0\xintisint }%
\def\xintisint #1%
   {\expandafter\XINT_ifint\romannumeral0\xintrawwithzeros {#1}.10}%
```

9.34 \xintJrr

```
\def\xintJrr {\romannumeral0\xintjrr }%
\def\xintjrr #1%
{%
    \expandafter\XINT_jrr_start\romannumeral0\xintrawwithzeros {#1}\Z
}%
\def\XINT_jrr_start #1#2/#3\Z
{%
    \if0\XINT_isOne {#3}\xint_afterfi
          {\xint_UDsignfork
               #1\XINT_jrr_negative
                -{\XINT_jrr_nonneg #1}%
           \krof}%
```

```
    \else
      \xint_afterfi{\XINT_jrr_denomisone #1}%
    \fi
    #2\Z {#3}%
}%
\def\XINT_jrr_denomisone #1\Z #2{ #1/1}% changed in 1.08
\def\XINT_jrr_negative   #1\Z #2{\XINT_jrr_D #1\Z #2\Z -}%
\def\XINT_jrr_nonneg     #1\Z #2{\XINT_jrr_D #1\Z #2\Z \space}%
\def\XINT_jrr_D #1#2\Z #3#4\Z
{%
    \xint_UDzerosfork
       #3#1\XINT_jrr_indeterminate
       #30\XINT_jrr_divisionbyzero
       #10\XINT_jrr_zero
        00\XINT_jrr_loop_a
    \krof
    {#3#4}{#1#2}1001%
}%
\def\XINT_jrr_indeterminate #1#2#3#4#5#6#7%
{%
    \XINT_signalcondition{DivisionUndefined}{0/0 indeterminate fraction.}{}{ 0/1}%
}%
\def\XINT_jrr_divisionbyzero #1#2#3#4#5#6#7%
{%
    \XINT_signalcondition{DivisionByZero}{Division by zero: #7#2/0.}{}{ 0/1}%
}%
\def\XINT_jrr_zero #1#2#3#4#5#6#7{ 0/1}% changed in 1.08
\def\XINT_jrr_loop_a #1#2%
{%
    \expandafter\XINT_jrr_loop_b
    \romannumeral0\XINT_div_prepare {#1}{#2}{#1}%
}%
\def\XINT_jrr_loop_b #1#2#3#4#5#6#7%
{%
    \expandafter \XINT_jrr_loop_c \expandafter
        {\romannumeral0\xintiiadd{\XINT_mul_fork #4\xint:#1\xint:}{#6}}%
        {\romannumeral0\xintiiadd{\XINT_mul_fork #5\xint:#1\xint:}{#7}}%
    {#2}{#3}{#4}{#5}%
}%
\def\XINT_jrr_loop_c #1#2%
{%
    \expandafter \XINT_jrr_loop_d \expandafter{#2}{#1}%
}%
\def\XINT_jrr_loop_d #1#2#3#4%
{%
    \XINT_jrr_loop_e #3\Z {#4}{#2}{#1}%
}%
\def\XINT_jrr_loop_e #1#2\Z
{%
    \xint_gob_til_zero #1\XINT_jrr_loop_exit0\XINT_jrr_loop_a {#1#2}%
}%
\def\XINT_jrr_loop_exit0\XINT_jrr_loop_a #1#2#3#4#5#6%
```

```
{%
    \XINT_irr_finish {#3}{#4}%
}%
```

9.35 \xintTFrac

Added at 1.09i (2013/12/18). For frac in \xintexpr. And \xintFrac is already assigned. T for truncation. However, potentially not very efficient with numbers in scientific notations, with big exponents. Will have to think it again some day. I hesitated how to call the macro. Same convention as in maple, but some people reserve fractional part to x - floor(x). Also, not clear if I had to make it negative (or zero) if x < 0, or rather always positive. There should be in fact such a thing for each rounding function, trunc, round, floor, ceil.

```
\def\xintTFrac {\romannumeral0\xinttfrac }%
\def\xinttfrac #1{\expandafter\XINT_tfrac_fork\romannumeral0\xintrawwithzeros {#1}\Z }%
\def\XINT_tfrac_fork #1%
{%
    \xint_UDzerominusfork
        #1-\XINT_tfrac_zero
        0#1{\xintiiopp\XINT_tfrac_P }%
         0-{\XINT_tfrac_P #1}%
    \krof
}%
\def\XINT_tfrac_zero #1\Z { 0/1[0]}%
\def\XINT_tfrac_P #1/#2\Z {\expandafter\XINT_rez_AB
                           \romannumeral0\xintiirem{#1}{#2}\Z {0}{#2}}%
```

9.36 \xintTrunc, \xintiTrunc

This of course has a long history. Only showing here some comments.

Modified at 1.2i (2016/12/13). 1.2i release notes: ever since its inception this macro was stupid for a decimal input: it did not handle it separately from the general fraction case A/B[N] with B>1, hence ended up doing divisions by powers of ten. But this meant that nesting \xintTrunc with itself was very inefficient.

1.2i version is better. However it still handles B>1, N<0 via adding zeros to B and dividing with this extended B. A possibly more efficient approach is implemented in \xintXTrunc, but its logic is more complicated, the code is quite longer and making it f-expandable would not shorten it... I decided for the time being to not complicate things here.

Modified at 1.4a (2020/02/19).

Adds handling of a negative first argument.

Zero input still gives single digit 0 output as I did not want to complicate the code. But if quantization gives 0, the exponent [D] will be there. Well actually eD because of problem that sign of original is preserved in output so we can have -0 and I can not use -0[D] notation as it is not legal for strict format. So I will use -0eD hence eD generally even though this means so slight suboptimality for trunc() function in \xintexpr.

The idea to give a meaning to negative D (in the context of optional argument to \xintiexpr) was suggested a long time ago by Kpym (October 20, 2015). His suggestion was then to treat it as positive D but trim trailing zeroes. But since then, there is \xintDecToString which can be combined with \xintREZ, and I feel matters of formatting output require a whole module (or rather use existing third-party tools), and I decided to opt rather for an operation similar as the quantize() of Python Decimal module. I.e. we truncate (or round) to an integer multiple of a given power of 10.

Other reason to decide to do this is that it looks as if I don't even need to understand the original code to hack into its ending via \XINT_trunc_G or \XINT_itrunc_G. For the latter it looks as if logically I simply have to do nothing. For the former I simply have to add some eD postfix.

```
\def\xintTrunc  {\romannumeral0\xinttrunc }%
\def\xintiTrunc {\romannumeral0\xintitrunc}%
\def\xinttrunc #1{\expandafter\XINT_trunc\the\numexpr#1.\XINT_trunc_G}%
\def\xintitrunc #1{\expandafter\XINT_trunc\the\numexpr#1.\XINT_itrunc_G}%
\def\XINT_trunc #1.#2#3%
{%
    \expandafter\XINT_trunc_a\romannumeral0\XINT_infrac{#3}#1.#2%
}%
\def\XINT_trunc_a #1#2#3#4.#5%
{%
    \if0\XINT_Sgn#2\xint:\xint_dothis\XINT_trunc_zero\fi
    \if1\XINT_is_One#3XY\xint_dothis\XINT_trunc_sp_b\fi
    \xint_orthat\XINT_trunc_b #1+#4.{#2}{#3}#5#4.%
}%
\def\XINT_trunc_zero #1.#2.{ 0}%
\def\XINT_trunc_b     {\expandafter\XINT_trunc_B\the\numexpr}%
\def\XINT_trunc_sp_b  {\expandafter\XINT_trunc_sp_B\the\numexpr}%
\def\XINT_trunc_B #1%
{%
    \xint_UDsignfork
      #1\XINT_trunc_C
       -\XINT_trunc_D
    \krof #1%
}%
\def\XINT_trunc_sp_B #1%
{%
    \xint_UDsignfork
      #1\XINT_trunc_sp_C
       -\XINT_trunc_sp_D
    \krof #1%
}%
\def\XINT_trunc_C -#1.#2#3%
{%
    \expandafter\XINT_trunc_CE
    \romannumeral0\XINT_dsx_addzeros{#1}#3;.{#2}%
}%
\def\XINT_trunc_CE #1.#2{\XINT_trunc_E #2.{#1}}%
\def\XINT_trunc_sp_C -#1.#2#3{\XINT_trunc_sp_Ca #2.#1.}%
\def\XINT_trunc_sp_Ca #1%
{%
    \xint_UDsignfork
       #1{\XINT_trunc_sp_Cb -}%
        -{\XINT_trunc_sp_Cb \space#1}%
    \krof
}%
\def\XINT_trunc_sp_Cb #1#2.#3.%
{%
    \expandafter\XINT_trunc_sp_Cc
    \romannumeral0\expandafter\XINT_split_fromright_a
```

```
    \the\numexpr#3-\numexpr\XINT_length_loop
    #2\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:\xint:
      \xint_c_viii\xint_c_vii\xint_c_vi\xint_c_v
      \xint_c_iv\xint_c_iii\xint_c_ii\xint_c_i\xint_c_\xint_bye
    .#2\xint_bye2345678\xint_bye..#1%
}%
\def\XINT_trunc_sp_Cc #1%
{%
    \if.#1\xint_dothis{\XINT_trunc_sp_Cd 0.}\fi
    \xint_orthat {\XINT_trunc_sp_Cd #1}%
}%
\def\XINT_trunc_sp_Cd #1.#2.#3%
{%
    \XINT_trunc_sp_F #3#1.%
}%
\def\XINT_trunc_D #1.#2%
{%
    \expandafter\XINT_trunc_E
    \romannumeral0\XINT_dsx_addzeros {#1}#2;.%
}%
\def\XINT_trunc_sp_D #1.#2#3%
{%
    \expandafter\XINT_trunc_sp_E
    \romannumeral0\XINT_dsx_addzeros {#1}#2;.%
}%
\def\XINT_trunc_E #1%
{%
    \xint_UDsignfork
       #1{\XINT_trunc_F -}%
        -{\XINT_trunc_F \space#1}%
    \krof
}%
\def\XINT_trunc_sp_E #1%
{%
    \xint_UDsignfork
       #1{\XINT_trunc_sp_F -}%
        -{\XINT_trunc_sp_F\space#1}%
    \krof
}%
\def\XINT_trunc_F #1#2.#3#4%
   {\expandafter#4\romannumeral`&&@\expandafter\xint_firstoftwo
                  \romannumeral0\XINT_div_prepare {#3}{#2}.#1}%
\def\XINT_trunc_sp_F #1#2.#3{#3#2.#1}%
\def\XINT_itrunc_G #1#2.#3#4.%
{%
    \if#10\xint_dothis{ 0}\fi
    \xint_orthat{#3#1}#2%
}%
\def\XINT_trunc_G #1.#2#3#4.%
{%
    \xint_gob_til_minus#3\XINT_trunc_Hc-%
    \expandafter\XINT_trunc_H
```

```
    \the\numexpr\romannumeral0\xintlength {#1}-#3#4.#3#4.{#1}#2%
}%
\def\XINT_trunc_Hc-\expandafter\XINT_trunc_H
    \the\numexpr\romannumeral0\xintlength #1.-#2.#3#4{#4#3e#2}%
\def\XINT_trunc_H #1.#2.%
{%
    \ifnum #1 > \xint_c_ \xint_dothis{\XINT_trunc_Ha {#2}}\fi
    \xint_orthat {\XINT_trunc_Hb {-#1}}% -0,--1,--2, ....
}%
\def\XINT_trunc_Ha%
{%
    \expandafter\XINT_trunc_Haa\romannumeral0\xintdecsplit
}%
\def\XINT_trunc_Haa #1#2#3{#3#1.#2}%
\def\XINT_trunc_Hb #1#2#3%
{%
    \expandafter #3\expandafter0\expandafter.%
    \romannumeral\xintreplicate{#1}0#2%
}%
```

9.37 \xintTTrunc

Added at 1.1 (2014/10/28).

```
\def\xintTTrunc {\romannumeral0\xintttrunc }%
\def\xintttrunc {\xintitrunc\xint_c_}%
```

9.38 \xintNum, \xintnum

```
\let\xintnum \xintttrunc
```

9.39 \xintRound, \xintiRound

Modified in 1.2i.

It benefits first of all from the faster \xintTrunc, particularly when the input is already a decimal number (denominator B=1).

And the rounding is now done in 1.2 style (with much delay, sorry), like of the rewritten \xintInc and \xintDec.

At 1.4a, first argument can be negative. This is handled at \XINT_trunc_G.

```
\def\xintRound  {\romannumeral0\xintround }%
\def\xintiRound {\romannumeral0\xintiround }%
\def\xintround  #1{\expandafter\XINT_round\the\numexpr #1.\XINT_round_A}%
\def\xintiround #1{\expandafter\XINT_round\the\numexpr #1.\XINT_iround_A}%
\def\XINT_round #1.{\expandafter\XINT_round_aa\the\numexpr #1+\xint_c_i.#1.}%
\def\XINT_round_aa #1.#2.#3#4%
{%
    \expandafter\XINT_round_a\romannumeral0\XINT_infrac{#4}#1.#3#2.%
}%
\def\XINT_round_a #1#2#3#4.%
{%
    \if0\XINT_Sgn#2\xint:\xint_dothis\XINT_trunc_zero\fi
    \if1\XINT_is_One#3XY\xint_dothis\XINT_trunc_sp_b\fi
    \xint_orthat\XINT_trunc_b #1+#4.{#2}{#3}%
```

```
}%
\def\XINT_round_A{\expandafter\XINT_trunc_G\romannumeral0\XINT_round_B}%
\def\XINT_iround_A{\expandafter\XINT_itrunc_G\romannumeral0\XINT_round_B}%
\def\XINT_round_B #1.%
    {\XINT_dsrr #1\xint_bye\xint_Bye3456789\xint_bye/\xint_c_x\relax.}%
```

9.40 \xintXTrunc

Added at 1.09j (2014/01/09) [on 2014/01/06]. This is completely expandable but not f-expandable.

Modified at 1.2i (2016/12/13). Rewritten:
- no more use of \xintiloop from xinttools.sty (replaced by \xintreplicate... from xintkernel.sty),
- no more use in 0>N>-D case of a dummy control sequence name via \csname...\endcsname
- handles better the case of an input already a decimal number

```
\def\xintXTrunc #1%#2%
{%
    \expandafter\XINT_xtrunc_a
    \the\numexpr #1\expandafter.\romannumeral0\xintraw
}%
\def\XINT_xtrunc_a #1.% ?? faire autre chose
{%
    \expandafter\XINT_xtrunc_b\the\numexpr\ifnum#1<\xint_c_i \xint_c_i-\fi #1.%
}%
\def\XINT_xtrunc_b #1.#2{\XINT_xtrunc_c #2{#1}}%
\def\XINT_xtrunc_c #1%
{%
    \xint_UDzerominusfork
        #1-\XINT_xtrunc_zero
        0#1{-\XINT_xtrunc_d {}}%
         0-{\XINT_xtrunc_d #1}%
    \krof
}%[
\def\XINT_xtrunc_zero #1#2]{0.\romannumeral\xintreplicate{#1}0}%
\def\XINT_xtrunc_d #1#2#3/#4[#5]%
{%
    \XINT_xtrunc_prepare_a#4\R\R\R\R\R\R\R\R {10}0000001\W
    !{#4};{#5}{#2}{#1#3}%
}%
\def\XINT_xtrunc_prepare_a #1#2#3#4#5#6#7#8#9%
{%
    \xint_gob_til_R #9\XINT_xtrunc_prepare_small\R
    \XINT_xtrunc_prepare_b #9%
}%
\def\XINT_xtrunc_prepare_small\R #1!#2;%
{%
    \ifcase #2
    \or\expandafter\XINT_xtrunc_BisOne
    \or\expandafter\XINT_xtrunc_BisTwo
    \or
    \or\expandafter\XINT_xtrunc_BisFour
    \or\expandafter\XINT_xtrunc_BisFive
    \or
```

```
    \or
    \or\expandafter\XINT_xtrunc_BisEight
    \fi\XINT_xtrunc_BisSmall {#2}%
}%
\def\XINT_xtrunc_BisOne\XINT_xtrunc_BisSmall #1#2#3#4%
   {\XINT_xtrunc_sp_e {#2}{#4}{#3}}%
\def\XINT_xtrunc_BisTwo\XINT_xtrunc_BisSmall #1#2#3#4%
{%
    \expandafter\XINT_xtrunc_sp_e\expandafter
    {\the\numexpr #2-\xint_c_i\expandafter}\expandafter
    {\romannumeral0\xintiimul 5{#4}}{#3}%
}%
\def\XINT_xtrunc_BisFour\XINT_xtrunc_BisSmall #1#2#3#4%
{%
    \expandafter\XINT_xtrunc_sp_e\expandafter
    {\the\numexpr #2-\xint_c_ii\expandafter}\expandafter
    {\romannumeral0\xintiimul {25}{#4}}{#3}%
}%
\def\XINT_xtrunc_BisFive\XINT_xtrunc_BisSmall #1#2#3#4%
{%
    \expandafter\XINT_xtrunc_sp_e\expandafter
    {\the\numexpr #2-\xint_c_i\expandafter}\expandafter
    {\romannumeral0\xintdouble {#4}}{#3}%
}%
\def\XINT_xtrunc_BisEight\XINT_xtrunc_BisSmall #1#2#3#4%
{%
    \expandafter\XINT_xtrunc_sp_e\expandafter
    {\the\numexpr #2-\xint_c_iii\expandafter}\expandafter
    {\romannumeral0\xintiimul {125}{#4}}{#3}%
}%
\def\XINT_xtrunc_BisSmall #1%
{%
    \expandafter\XINT_xtrunc_e\expandafter
    {\expandafter\XINT_xtrunc_small_a
    \the\numexpr #1/\xint_c_ii\expandafter
    .\the\numexpr \xint_c_x^viii+#1!}%
}%
\def\XINT_xtrunc_small_a #1.#2!#3%
{%
    \expandafter\XINT_div_small_b\the\numexpr #1\expandafter
    \xint:\the\numexpr #2\expandafter!%
    \romannumeral0\XINT_div_small_ba #3\R\R\R\R\R\R\R\R{10}0000001\W
       #3\XINT_sepbyviii_Z_end 2345678\relax
}%
\def\XINT_xtrunc_prepare_b
   {\expandafter\XINT_xtrunc_prepare_c\romannumeral0\XINT_zeroes_forviii }%
\def\XINT_xtrunc_prepare_c #1!%
{%
     \XINT_xtrunc_prepare_d  #1.00000000!{#1}%
}%
\def\XINT_xtrunc_prepare_d #1#2#3#4#5#6#7#8#9%
{%
```

```
    \expandafter\XINT_xtrunc_prepare_e
    \xint_gob_til_dot #1#2#3#4#5#6#7#8#9!%
}%
\def\XINT_xtrunc_prepare_e #1!#2!#3#4%
{%
    \XINT_xtrunc_prepare_f #4#3\X {#1}{#3}%
}%
\def\XINT_xtrunc_prepare_f #1#2#3#4#5#6#7#8#9\X
{%
    \expandafter\XINT_xtrunc_prepare_g\expandafter
    \XINT_div_prepare_g
     \the\numexpr  #1#2#3#4#5#6#7#8+\xint_c_i\expandafter
    \xint:\the\numexpr (#1#2#3#4#5#6#7#8+\xint_c_i)/\xint_c_ii\expandafter
    \xint:\the\numexpr #1#2#3#4#5#6#7#8\expandafter
    \xint:\romannumeral0\XINT_sepandrev_andcount
    #1#2#3#4#5#6#7#8#9\XINT_rsepbyviii_end_A 2345678%
                      \XINT_rsepbyviii_end_B 2345678\relax\xint_c_ii\xint_c_i
              \R\xint:\xint_c_xii \R\xint:\xint_c_x  \R\xint:\xint_c_viii \R\xint:\xint_c_vi
              \R\xint:\xint_c_iv  \R\xint:\xint_c_ii \R\xint:\xint_c_\W
    \X
}%
\def\XINT_xtrunc_prepare_g #1;{\XINT_xtrunc_e {#1}}%
\def\XINT_xtrunc_e #1#2%
{%
    \ifnum #2<\xint_c_
        \expandafter\XINT_xtrunc_I
    \else
        \expandafter\XINT_xtrunc_II
    \fi  #2\xint:{#1}%
}%
\def\XINT_xtrunc_I -#1\xint:#2#3#4%
{%
    \expandafter\XINT_xtrunc_I_a\romannumeral0#2{#4}{#2}{#1}{#3}%
}%
\def\XINT_xtrunc_I_a #1#2#3#4#5%
{%
    \expandafter\XINT_xtrunc_I_b\the\numexpr #4-#5\xint:#4\xint:{#5}{#2}{#3}{#1}%
}%
\def\XINT_xtrunc_I_b #1%
{%
    \xint_UDsignfork
      #1\XINT_xtrunc_IA_c
       -\XINT_xtrunc_IB_c
    \krof #1%
}%
\def\XINT_xtrunc_IA_c -#1\xint:#2\xint:#3#4#5#6%
{%
   \expandafter\XINT_xtrunc_IA_d
   \the\numexpr#2-\xintLength{#6}\xint:{#6}%
   \expandafter\XINT_xtrunc_IA_xd
   \the\numexpr (#1+\xint_c_ii^v)/\xint_c_ii^vi-\xint_c_i\xint:#1\xint:{#5}{#4}%
}%
```

```
\def\XINT_xtrunc_IA_d #1%
{%
    \xint_UDsignfork
      #1\XINT_xtrunc_IAA_e
       -\XINT_xtrunc_IAB_e
    \krof #1%
}%
\def\XINT_xtrunc_IAA_e -#1\xint:#2%
{%
    \romannumeral0\XINT_split_fromleft
    #1.#2\xint_gobble_i\xint_bye2345678\xint_bye..%
}%
\def\XINT_xtrunc_IAB_e #1\xint:#2%
{%
    0.\romannumeral\XINT_rep#1\endcsname0#2%
}%
\def\XINT_xtrunc_IA_xd #1\xint:#2\xint:%
{%
    \expandafter\XINT_xtrunc_IA_xe\the\numexpr #2-\xint_c_ii^vi*#1\xint:#1\xint:%
}%
\def\XINT_xtrunc_IA_xe #1\xint:#2\xint:#3#4%
{%
    \XINT_xtrunc_loop {#2}{#4}{#3}{#1}%
}%
\def\XINT_xtrunc_IB_c #1\xint:#2\xint:#3#4#5#6%
{%
    \expandafter\XINT_xtrunc_IB_d
    \romannumeral0\XINT_split_xfork #1.#6\xint_bye2345678\xint_bye..{#3}%
}%
\def\XINT_xtrunc_IB_d #1.#2.#3%
{%
    \expandafter\XINT_xtrunc_IA_d\the\numexpr#3-\xintLength {#1}\xint:{#1}%
}%
\def\XINT_xtrunc_II #1\xint:%
{%
    \expandafter\XINT_xtrunc_II_a\romannumeral\xintreplicate{#1}0\xint:%
}%
\def\XINT_xtrunc_II_a #1\xint:#2#3#4%
{%
    \expandafter\XINT_xtrunc_II_b
    \the\numexpr (#3+\xint_c_ii^v)/\xint_c_ii^vi-\xint_c_i\expandafter\xint:%
    \the\numexpr #3\expandafter\xint:\romannumeral0#2{#4#1}{#2}%
}%
\def\XINT_xtrunc_II_b #1\xint:#2\xint:%
{%
    \expandafter\XINT_xtrunc_II_c\the\numexpr #2-\xint_c_ii^vi*#1\xint:#1\xint:%
}%
\def\XINT_xtrunc_II_c #1\xint:#2\xint:#3#4#5%
{%
    #3.\XINT_xtrunc_loop {#2}{#4}{#5}{#1}%
}%
\def\XINT_xtrunc_loop #1%
```

```
{%
    \ifnum #1=\xint_c_ \expandafter\XINT_xtrunc_transition\fi
    \expandafter\XINT_xtrunc_loop_a\the\numexpr #1-\xint_c_i\xint:%
}%
\def\XINT_xtrunc_loop_a #1\xint:#2#3%
{%
    \expandafter\XINT_xtrunc_loop_b\romannumeral0#3%
    {#20000000000000000000000000000000000000000000000000000000000000000}%
    {#1}{#3}%
}%
\def\XINT_xtrunc_loop_b #1#2#3%
{%
    \romannumeral\xintreplicate{\xint_c_ii^vi-\xintLength{#1}}0#1%
    \XINT_xtrunc_loop {#3}{#2}%
}%
\def\XINT_xtrunc_transition
    \expandafter\XINT_xtrunc_loop_a\the\numexpr #1\xint:#2#3#4%
{%
    \ifnum #4=\xint_c_ \expandafter\xint_gobble_vi\fi
    \expandafter\XINT_xtrunc_finish\expandafter
    {\romannumeral0\XINT_dsx_addzeros{#4}#2;}{#3}{#4}%
}%
\def\XINT_xtrunc_finish #1#2%
{%
    \expandafter\XINT_xtrunc_finish_a\romannumeral0#2{#1}%
}%
\def\XINT_xtrunc_finish_a #1#2#3%
{%
    \romannumeral\xintreplicate{#3-\xintLength{#1}}0#1%
}%
\def\XINT_xtrunc_sp_e #1%
{%
    \ifnum #1<\xint_c_
        \expandafter\XINT_xtrunc_sp_I
    \else
        \expandafter\XINT_xtrunc_sp_II
    \fi  #1\xint:%
}%
\def\XINT_xtrunc_sp_I -#1\xint:#2#3%
{%
    \expandafter\XINT_xtrunc_sp_I_a\the\numexpr #1-#3\xint:#1\xint:{#3}{#2}%
}%
\def\XINT_xtrunc_sp_I_a #1%
{%
    \xint_UDsignfork
      #1\XINT_xtrunc_sp_IA_b
       -\XINT_xtrunc_sp_IB_b
    \krof #1%
}%
\def\XINT_xtrunc_sp_IA_b -#1\xint:#2\xint:#3#4%
{%
  \expandafter\XINT_xtrunc_sp_IA_c
```

```
   \the\numexpr#2-\xintLength{#4}\xint:{#4}\romannumeral\XINT_rep#1\endcsname0%
}%
\def\XINT_xtrunc_sp_IA_c #1%
{%
    \xint_UDsignfork
      #1\XINT_xtrunc_sp_IAA
       -\XINT_xtrunc_sp_IAB
    \krof #1%
}%
\def\XINT_xtrunc_sp_IAA -#1\xint:#2%
{%
    \romannumeral0\XINT_split_fromleft
    #1.#2\xint_gobble_i\xint_bye2345678\xint_bye..%
}%
\def\XINT_xtrunc_sp_IAB #1\xint:#2%
{%
    0.\romannumeral\XINT_rep#1\endcsname0#2%
}%
\def\XINT_xtrunc_sp_IB_b #1\xint:#2\xint:#3#4%
{%
    \expandafter\XINT_xtrunc_sp_IB_c
    \romannumeral0\XINT_split_xfork #1.#4\xint_bye2345678\xint_bye..{#3}%
}%
\def\XINT_xtrunc_sp_IB_c #1.#2.#3%
{%
    \expandafter\XINT_xtrunc_sp_IA_c\the\numexpr#3-\xintLength {#1}\xint:{#1}%
}%
\def\XINT_xtrunc_sp_II #1\xint:#2#3%
{%
    #2\romannumeral\XINT_rep#1\endcsname0.\romannumeral\XINT_rep#3\endcsname0%
}%
```

9.41 \xintAdd

Modified at 1.3 (2018/03/01). Big change at 1.3: a/b+c/d uses lcm(b,d) as denominator.

```
\def\xintAdd {\romannumeral0\xintadd }%
\def\xintadd #1{\expandafter\XINT_fadd\romannumeral0\xintraw {#1}}%
\def\XINT_fadd #1{\xint_gob_til_zero #1\XINT_fadd_Azero 0\XINT_fadd_a #1}%
\def\XINT_fadd_Azero #1]{\xintraw }%
\def\XINT_fadd_a #1/#2[#3]#4%
   {\expandafter\XINT_fadd_b\romannumeral0\xintraw {#4}{#3}{#1}{#2}}%
\def\XINT_fadd_b #1{\xint_gob_til_zero #1\XINT_fadd_Bzero 0\XINT_fadd_c #1}%
\def\XINT_fadd_Bzero #1]#2#3#4{ #3/#4[#2]}%
\def\XINT_fadd_c #1/#2[#3]#4%
{%
    \expandafter\XINT_fadd_Aa\the\numexpr #4-#3.{#3}{#4}{#1}{#2}%
}%
\def\XINT_fadd_Aa #1%
{%
    \xint_UDzerominusfork
       #1-\XINT_fadd_B
        0#1\XINT_fadd_Bb
```

```
        0-\XINT_fadd_Ba
    \krof #1%
}%
\def\XINT_fadd_B   #1.#2#3#4#5#6#7{\XINT_fadd_C {#4}{#5}{#7}{#6}[#3]}%
\def\XINT_fadd_Ba  #1.#2#3#4#5#6#7%
{%
    \expandafter\XINT_fadd_C\expandafter
        {\romannumeral0\XINT_dsx_addzeros {#1}#6;}%
    {#7}{#5}{#4}[#2]%
}%
\def\XINT_fadd_Bb -#1.#2#3#4#5#6#7%
{%
    \expandafter\XINT_fadd_C\expandafter
        {\romannumeral0\XINT_dsx_addzeros {#1}#4;}%
    {#5}{#7}{#6}[#3]%
}%
\def\XINT_fadd_iszero #1[#2]{ 0/1[0]}% ou [#2] originel?
\def\XINT_fadd_C #1#2#3%
{%
    \expandafter\XINT_fadd_D_b
    \romannumeral0\XINT_div_prepare{#2}{#3}{#2}{#2}{#3}{#1}%
}%
```

Basically a clone of the \XINT_irr_loop_a loop. I should modify the output of \XINT_div_prepare perhaps to be optimized for checking if remainder vanishes.

```
\def\XINT_fadd_D_a #1#2%
{%
    \expandafter\XINT_fadd_D_b
    \romannumeral0\XINT_div_prepare {#1}{#2}{#1}%
}%
\def\XINT_fadd_D_b #1#2{\XINT_fadd_D_c #2\Z}%
\def\XINT_fadd_D_c #1#2\Z
{%
    \xint_gob_til_zero #1\XINT_fadd_D_exit0\XINT_fadd_D_a {#1#2}%
}%
\def\XINT_fadd_D_exit0\XINT_fadd_D_a #1#2#3%
{%
    \expandafter\XINT_fadd_E
    \romannumeral0\xintiiquo {#3}{#2}.{#2}%
}%
\def\XINT_fadd_E #1.#2#3%
{%
    \expandafter\XINT_fadd_F
    \romannumeral0\xintiimul{#1}{#3}.{\xintiiQuo{#3}{#2}}{#1}%
}%
\def\XINT_fadd_F #1.#2#3#4#5%
{%
    \expandafter\XINT_fadd_G
    \romannumeral0\xintiiadd{\xintiiMul{#2}{#4}}{\xintiiMul{#3}{#5}}/#1%
}%
\def\XINT_fadd_G #1{%
\def\XINT_fadd_G ##1{\if0##1\expandafter\XINT_fadd_iszero\fi#1##1}%
}\XINT_fadd_G{ }%
```

9.42 \xintSub

Modified at 1.3 (2018/03/01). Since 1.3 will use least common multiple of denominators.

```
\def\xintSub   {\romannumeral0\xintsub }%
\def\xintsub #1{\expandafter\XINT_fsub\romannumeral0\xintraw {#1}}%
\def\XINT_fsub #1{\xint_gob_til_zero #1\XINT_fsub_Azero 0\XINT_fsub_a #1}%
\def\XINT_fsub_Azero #1]{\xintopp }%
\def\XINT_fsub_a #1/#2[#3]#4%
   {\expandafter\XINT_fsub_b\romannumeral0\xintraw {#4}{#3}{#1}{#2}}%
\def\XINT_fsub_b #1{\xint_UDzerominusfork
                      #1-\XINT_fadd_Bzero
                       0#1\XINT_fadd_c
                       0-{\XINT_fadd_c -#1}%
                     \krof }%
```

9.43 \xintSum

There was (not documented anymore since 1.09d, 2013/10/22) a macro \xintSumExpr, but it has been deleted at 1.21.

Empty items in the input are not accepted by this macro, but the input may be empty.

Refactored slightly at 1.4. \XINT_Sum used in xintexpr code.

```
\def\xintSum {\romannumeral0\xintsum }%
\def\xintsum #1{\expandafter\XINT_sum\romannumeral`&&@#1^}%
\def\XINT_Sum{\romannumeral0\XINT_sum}%
\def\XINT_sum#1%
{%
    \xint_gob_til_^ #1\XINT_sum_empty ^%
    \expandafter\XINT_sum_loop\romannumeral0\xintraw{#1}\xint:
}%
\def\XINT_sum_empty ^#1\xint:{ 0/1[0]}%
\def\XINT_sum_loop #1\xint:#2%
{%
    \xint_gob_til_^ #2\XINT_sum_end ^%
    \expandafter\XINT_sum_loop
    \romannumeral0\xintadd{#1}{\romannumeral0\xintraw{#2}}\xint:
}%
\def\XINT_sum_end ^#1\xintadd #2#3\xint:{ #2}%
```

9.44 \xintMul

```
\def\xintMul {\romannumeral0\xintmul }%
\def\xintmul #1{\expandafter\XINT_fmul\romannumeral0\xintraw {#1}.}%
\def\XINT_fmul #1{\xint_gob_til_zero #1\XINT_fmul_zero 0\XINT_fmul_a #1}%
\def\XINT_fmul_a #1[#2].#3%
   {\expandafter\XINT_fmul_b\romannumeral0\xintraw {#3}#1[#2.]}%
\def\XINT_fmul_b #1{\xint_gob_til_zero #1\XINT_fmul_zero 0\XINT_fmul_c #1}%
\def\XINT_fmul_c #1/#2[#3]#4/#5[#6.]%
{%
    \expandafter\XINT_fmul_d
    \expandafter{\the\numexpr #3+#6\expandafter}%
    \expandafter{\romannumeral0\xintiimul {#5}{#2}}%
    {\romannumeral0\xintiimul {#4}{#1}}%
}%
```

```
\def\XINT_fmul_d #1#2#3%
{%
    \expandafter \XINT_fmul_e \expandafter{#3}{#1}{#2}%
}%
\def\XINT_fmul_e #1#2{\XINT_outfrac {#2}{#1}}%
\def\XINT_fmul_zero #1.#2{ 0/1[0]}%
```

9.45 \xintSqr

```
\def\xintSqr {\romannumeral0\xintsqr }%
\def\xintsqr #1{\expandafter\XINT_fsqr\romannumeral0\xintraw {#1}}%
\def\XINT_fsqr #1{\xint_gob_til_zero #1\XINT_fsqr_zero 0\XINT_fsqr_a #1}%
\def\XINT_fsqr_a #1/#2[#3]%
{%
    \expandafter\XINT_fsqr_b
    \expandafter{\the\numexpr #3+#3\expandafter}%
    \expandafter{\romannumeral0\xintiisqr {#2}}%
    {\romannumeral0\xintiisqr {#1}}%
}%
\def\XINT_fsqr_b #1#2#3{\expandafter \XINT_fmul_e \expandafter{#3}{#1}{#2}}%
\def\XINT_fsqr_zero #1]{ 0/1[0]}%
```

9.46 \xintPow

1.2f: to be coherent with the "i" convention \xintiPow should parse also its exponent via \xintNum when xintfrac.sty is loaded. This was not the case so far. Cependant le problème est que le fait d'appliquer \xintNum rend impossible certains inputs qui auraient pu être gérès par \numexpr. Le \numexpr externe est ici pour intercepter trop grand input.

```
\def\xintipow #1#2%
{%
    \expandafter\xint_pow\the\numexpr \xintNum{#2}\expandafter
    .\romannumeral0\xintnum{#1}\xint:
}%
\def\xintPow {\romannumeral0\xintpow }%
\def\xintpow #1%
{%
    \expandafter\XINT_fpow\expandafter {\romannumeral0\XINT_infrac {#1}}%
}%
\def\XINT_fpow #1#2%
{%
    \expandafter\XINT_fpow_fork\the\numexpr \xintNum{#2}\relax\Z #1%
}%
\def\XINT_fpow_fork #1#2\Z
{%
    \xint_UDzerominusfork
      #1-\XINT_fpow_zero
      0#1\XINT_fpow_neg
       0-{\XINT_fpow_pos #1}%
    \krof
    {#2}%
}%
\def\XINT_fpow_zero #1#2#3#4{ 1/1[0]}%
\def\XINT_fpow_pos #1#2#3#4#5%
```

```
{%
    \expandafter\XINT_fpow_pos_A\expandafter
    {\the\numexpr #1#2*#3\expandafter}\expandafter
    {\romannumeral0\xintiipow {#5}{#1#2}}%
    {\romannumeral0\xintiipow {#4}{#1#2}}%
}%
\def\XINT_fpow_neg #1#2#3#4%
{%
    \expandafter\XINT_fpow_pos_A\expandafter
    {\the\numexpr -#1*#2\expandafter}\expandafter
    {\romannumeral0\xintiipow {#3}{#1}}%
    {\romannumeral0\xintiipow {#4}{#1}}%
}%
\def\XINT_fpow_pos_A #1#2#3%
{%
    \expandafter\XINT_fpow_pos_B\expandafter {#3}{#1}{#2}%
}%
\def\XINT_fpow_pos_B #1#2{\XINT_outfrac {#2}{#1}}%
```

9.47 \xintFac

Factorial coefficients: variant which can be chained with other xintfrac macros.

```
\def\xintFac  {\romannumeral0\xintfac}%
\def\xintfac  #1{\expandafter\XINT_fac_fork\the\numexpr\xintNum{#1}.[0]}%
```

9.48 \xintBinomial

Added at 1.2f (2016/03/12).

```
\def\xintBinomial {\romannumeral0\xintbinomial}%
\def\xintbinomial #1#2%
{%
    \expandafter\XINT_binom_pre
    \the\numexpr\xintNum{#1}\expandafter.\the\numexpr\xintNum{#2}.[0]%
}%
```

9.49 \xintPFactorial

Added at 1.2f (2016/03/12). Partial factorial. For needs of xintexpr.sty.

```
\def\xintipfactorial #1#2%
{%
    \expandafter\XINT_pfac_fork
    \the\numexpr\xintNum{#1}\expandafter.\the\numexpr\xintNum{#2}.%
}%
\def\xintPFactorial {\romannumeral0\xintpfactorial}%
\def\xintpfactorial #1#2%
{%
    \expandafter\XINT_pfac_fork
    \the\numexpr\xintNum{#1}\expandafter.\the\numexpr\xintNum{#2}.[0]%
}%
```

9.50 \xintPrd

Refactored at 1.4. After some hesitation the routine still does not try to detect on the fly a zero item, to abort the loop. Indeed this would add some overhead generally (as we need normalizing the item before checking if it vanishes hence we must then grab things once more).

```
\def\xintPrd {\romannumeral0\xintprd }%
\def\xintprd #1{\expandafter\XINT_prd\romannumeral`&&@#1^}%
\def\XINT_Prd{\romannumeral0\XINT_prd}%
\def\XINT_prd#1%
{%
    \xint_gob_til_^ #1\XINT_prd_empty ^%
    \expandafter\XINT_prd_loop\romannumeral0\xintraw{#1}\xint:
}%
\def\XINT_prd_empty ^#1\xint:{ 1/1[0]}%
\def\XINT_prd_loop #1\xint:#2%
{%
    \xint_gob_til_^ #2\XINT_prd_end ^%
    \expandafter\XINT_prd_loop
    \romannumeral0\xintmul{#1}{\romannumeral0\xintraw{#2}}\xint:
}%
\def\XINT_prd_end ^#1\xintmul #2#3\xint:{ #2}%
```

9.51 \xintDiv

```
\def\xintDiv {\romannumeral0\xintdiv }%
\def\xintdiv #1%
{%
    \expandafter\XINT_fdiv\expandafter {\romannumeral0\XINT_infrac {#1}}%
}%
\def\XINT_fdiv #1#2%
   {\expandafter\XINT_fdiv_A\romannumeral0\XINT_infrac {#2}#1}%
\def\XINT_fdiv_A #1#2#3#4#5#6%
{%
    \expandafter\XINT_fdiv_B
    \expandafter{\the\numexpr #4-#1\expandafter}%
    \expandafter{\romannumeral0\xintiimul {#2}{#6}}%
    {\romannumeral0\xintiimul {#3}{#5}}%
}%
\def\XINT_fdiv_B #1#2#3%
{%
    \expandafter\XINT_fdiv_C
    \expandafter{#3}{#1}{#2}%
}%
\def\XINT_fdiv_C #1#2{\XINT_outfrac {#2}{#1}}%
```

9.52 \xintDivFloor

Added at 1.1 (2014/10/28). Changed at 1.2p to not append /1[0] ending but rather output a big integer in strict format, like \xintDivTrunc and \xintDivRound.

```
\def\xintDivFloor     {\romannumeral0\xintdivfloor }%
\def\xintdivfloor #1#2{\xintifloor{\xintDiv {#1}{#2}}}%
```

9.53 \xintDivTrunc

Added at 1.1 (2014/10/28).

```
\def\xintDivTrunc     {\romannumeral0\xintdivtrunc }%
\def\xintdivtrunc #1#2{\xintttrunc {\xintDiv {#1}{#2}}}%
```

9.54 \xintDivRound

1.1

```
\def\xintDivRound     {\romannumeral0\xintdivround }%
\def\xintdivround #1#2{\xintiround 0{\xintDiv {#1}{#2}}}%
```

9.55 \xintModTrunc

Added at 1.1 (2014/10/28). \xintModTrunc {q1}{q2} computes q1 - q2*t(q1/q2) with t(q1/q2) equal to the truncated division of two fractions q1 and q2.
Its former name, prior to 1.2p, was \xintMod.

Modified at 1.3 (2018/03/01). At 1.3, uses least common multiple denominator, like \xintMod (next).

```
\def\xintModTrunc {\romannumeral0\xintmodtrunc }%
\def\xintmodtrunc #1{\expandafter\XINT_modtrunc_a\romannumeral0\xintraw{#1}.}%
\def\XINT_modtrunc_a #1#2.#3%
   {\expandafter\XINT_modtrunc_b\expandafter #1\romannumeral0\xintraw{#3}#2.}%
\def\XINT_modtrunc_b #1#2% #1 de A, #2 de B.
{%
    \if0#2\xint_dothis{\XINT_modtrunc_divbyzero #1#2}\fi
    \if0#1\xint_dothis\XINT_modtrunc_aiszero\fi
    \if-#2\xint_dothis{\XINT_modtrunc_bneg #1}\fi
          \xint_orthat{\XINT_modtrunc_bpos #1#2}%
}%
\def\XINT_modtrunc_divbyzero #1#2[#3]#4.%
{%
    \XINT_signalcondition{DivisionByZero}{Division by zero: #1#4/(#2[#3]).}{}{ 0/1[0]}%
}%
\def\XINT_modtrunc_aiszero #1.{ 0/1[0]}%
\def\XINT_modtrunc_bneg #1%
{%
    \xint_UDsignfork
         #1{\xintiiopp\XINT_modtrunc_pos {}}%
          -{\XINT_modtrunc_pos #1}%
    \krof
}%
\def\XINT_modtrunc_bpos #1%
{%
    \xint_UDsignfork
            #1{\xintiiopp\XINT_modtrunc_pos {}}%
             -{\XINT_modtrunc_pos #1}%
    \krof
}%
```

Attention. This crucially uses that xint's \xintiiE{x}{e} is defined to return x unchanged if e is negative (and x extended by e zeroes if e >= 0).

```
\def\XINT_modtrunc_pos #1#2/#3[#4]#5/#6[#7].%
{%
    \expandafter\XINT_modtrunc_pos_a
    \the\numexpr\ifnum#7>#4 #4\else #7\fi\expandafter.%
    \romannumeral0\expandafter\XINT_mod_D_b
    \romannumeral0\XINT_div_prepare{#3}{#6}{#3}{#3}{#6}%
    {#1#5}{#7-#4}{#2}{#4-#7}%
}%
\def\XINT_modtrunc_pos_a #1.#2#3#4{\xintiirem {#3}{#4}/#2[#1]}%
```

9.56 \xintDivMod

Added at 1.2p (2017/12/05). \xintDivMod{q1}{q2} outputs {floor(q1/q2)}{q1 - q2*floor(q1/q2)}. Attention that it relies on \xintiiE{x}{e} returning x if e < 0.

Modified at 1.3 (2018/03/01). Modified (like \xintAdd and \xintSub) at 1.3 to use a l.c.m for final denominator of the "mod" part.

```
\def\xintDivMod {\romannumeral0\xintdivmod }%
\def\xintdivmod #1{\expandafter\XINT_divmod_a\romannumeral0\xintraw{#1}.}%
\def\XINT_divmod_a #1#2.#3%
   {\expandafter\XINT_divmod_b\expandafter #1\romannumeral0\xintraw{#3}#2.}%
\def\XINT_divmod_b #1#2% #1 de A, #2 de B.
{%
    \if0#2\xint_dothis{\XINT_divmod_divbyzero #1#2}\fi
    \if0#1\xint_dothis\XINT_divmod_aiszero\fi
    \if-#2\xint_dothis{\XINT_divmod_bneg #1}\fi
          \xint_orthat{\XINT_divmod_bpos #1#2}%
}%
\def\XINT_divmod_divbyzero #1#2[#3]#4.%
{%
    \XINT_signalcondition{DivisionByZero}{Division by zero: #1#4/(#2[#3]).}{}%
    {{0}{0/1[0]}}% à revoir...
}%
\def\XINT_divmod_aiszero #1.{{0}{0/1[0]}}%
\def\XINT_divmod_bneg #1% f // -g = (-f) // g, f % -g = - ((-f) % g)
{%
    \expandafter\XINT_divmod_bneg_finish
    \romannumeral0\xint_UDsignfork
        #1{\XINT_divmod_bpos {}}%
         -{\XINT_divmod_bpos {-#1}}%
    \krof
}%
\def\XINT_divmod_bneg_finish#1#2%
{%
    \expandafter\xint_exchangetwo_keepbraces\expandafter
    {\romannumeral0\xintiiopp#2}{#1}%
}%
\def\XINT_divmod_bpos #1#2/#3[#4]#5/#6[#7].%
{%
    \expandafter\XINT_divmod_bpos_a
    \the\numexpr\ifnum#7>#4 #4\else #7\fi\expandafter.%
    \romannumeral0\expandafter\XINT_mod_D_b
    \romannumeral0\XINT_div_prepare{#3}{#6}{#3}{#3}{#6}%
```

```
    {#1#5}{#7-#4}{#2}{#4-#7}%
}%
\def\XINT_divmod_bpos_a #1.#2#3#4%
{%
    \expandafter\XINT_divmod_bpos_finish
    \romannumeral0\xintiidivision{#3}{#4}{/#2[#1]}%
}%
\def\XINT_divmod_bpos_finish #1#2#3{{#1}{#2#3}}%
```

9.57 \xintMod

Added at 1.2p (2017/12/05). \xintMod{q1}{q2} computes q1 - q2*floor(q1/q2). Attention that it relies on \xintiiE{x}{e} returning x if e < 0.
Prior to 1.2p, that macro had the meaning now attributed to \xintModTrunc.

Modified at 1.3 (2018/03/01). Modified (like \xintAdd and \xintSub) at 1.3 to use a l.c.m for final denominator.

```
\def\xintMod {\romannumeral0\xintmod }%
\def\xintmod #1{\expandafter\XINT_mod_a\romannumeral0\xintraw{#1}.}%
\def\XINT_mod_a #1#2.#3%
   {\expandafter\XINT_mod_b\expandafter #1\romannumeral0\xintraw{#3}#2.}%
\def\XINT_mod_b #1#2% #1 de A, #2 de B.
{%
    \if0#2\xint_dothis{\XINT_mod_divbyzero #1#2}\fi
    \if0#1\xint_dothis\XINT_mod_aiszero\fi
    \if-#2\xint_dothis{\XINT_mod_bneg #1}\fi
          \xint_orthat{\XINT_mod_bpos #1#2}%
}%
```

Attention to not move ModTrunc code beyond that point.

```
\let\XINT_mod_divbyzero\XINT_modtrunc_divbyzero
\let\XINT_mod_aiszero  \XINT_modtrunc_aiszero
\def\XINT_mod_bneg #1% f % -g = - ((-f) % g), for g > 0
{%
    \xintiiopp\xint_UDsignfork
        #1{\XINT_mod_bpos {}}%
         -{\XINT_mod_bpos {-#1}}%
    \krof
}%
\def\XINT_mod_bpos #1#2/#3[#4]#5/#6[#7].%
{%
    \expandafter\XINT_mod_bpos_a
    \the\numexpr\ifnum#7>#4 #4\else #7\fi\expandafter.%
    \romannumeral0\expandafter\XINT_mod_D_b
    \romannumeral0\XINT_div_prepare{#3}{#6}{#3}{#3}{#6}%
    {#1#5}{#7-#4}{#2}{#4-#7}%
}%
\def\XINT_mod_D_a #1#2%
{%
    \expandafter\XINT_mod_D_b
    \romannumeral0\XINT_div_prepare {#1}{#2}{#1}%
}%
\def\XINT_mod_D_b #1#2{\XINT_mod_D_c #2\Z}%
\def\XINT_mod_D_c #1#2\Z
```

```
{%
    \xint_gob_til_zero #1\XINT_mod_D_exit0\XINT_mod_D_a {#1#2}%
}%
\def\XINT_mod_D_exit0\XINT_mod_D_a #1#2#3%
{%
    \expandafter\XINT_mod_E
    \romannumeral0\xintiiquo {#3}{#2}.{#2}%
}%
\def\XINT_mod_E #1.#2#3%
{%
    \expandafter\XINT_mod_F
    \romannumeral0\xintiimul{#1}{#3}.{\xintiiQuo{#3}{#2}}{#1}%
}%
\def\XINT_mod_F #1.#2#3#4#5#6#7%
{%
    {#1}{\xintiiE{\xintiiMul{#4}{#3}}{#5}}%
        {\xintiiE{\xintiiMul{#6}{#2}}{#7}}%
}%
\def\XINT_mod_bpos_a #1.#2#3#4{\xintiirem {#3}{#4}/#2[#1]}%
```

9.58 \xintIsOne

Added at 1.09a (2013/09/24). Could be more efficient. For fractions with big powers of tens, it is better to use \xintCmp{f}{1}. Restyled in 1.09i.

```
\def\xintIsOne   {\romannumeral0\xintisone }%
\def\xintisone #1{\expandafter\XINT_fracisone
                  \romannumeral0\xintrawwithzeros{#1}\Z }%
\def\XINT_fracisone #1/#2\Z
    {\if0\xintiiCmp {#1}{#2}\xint_afterfi{ 1}\else\xint_afterfi{ 0}\fi}%
```

9.59 \xintGeq

```
\def\xintGeq {\romannumeral0\xintgeq }%
\def\xintgeq #1%
{%
    \expandafter\XINT_fgeq\expandafter {\romannumeral0\xintabs {#1}}%
}%
\def\XINT_fgeq #1#2%
{%
    \expandafter\XINT_fgeq_A \romannumeral0\xintabs {#2}#1%
}%
\def\XINT_fgeq_A #1%
{%
    \xint_gob_til_zero #1\XINT_fgeq_Zii 0%
    \XINT_fgeq_B #1%
}%
\def\XINT_fgeq_Zii 0\XINT_fgeq_B #1[#2]#3[#4]{ 1}%
\def\XINT_fgeq_B #1/#2[#3]#4#5/#6[#7]%
{%
    \xint_gob_til_zero #4\XINT_fgeq_Zi 0%
    \expandafter\XINT_fgeq_C\expandafter
    {\the\numexpr #7-#3\expandafter}\expandafter
```

```
    {\romannumeral0\xintiimul {#4#5}{#2}}%
    {\romannumeral0\xintiimul {#6}{#1}}%
}%
\def\XINT_fgeq_Zi 0#1#2#3#4#5#6#7{ 0}%
\def\XINT_fgeq_C #1#2#3%
{%
    \expandafter\XINT_fgeq_D\expandafter
    {#3}{#1}{#2}%
}%
\def\XINT_fgeq_D #1#2#3%
{%
    \expandafter\XINT_cntSgnFork\romannumeral`&&@\expandafter\XINT_cntSgn
     \the\numexpr #2+\xintLength{#3}-\xintLength{#1}\relax\xint:
    { 0}{\XINT_fgeq_E #2\Z {#3}{#1}}{ 1}%
}%
\def\XINT_fgeq_E #1%
{%
    \xint_UDsignfork
        #1\XINT_fgeq_Fd
         -{\XINT_fgeq_Fn #1}%
    \krof
}%
\def\XINT_fgeq_Fd #1\Z #2#3%
{%
    \expandafter\XINT_fgeq_Fe
    \romannumeral0\XINT_dsx_addzeros {#1}#3;\xint:#2\xint:
}%
\def\XINT_fgeq_Fe #1\xint:#2#3\xint:{\XINT_geq_plusplus #2#1\xint:#3\xint:}%
\def\XINT_fgeq_Fn #1\Z #2#3%
{%
    \expandafter\XINT_fgeq_Fo
    \romannumeral0\XINT_dsx_addzeros {#1}#2;\xint:#3\xint:
}%
\def\XINT_fgeq_Fo #1#2\xint:#3\xint:{\XINT_geq_plusplus #1#3\xint:#2\xint:}%
```

9.60 \xintMax

```
\def\xintMax {\romannumeral0\xintmax }%
\def\xintmax #1%
{%
    \expandafter\XINT_fmax\expandafter {\romannumeral0\xintraw {#1}}%
}%
\def\XINT_fmax #1#2%
{%
    \expandafter\XINT_fmax_A\romannumeral0\xintraw {#2}#1%
}%
\def\XINT_fmax_A #1#2/#3[#4]#5#6/#7[#8]%
{%
    \xint_UDsignsfork
      #1#5\XINT_fmax_minusminus
       -#5\XINT_fmax_firstneg
       #1-\XINT_fmax_secondneg
        --\XINT_fmax_nonneg_a
```

```
    \krof
    #1#5{#2/#3[#4]}{#6/#7[#8]}%
}%
\def\XINT_fmax_minusminus --%
   {\expandafter-\romannumeral0\XINT_fmin_nonneg_b }%
\def\XINT_fmax_firstneg #1-#2#3{ #1#2}%
\def\XINT_fmax_secondneg -#1#2#3{ #1#3}%
\def\XINT_fmax_nonneg_a #1#2#3#4%
{%
    \XINT_fmax_nonneg_b {#1#3}{#2#4}%
}%
\def\XINT_fmax_nonneg_b #1#2%
{%
    \if0\romannumeral0\XINT_fgeq_A #1#2%
          \xint_afterfi{ #1}%
    \else \xint_afterfi{ #2}%
    \fi
}%
```

9.61 \xintMaxof

1.21 protects \xintMaxof against items with non terminated \the\numexpr expressions.

1.4 renders the macro compatible with an empty argument and it also defines an accessor \XINT_Maxof suitable for xintexpr usage (formerly xintexpr had its own macro handling comma separated values, but it changed internal representation at 1.4).

```
\def\xintMaxof {\romannumeral0\xintmaxof }%
\def\xintmaxof #1{\expandafter\XINT_maxof\romannumeral`&&@#1^}%
\def\XINT_Maxof{\romannumeral0\XINT_maxof}%
\def\XINT_maxof#1%
{%
    \xint_gob_til_^ #1\XINT_maxof_empty ^%
    \expandafter\XINT_maxof_loop\romannumeral0\xintraw{#1}\xint:
}%
\def\XINT_maxof_empty ^#1\xint:{ 0/1[0]}%
\def\XINT_maxof_loop #1\xint:#2%
{%
    \xint_gob_til_^ #2\XINT_maxof_e ^%
    \expandafter\XINT_maxof_loop
    \romannumeral0\xintmax{#1}{\romannumeral0\xintraw{#2}}\xint:
}%
\def\XINT_maxof_e ^#1\xintmax #2#3\xint:{ #2}%
```

9.62 \xintMin

```
\def\xintMin {\romannumeral0\xintmin }%
\def\xintmin #1%
{%
    \expandafter\XINT_fmin\expandafter {\romannumeral0\xintraw {#1}}%
}%
\def\XINT_fmin #1#2%
{%
    \expandafter\XINT_fmin_A\romannumeral0\xintraw {#2}#1%
}%
```

```
\def\XINT_fmin_A #1#2/#3[#4]#5#6/#7[#8]%
{%
    \xint_UDsignsfork
      #1#5\XINT_fmin_minusminus
       -#5\XINT_fmin_firstneg
       #1-\XINT_fmin_secondneg
        --\XINT_fmin_nonneg_a
    \krof
    #1#5{#2/#3[#4]}{#6/#7[#8]}%
}%
\def\XINT_fmin_minusminus --%
   {\expandafter-\romannumeral0\XINT_fmax_nonneg_b }%
\def\XINT_fmin_firstneg #1-#2#3{ -#3}%
\def\XINT_fmin_secondneg -#1#2#3{ -#2}%
\def\XINT_fmin_nonneg_a #1#2#3#4%
{%
    \XINT_fmin_nonneg_b {#1#3}{#2#4}%
}%
\def\XINT_fmin_nonneg_b #1#2%
{%
    \if0\romannumeral0\XINT_fgeq_A #1#2%
          \xint_afterfi{ #2}%
    \else \xint_afterfi{ #1}%
    \fi
}%
```

9.63 \xintMinof

1.2l protects \xintMinof against items with non terminated \the\numexpr expressions.

1.4 version is compatible with an empty input (empty items are handled as zero).

```
\def\xintMinof {\romannumeral0\xintminof }%
\def\xintminof #1{\expandafter\XINT_minof\romannumeral`&&@#1^}%
\def\XINT_Minof{\romannumeral0\XINT_minof}%
\def\XINT_minof#1%
{%
    \xint_gob_til_^ #1\XINT_minof_empty ^%
    \expandafter\XINT_minof_loop\romannumeral0\xintraw{#1}\xint:
}%
\def\XINT_minof_empty ^#1\xint:{ 0/1[0]}%
\def\XINT_minof_loop #1\xint:#2%
{%
    \xint_gob_til_^ #2\XINT_minof_e ^%
    \expandafter\XINT_minof_loop\romannumeral0\xintmin{#1}{\romannumeral0\xintraw{#2}}\xint:
}%
\def\XINT_minof_e ^#1\xintmin #2#3\xint:{ #2}%
```

9.64 \xintCmp

```
\def\xintCmp {\romannumeral0\xintcmp }%
\def\xintcmp #1%
{%
    \expandafter\XINT_fcmp\expandafter {\romannumeral0\xintraw {#1}}%
}%
```

```
\def\XINT_fcmp #1#2%
{%
    \expandafter\XINT_fcmp_A\romannumeral0\xintraw {#2}#1%
}%
\def\XINT_fcmp_A #1#2/#3[#4]#5#6/#7[#8]%
{%
    \xint_UDsignsfork
      #1#5\XINT_fcmp_minusminus
       -#5\XINT_fcmp_firstneg
       #1-\XINT_fcmp_secondneg
        --\XINT_fcmp_nonneg_a
    \krof
    #1#5{#2/#3[#4]}{#6/#7[#8]}%
}%
\def\XINT_fcmp_minusminus --#1#2{\XINT_fcmp_B #2#1}%
\def\XINT_fcmp_firstneg #1-#2#3{ -1}%
\def\XINT_fcmp_secondneg -#1#2#3{ 1}%
\def\XINT_fcmp_nonneg_a #1#2%
{%
    \xint_UDzerosfork
      #1#2\XINT_fcmp_zerozero
       0#2\XINT_fcmp_firstzero
       #10\XINT_fcmp_secondzero
        00\XINT_fcmp_pos
    \krof
    #1#2%
}%
\def\XINT_fcmp_zerozero   #1#2#3#4{ 0}%
\def\XINT_fcmp_firstzero  #1#2#3#4{ -1}%
\def\XINT_fcmp_secondzero #1#2#3#4{ 1}%
\def\XINT_fcmp_pos #1#2#3#4%
{%
    \XINT_fcmp_B #1#3#2#4%
}%
\def\XINT_fcmp_B #1/#2[#3]#4/#5[#6]%
{%
    \expandafter\XINT_fcmp_C\expandafter
    {\the\numexpr #6-#3\expandafter}\expandafter
    {\romannumeral0\xintiimul {#4}{#2}}%
    {\romannumeral0\xintiimul {#5}{#1}}%
}%
\def\XINT_fcmp_C #1#2#3%
{%
    \expandafter\XINT_fcmp_D\expandafter
    {#3}{#1}{#2}%
}%
\def\XINT_fcmp_D #1#2#3%
{%
    \expandafter\XINT_cntSgnFork\romannumeral`&&@\expandafter\XINT_cntSgn
    \the\numexpr #2+\xintLength{#3}-\xintLength{#1}\relax\xint:
    { -1}{\XINT_fcmp_E #2\Z {#3}{#1}}{ 1}%
}%
```

```
\def\XINT_fcmp_E #1%
{%
    \xint_UDsignfork
        #1\XINT_fcmp_Fd
         -{\XINT_fcmp_Fn #1}%
    \krof
}%
\def\XINT_fcmp_Fd #1\Z #2#3%
{%
    \expandafter\XINT_fcmp_Fe
    \romannumeral0\XINT_dsx_addzeros {#1}#3;\xint:#2\xint:
}%
\def\XINT_fcmp_Fe #1\xint:#2#3\xint:{\XINT_cmp_plusplus #2#1\xint:#3\xint:}%
\def\XINT_fcmp_Fn #1\Z #2#3%
{%
    \expandafter\XINT_fcmp_Fo
    \romannumeral0\XINT_dsx_addzeros {#1}#2;\xint:#3\xint:
}%
\def\XINT_fcmp_Fo #1#2\xint:#3\xint:{\XINT_cmp_plusplus #1#3\xint:#2\xint:}%
```

9.65 \xintAbs

```
\def\xintAbs   {\romannumeral0\xintabs }%
\def\xintabs #1{\expandafter\XINT_abs\romannumeral0\xintraw {#1}}%
```

9.66 \xintOpp

```
\def\xintOpp   {\romannumeral0\xintopp }%
\def\xintopp #1{\expandafter\XINT_opp\romannumeral0\xintraw {#1}}%
```

9.67 \xintInv

Modified at 1.3d (2019/01/06).

```
\def\xintInv   {\romannumeral0\xintinv }%
\def\xintinv #1{\expandafter\XINT_inv\romannumeral0\xintraw {#1}}%
\def\XINT_inv #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_inv_iszero
      0#1\XINT_inv_a
       0-{\XINT_inv_a {}}%
    \krof #1%
}%
\def\XINT_inv_iszero #1]%
   {\XINT_signalcondition{DivisionByZero}{Inverse of zero: inv(#1]).}{}{ 0/1[0]}}%
\def\XINT_inv_a #1#2/#3[#4#5]%
{%
    \xint_UDzerominusfork
      #4-\XINT_inv_expiszero
      0#4\XINT_inv_b
       0-{\XINT_inv_b -#4}%
    \krof #5.{#1#3/#2}%
```

```
}%
\def\XINT_inv_expiszero #1.#2{ #2[0]}%
\def\XINT_inv_b #1.#2{ #2[#1]}%
```

9.68 \xintSgn

```
\def\xintSgn   {\romannumeral0\xintsgn }%
\def\xintsgn #1{\expandafter\XINT_sgn\romannumeral0\xintraw {#1}\xint:}%
```

9.69 \xintSignBit

Added at 1.4l (2022/05/29).

```
\def\xintSignBit   {\romannumeral0\xintsignbit }%
\def\xintsignbit #1{\expandafter\XINT_signbit\romannumeral0\xintraw {#1}\xint:}%
\def\XINT_signbit #1#2\xint:
{%
    \xint_UDzerominusfork
      #1-{ 0}%
      0#1{ 1}%
       0-{ 0}%
    \krof
}%
```

9.70 \xintGCD

Modified at 1.4 (2020/01/31). They replace the former xintgcd macros of the same names which truncated to integers their arguments. Fraction-producing gcd() and lcm() functions were available since 1.3d xintexpr, with non-public support macros handling comma separated values.

Modified at 1.4d (2021/03/29). Somewhat strangely \xintGCD was formerly \xintGCDof used with only two arguments, as the latter directly implemented a fractionl gcd algorithm using \xintMod repeatedly for two arguments.

Now \xintGCD contains the pairwise gcd routine and \xintGCDof is only a wrapper. And the pairwise gcd is reduced to integer-only computations to hopefully reduce fraction overhead.

Each input is filtered via \xintPIrr and \xintREZ to reduce size of maniuplate integers in algebra.

But hesitation about applying \xintPIrr to output, and/or \xintREZ. (as it is applied on input).

But as the code is now used for frational lcm's we actually need to do some reduction of output else lcm's of integers will not be necessarily printed by \xinteval as integers.

Well finally I apply \xintIrr (but not \xintREZ to output). Hesitations here (thinking of inputs with large [n] parts, the output will have many zeros). So I do this only for the user macro but the core routine as used by \xintGCDof will not do it.

Also at 1.4d the code uses \expanded.

```
\def\xintGCD {\romannumeral0\xintgcd}%
\def\xintgcd #1%
{%
    \expandafter\XINT_fgcd_in
    \romannumeral0\xintrez{\xintPIrr{\xintAbs{#1}}}\xint:
}%
\def\XINT_fgcd_in #1#2\xint:#3%
{%
    \expandafter\XINT_fgcd_out
    \romannumeral0\expandafter\XINT_fgcd_chkzeros\expandafter#1%
```

```
    \romannumeral0\xintrez{\xintPIrr{\xintAbs{#3}}}\xint:#1#2\xint:
}%
\def\XINT_fgcd_out#1[#2]{\xintirr{#1[#2]}[0]}%
\def\XINT_fgcd_chkzeros #1#2%
{%
    \xint_UDzerofork
       #1\XINT_fgcd_aiszero
       #2\XINT_fgcd_biszero
        0\XINT_fgcd_main
    \krof #2%
}%
\def\XINT_fgcd_aiszero #1\xint:#2\xint:{ #1}%
\def\XINT_fgcd_biszero #1\xint:#2\xint:{ #2}%
\def\XINT_fgcd_main #1/#2[#3]\xint:#4/#5[#6]\xint:
{%
    \expandafter\XINT_fgcd_a
      \romannumeral0\XINT_gcd_loop #2\xint:#5\xint:\xint:
      #2\xint:#5\xint:#1\xint:#4\xint:#3.#6.%
}%
\def\XINT_fgcd_a #1\xint:#2\xint:
{%
    \expandafter\XINT_fgcd_b
    \romannumeral0\xintiiquo{#2}{#1}\xint:#1\xint:#2\xint:
}%
\def\XINT_fgcd_b #1\xint:#2\xint:#3\xint:#4\xint:#5\xint:#6\xint:#7.#8.%
{%
   \expanded{%
   \xintiigcd{\xintiiE{\xintiiMul{#5}{\xintiiQuo{#4}{#2}}}{#7-#8}}%
             {\xintiiE{\xintiiMul{#6}{#1}}{#8-#7}}%
    /\xintiiMul{#1}{#4}%
    [\ifnum#7>#8 #8\else #7\fi]%
   }%
}%
```

9.71 \xintGCDof

Modified at 1.4 (2020/01/31). This inherits from former non public xintexpr macro called \xintGCDof:csv, which handled comma separated items.

It handles fractions presented as braced items and is the support macro for the gcd() function in \xintexpr and \xintfloatexpr. The support macro for the gcd() function in \xintiiexpr is \xintiiGCDof, from xint.

An empty input is allowed but I have some hesitations on the return value of 1.

Modified at 1.4d (2021/03/29). Sadly the 1.4 version had multiple problems:

- broken if first argument vanished,
- broken if some argument was not in strict format, for example had leading chains of signs or zeros (\xintGCDof{2}{03}). This bug originates in the fact the original macro was used only in xintexpr sanitized context.

Also, output is now always an irreducible fraction (ending with [0]).

```
\def\xintGCDof {\romannumeral0\xintgcdof}%
\def\xintgcdof #1{\expandafter\XINT_fgcdof\romannumeral`&&@#1^}%
```

```
\def\XINT_GCDof{\romannumeral0\XINT_fgcdof}%
\def\XINT_fgcdof #1%
{%
    \expandafter\XINT_fgcdof_chkempty\romannumeral`&&@#1\xint:
}%
\def\XINT_fgcdof_chkempty #1%
{%
    \xint_gob_til_^#1\XINT_fgcdof_empty ^\XINT_fgcdof_in #1%
}%
\def\XINT_fgcdof_empty #1\xint:{ 1/1[0]}% hesitation, should it be infinity? 0?
\def\XINT_fgcdof_in #1\xint:
{%
    \expandafter\XINT_fgcd_out
    \romannumeral0\expandafter\XINT_fgcdof_loop
    \romannumeral0\xintrez{\xintPIrr{\xintAbs{#1}}}\xint:
}%
\def\XINT_fgcdof_loop #1\xint:#2%
{%
    \expandafter\XINT_fgcdof_chkend\romannumeral`&&@#2\xint:#1\xint:\xint:
}%
\def\XINT_fgcdof_chkend #1%
{%
    \xint_gob_til_^#1\XINT_fgcdof_end ^\XINT_fgcdof_loop_pair #1%
}%
\def\XINT_fgcdof_end #1\xint:#2\xint:\xint:{ #2}%
\def\XINT_fgcdof_loop_pair #1\xint:#2%
{%
    \expandafter\XINT_fgcdof_loop
    \romannumeral0\expandafter\XINT_fgcd_chkzeros\expandafter#2%
    \romannumeral0\xintrez{\xintPIrr{\xintAbs{#1}}}\xint:#2%
}%
```

9.72 \xintLCM

Same comments as for \xintGCD. Entirely redone for 1.4d. Well, actually we can express it in terms of fractional gcd.

```
\def\xintLCM {\romannumeral0\xintlcm}%
\def\xintlcm #1%
{%
    \expandafter\XINT_flcm_in
    \romannumeral0\xintrez{\xintPIrr{\xintAbs{#1}}}\xint:
}%
\def\XINT_flcm_in #1#2\xint:#3%
{%
    \expandafter\XINT_fgcd_out
    \romannumeral0\expandafter\XINT_flcm_chkzeros\expandafter#1%
    \romannumeral0\xintrez{\xintPIrr{\xintAbs{#3}}}\xint:#1#2\xint:
}%
\def\XINT_flcm_chkzeros #1#2%
{%
    \xint_UDzerofork
       #1\XINT_flcm_zero
```

```
          #2\XINT_flcm_zero
           0\XINT_flcm_main
    \krof #2%
}%
\def\XINT_flcm_zero #1\xint:#2\xint:{ 0/1[0]}%
\def\XINT_flcm_main #1/#2[#3]\xint:#4/#5[#6]\xint:
{%
    \xintinv
    {%
      \romannumeral0\XINT_fgcd_main #2/#1[-#3]\xint:#5/#4[-#6]\xint:
    }%
}%
```

9.73 \xintLCMof

See comments for \xintGCDof. xint provides the integer only \xintiiLCMof.

Modified at 1.4d (2021/03/29). Sadly, although a public xintfrac macro, it did not (since 1.4) sanitize its arguments like other xintfrac macros.

```
\def\xintLCMof {\romannumeral0\xintlcmof}%
\def\xintlcmof #1{\expandafter\XINT_flcmof\romannumeral`&&@#1^}%
\def\XINT_LCMof{\romannumeral0\XINT_flcmof}%
\def\XINT_flcmof #1%
{%
    \expandafter\XINT_flcmof_chkempty\romannumeral`&&@#1\xint:
}%
\def\XINT_flcmof_chkempty #1%
{%
    \xint_gob_til_^#1\XINT_flcmof_empty ^\XINT_flcmof_in #1%
}%
\def\XINT_flcmof_empty #1\xint:{ 0/1[0]}% hesitation
\def\XINT_flcmof_in #1\xint:
{%
    \expandafter\XINT_fgcd_out
    \romannumeral0\expandafter\XINT_flcmof_loop
    \romannumeral0\xintrez{\xintPIrr{\xintAbs{#1}}}\xint:
}%
\def\XINT_flcmof_loop #1\xint:#2%
{%
    \expandafter\XINT_flcmof_chkend\romannumeral`&&@#2\xint:#1\xint:\xint:
}%
\def\XINT_flcmof_chkend #1%
{%
    \xint_gob_til_^#1\XINT_flcmof_end ^\XINT_flcmof_loop_pair #1%
}%
\def\XINT_flcmof_end #1\xint:#2\xint:\xint:{ #2}%
\def\XINT_flcmof_loop_pair #1\xint:#2%
{%
    \expandafter\XINT_flcmof_chkzero
    \romannumeral0\expandafter\XINT_flcm_chkzeros\expandafter#2%
    \romannumeral0\xintrez{\xintPIrr{\xintAbs{#1}}}\xint:#2%
}%
\def\XINT_flcmof_chkzero #1%
```

```
{%
    \xint_gob_til_zero#1\XINT_flcmof_zero0\XINT_flcmof_loop#1%
}%
\def\XINT_flcmof_zero#1^{ 0/1[0]}%
```

9.74 Floating point macros

For a long time the float routines dating back to releases 1.07/1.08a (May-June 2013) were not modified.

Since 1.2f (March 2016) the four operations first round their arguments to \xinttheDigits-floats (or P-floats), not (\xinttheDigits+2)-floats or (P+2)-floats as was the case with earlier releases.

The four operations addition, subtraction, multiplication, division have always produced the correct rounding of the theoretical exact value to P or \xinttheDigits digits when the inputs are decimal numbers with at most P digits, and arbitrary decimal exponent part.

From 1.08a to 1.2j, \xintFloat (and \XINTinFloat which is used to parse inputs to other float macros) handled a fractional input A/B via an initial replacement to A'/B' where A' and B' were A and B truncated to Q+2 digits (where asked-for precision is Q), and then they correctly rounded A'/B' to Q digits. But this meant that this rounding of the input could differ (by up to one unit in the last place) from the correct rounding of the original A/B to the asked-for number of digits (which until 1.2f in uses as auxiliary to the macros for the basic operations was 2 more than the prevailing precision).

Since 1.2k all inputs are correctly rounded to the asked-for number of digits (this was, I think, the case in the 1.07 release -- there are no code comments -- but was, afaicr, not very efficiently done, and this is why the 1.08a release opeted for truncation of the numerator and denominator.)

Notice that in float expressions, the / is treated as operator, hence the above discussion makes a difference only for the special input form qfloat(A/B) or for an \xintexpr A/B\relax embedded in the float expression, with A or B having more digits than the prevailing float precision.

> Internally there is no inner representation of P-floats as such !!!!!
>
> The input parser will again compute the length of the mantissa on each use !!! This is obviously something that must be improved upon before implementation of higher functions.
>
> Currently, special tricks are used to quickly recognize inputs having no denominators, or fractions whose numerators and denominators are not too long compared to the target precision P, and in particular P-floats or quotients of two such.
>
> Another long-standing issue is that float multiplication will first compute the 2P or 2P-1 digits of the exact product, and then round it to P digits. This is sub-optimal for large P particularly as the multiplication algorithm is basically the schoolbook one, hence *worse* than quadratic in the TeX implementation which has extra cost of fetching long sequences of tokens.

Changes at 1.4e (done 2021/04/15; undone 2021/04/29)

Macros named \XINTinFloat<name> are not public user-level but were designed a long time ago for \xintfloatexpr context as a very preliminary step towards attempting to preserve some internal format, here A[N] type.

When <name> is lowercased it means it needs a \romannumeral0 trigger (\XINTinfloatS keeps an uppercase S).

Most were coded to check for an optional argument [D], and to use D=\XINTdigits in its place if absent but it turned out only \XINTinfloatpow, \XINTinfloatmul, \XINTinfloatadd were actually used with an optional argument and this happened only in macros from the very old xintseries.sty, so I changed all of them to not check for optional argument [D] anymore, keeping only some private interface for the xintseries.sty use case. Some required being used with [D], some still had names ending in "digits" indicating they would use \XINTdigits always.

Indeed basically all algebra is done "exactly" and the [D] governs rules of float-rounding on input and output.

During development of 1.4e we fleetingly experimented with letting the value used in place of D be \XINTdigitsx to 1.4e, i.e. \XINTdigits with guard digits, a situation which was motivated by the implementation of trigonometrical functions at high level, i.e. using \xintdeffloatfunc which had no mechanism to make intermediate calculations with guard digits.

Simply doing everything "as is" but with 2 guard digits proved very good (surprisingly efficient, even) to the trigonometrical functions. However using them systematically raises many issues (for example, the correct rounding at P digits is destroyed if we obtain it a D=P+2 then round from P+2 to P digits so we definitely can not do this as default, so some interface is needed to define intermediate functions only using such guard digits and keeping them in their output).

Finally, an approach limited to the xinttrig.sty scope was used and I removed all \XINTdigitsx related matters from 1.4e. But this left some modifications of the interfaces of the "float" macros here which this list tries to document, mainly for the author's benefit.

Macros always using \XINTdigits and now not allowing [P] option

\XINTinFloatAdd
\XINTinFloatSub
\XINTinFloatMul
\XINTinFloatSqr
\XINTinFloatInv
\XINTinFloatDiv
\XINTinFloatPow
\XINTinFloatPower
\XINTinFloatPFactorial
\XINTinFloatBinomial

Macros which already did not allow [P] option prior to 1.4e refactoring

\XINTinFloatFrac (renamed from \XINTinFloatFracdigits)
\XINTinFloatE
\XINTinFloatMod
\XINTinFloatDivFloor
\XINTinFloatDivMod

Macros requiring a [P]. Some of the "_wopt" named macros are renamings of macros formerly requiring [P].

\XINTinFloat
\XINTinFloatS
\XINTFloatiLogTen
\XINTinRandomFloatS (this one has only the [P] mandatory argument)
\XINTinFloatFac
\XINTinFloatSqrt
\XINTinFloatAdd_wopt, \XINTinfloatadd_wopt
\XINTinFloatSub_wopt, \XINTinfloatsub_wopt
\XINTinFloatMul_wopt, \XINTinfloatmul_wopt
\XINTinFloatSqr_wopt
\XINTinfloatpow_wopt (not FloatPow)
\XINTinFloatDiv_wopt
\XINTinFloatInv_wopt

Specially named macros indicating usage of \XINTdigits

\XINTinFloatdigits
\XINTinFloatSdigits
\XINTFloatiLogTendigits

\XINTinRandomFloatSdigits
\XINTinFloatFacdigits
\XINTinFloatSqrtdigits

9.75 \xintDigits, \xintSetDigits

Modified at 1.3 (2018/03/01). 1.3f allows \xintDigits= in place of \xintDigits:= syntax. It defines \xintDigits*[:]= which reloads xinttrig.sty. Perhaps this should be default, well.

During 1.4e development I added an interface for guard digits, but I decided to drop inclusion from 1.4e release because there were pending issues both in documentation and functionalities for which I did not have time left.

1.4e fixes the issue that \xinttheDigits could not be used in the right hand side of \xintDigits[*][:]=...; or inside the argument to \xintSetDigits.

```
\mathchardef\XINTdigits  16
\chardef\XINTguarddigits 0
\def\xinttheDigits     {\number\XINTdigits}%
%\def\xinttheGuardDigits{\number\XINTguarddigits}%
\def\xinttheGuardDigits{0}% in case used in some of my test files
\def\xintDigits #1={\afterassignment\xintDigits_i\mathchardef\XINT_digits=}%
\def\xintDigits_i#1%
{%
    \let\XINTdigits\XINT_digits
}%
\def\xintSetDigits #1%
{%
    \mathchardef\XINT_digits=\numexpr#1\relax
    \let\XINTdigits=\XINT_digits
}%
```

9.76 \xintFloat, \xintFloatZero

1.2f and 1.2g brought some refactoring which resulted in faster treatment of decimal inputs. 1.2i dropped use of some old routines dating back to pre 1.2 era in favor of more modern \xintDSRr for rounding. Then 1.2k improves again the handling of denominators B with few digits.

But the main change with 1.2k is a complete rewrite of the B>1 case in order to achieve again correct rounding in all cases.

The original version from 1.07 (May 2013) computed the exact rounding to P digits for all inputs. But from 1.08 on (June 2013), the macro handled A/B input by first truncating both A and B to at most P+2 digits. This meant that decimal input (arbitrarily long, with scientific part) was correctly rounded, but in case of fractional input there could be up to 0.6 unit in the last place difference of the produced rounding to the input, hence the output could differ from the correct rounding.

Example with 16 digits (the default): \xintFloat {1/17597472569900621233}
with xintfrac 1.07: 5.682634230727187e-20
with xintfrac 1.08b--1.2j: 5.682634230727188e-20
with xintfrac 1.2k: 5.682634230727187e-20
The exact value is 5.682634230727187499924124...e-20, showing that 1.07 and 1.2k produce the correct rounding.

Currently the code ends in a more costly branch in about 1 case among 500, where it does some extra operations (a multiplication in particular). There is a free parameter delta (here set at 4), I have yet to make some numerical explorations, to see if it could be favorable to set it to a higher value (with delta=5, there is only 1 exceptional case in 5000, etc...).

I have always hesitated about the policy of printing 10.00...0 in case of rounding upwards to the next power of ten. Already since 1.2f \XINTinFloat always produced a mantissa with exactly P digits (except for the zero value). Starting with 1.2k, \xintFloat drops this habit of printing 10.00..0 in such cases. Side note: the rounding-up detection worked when the input A/B was with numerator A and denominator B having each less than P+2 digits, or with B=1, else, it could happen that the output was a power of ten but not detected to be a rounding up of the original fraction. The value was ok, but printed 1.0...0eN with P-1 zeroes, not 10.0...0e(N-1).

I decided it was not worth the effort to enhance the algorithm to detect with 100% fiability all cases of rounding up to next power of ten, hence 1.2k dropped this.

To avoid duplication of code, and any extra burden on \XINTinFloat, which is the macro used internally by the float macros for parsing their inputs, we simply make now \xintFloat a wrapper of \XINTinFloat.

```
\def\xintFloatZero{0.0e0}% 1.4k breaking change.  Replaces hard-coded 0.e0
\def\xintFloat    {\romannumeral0\xintfloat }%
\def\xintfloat #1{\XINT_float_chkopt #1\xint:}%
\def\XINT_float_chkopt #1%
{%
    \ifx [#1\expandafter\XINT_float_opt
       \else\expandafter\XINT_float_noopt
    \fi  #1%
}%
\def\XINT_float_noopt #1\xint:%
{%
    \expandafter\XINT_float_post
    \romannumeral0\XINTinfloat[\XINTdigits]{#1}\XINTdigits.%
}%
\def\XINT_float_opt [\xint:
{%
    \expandafter\XINT_float_opt_a\the\numexpr
}%
\def\XINT_float_opt_a #1]#2%
{%
    \expandafter\XINT_float_post
    \romannumeral0\XINTinfloat[#1]{#2}#1.%
}%
\def\XINT_float_post #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_float_zero
       0#1\XINT_float_neg
       0-\XINT_float_pos
    \krof #1%
}%[
\def\XINT_float_zero #1]#2.{\expanded{ \xintFloatZero}}%
\def\XINT_float_neg-{\expandafter-\romannumeral0\XINT_float_pos}%
\def\XINT_float_pos #1#2[#3]#4.%
{%
    \expandafter\XINT_float_pos_done\the\numexpr#3+#4-\xint_c_i.#1.#2;%
}%
\def\XINT_float_pos_done #1.#2;{ #2e#1}%
```

9.77 \xintFloatBraced

Added at 1.4l (2022/05/29). Je ne le fais pas comme un wrapper au-dessus de \xintFloat car c'est pénible avec argument optionnel donc finalemnt on est obligé de rajouter overhead comme ici.

Hésitation si on obéit à \xintFloatZero ou pas. Finalement non.

Hésitation si on renvoie avec séparateur décimal ou pas.

Hésitation si on met l'exposant scientifique en premier.

Hésitation si on sépare le signe pour le mettre en premier.

Hésitation si on renvoie un exposant pour mantisse normalisée ou pas normalisée.

Finalement je décide {signe}{exposant}{mantisse sans point décimal}. Avec en fait 0 ou 1 pour signe (mais ce sign bit mais ça n'a pas grand sens en décimal...). Non finalement mantisse avec point décimal.

```
\def\xintFloatBraced{\romannumeral0\xintfloatbraced }%
\def\xintfloatbraced#1{\XINT_floatbr_chkopt #1\xint:}%
\def\XINT_floatbr_chkopt #1%
{%
    \ifx [#1\expandafter\XINT_floatbr_opt
       \else\expandafter\XINT_floatbr_noopt
    \fi  #1%
}%
\def\XINT_floatbr_noopt #1\xint:%
{%
    \expandafter\XINT_floatbr_post
    \romannumeral0\XINTinfloat[\XINTdigits]{#1}\XINTdigits.%
}%
\def\XINT_floatbr_opt [\xint:
{%
    \expandafter\XINT_floatbr_opt_a\the\numexpr
}%
\def\XINT_floatbr_opt_a #1]#2%
{%
    \expandafter\XINT_floatbr_post
    \romannumeral0\XINTinfloat[#1]{#2}#1.%
}%
\def\XINT_floatbr_post #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_floatbr_zero
       0#1\XINT_floatbr_neg
       0-\XINT_floatbr_pos
    \krof #1%
}%
```

Hésitation à faire

```
\def\XINT_floatbr_zero #1]#2.{\expandafter\XINT_floatbr_zero_a\xintFloatZero e0e\relax}
\def\XINT_floatbr_zero_a#1e#2e#3\relax{{#1}{#2}}
```

Finalement non. Et même je décide de renvoyer autant de zéros que P. De plus depuis j'ai opté pour {sign bit}{exposant}{mantisse} Hésitation si mantisse avec ou sans le séparateur décimal. Est-ce que je devrais mettre plutôt -0+ au début?

```
\def\XINT_floatbr_zero #1]#2.{\expanded{{0}{0}{0.\xintReplicate{#2-\xint_c_i}0}}}%
\def\XINT_floatbr_neg-{\expandafter\XINT_floatbr_neg_a\romannumeral0\XINT_floatbr_pos}%
\def\XINT_floatbr_neg_a#1{{1}}%
\def\XINT_floatbr_pos #1#2[#3]#4.%
```

```
{%
    \expanded{{0}{\the\numexpr#3+#4-\xint_c_i}}{#1.#2}%
}%
```

9.78 \XINTinFloat, \XINTinFloatS

This routine is like \xintFloat but produces an output of the shape A[N] which is then parsed faster as input to other float macros. Float operations in \xintfloatexpr...\relax use internally this format.

It must be used in form \XINTinFloat[P]{f}: the optional [P] is mandatory.

Since 1.2f, the mantissa always has exactly P digits even in case of rounding up to next power of ten. This simplifies other routines.

(but the zero value must always be checked for, as it outputs 0[0])

1.2g added a variant \XINTinFloatS which, in case of decimal input with less than the asked for precision P will not add extra zeros to the mantissa. For example it may output 2[0] even if P=500, rather than the canonical representation 200...000[-499]. This is how \xintFloatMul and \xintFloatDiv parse their inputs, which speeds-up follow-up processing. But \xintFloatAdd and \xintFloatSub still use \XINTinFloat for parsing their inputs; anyway this will have to be changed again when inner structure will carry upfront at least the length of mantissa as data.

Each time \XINTinFloat is called it at least computes a length. Naturally if we had some format for floats that would be dispensed of...
something like <letterP><length of mantissa>.mantissa.exponent, etc... not yet.

Since 1.2k, \XINTinFloat always correctly rounds its argument, even if it is a fraction with very big numerator and denominator. See the discussion of \xintFloat.

```
\def\XINTinFloat {\romannumeral0\XINTinfloat }%
\def\XINTinfloat
   {\expandafter\XINT_infloat_clean\romannumeral0\XINT_infloat}%
```

Attention que ici le fait que l'on grabbe #1 est important car il pourrait y avoir un zéro (en particulier dans le cas où input est nul).

```
\def\XINT_infloat_clean #1%
   {\if #1!\xint_dothis\XINT_infloat_clean_a\fi\xint_orthat{ }#1}%
```

Ici on ajoute les zeros pour faire exactement avec P chiffres. Car le #1 = P - L avec L la longueur de #2, (ou plutôt de abs(#2), car ici le #2 peut avoir un signe) et L < P

```
\def\XINT_infloat_clean_a !#1.#2[#3]%
{%
    \expandafter\XINT_infloat_done
    \the\numexpr #3-#1\expandafter.%
    \romannumeral0\XINT_dsx_addzeros {#1}#2;;%
}%
\def\XINT_infloat_done #1.#2;{ #2[#1]}%
```

variant which allows output with shorter mantissas.

```
\def\XINTinFloatS {\romannumeral0\XINTinfloatS}%
\def\XINTinfloatS
   {\expandafter\XINT_infloatS_clean\romannumeral0\XINT_infloat}%
\def\XINT_infloatS_clean #1%
   {\if #1!\xint_dothis\XINT_infloatS_clean_a\fi\xint_orthat{ }#1}%
\def\XINT_infloatS_clean_a !#1.{ }%
```

début de la routine proprement dite, l'argument optionnel est obligatoire.

```
\def\XINT_infloat [#1]%#2%
{%
    \expandafter\XINT_infloat_a\the\numexpr #1\expandafter.%
```

```
    \romannumeral0\XINT_infrac% {#2}%
}%
```

#1=P, #2=n, #3=A, #4=B.

```
\def\XINT_infloat_a #1.#2#3#4%
{%
```

micro boost au lieu d'utiliser \XINT_isOne{#4}, mais pas bon style.

```
    \if1\XINT_is_One#4XY%
      \expandafter\XINT_infloat_sp
    \else\expandafter\XINT_infloat_fork
    \fi #3.{#1}{#2}{#4}%
}%
```

Special quick treatment of B=1 case (1.2f then again 1.2g.)
maintenant: A.{P}{N}{1} Il est possible que A soit nul.

```
\def\XINT_infloat_sp #1%
{%
    \xint_UDzerominusfork
     #1-\XINT_infloat_spzero
     0#1\XINT_infloat_spneg
      0-\XINT_infloat_sppos
    \krof #1%
}%
```

Attention surtout pas 0/1[0] ici.

```
\def\XINT_infloat_spzero 0.#1#2#3{ 0[0]}%
\def\XINT_infloat_spneg-%
    {\expandafter\XINT_infloat_spnegend\romannumeral0\XINT_infloat_sppos}%
\def\XINT_infloat_spnegend #1%
    {\if#1!\expandafter\XINT_infloat_spneg_needzeros\fi -#1}%
\def\XINT_infloat_spneg_needzeros -!#1.{!#1.-}%
```

in: A.{P}{N}{1}
out: P-L.A.P.N.

```
\def\XINT_infloat_sppos #1.#2#3#4%
{%
    \expandafter\XINT_infloat_sp_b\the\numexpr#2-\xintLength{#1}.#1.#2.#3.%
}%
```

#1= P-L. Si c'est positif ou nul il faut retrancher #1 à l'exposant, et ajouter autant de zéros.
On regarde premier token. P-L.A.P.N.

```
\def\XINT_infloat_sp_b #1%
{%
    \xint_UDzerominusfork
     #1-\XINT_infloat_sp_quick
     0#1\XINT_infloat_sp_c
      0-\XINT_infloat_sp_needzeros
    \krof #1%
}%
```

Ici P=L. Le cas usuel dans \xintfloatexpr.

```
\def\XINT_infloat_sp_quick 0.#1.#2.#3.{ #1[#3]}%
```

Ici #1=P-L est >0. L'exposant sera N-(P-L). #2=A. #3=P. #4=N.
18 mars 2016. En fait dans certains contextes il est sous-optimal d'ajouter les zéros. Par exemple quand c'est appelé par la multiplication ou la division, c'est idiot de convertir 2 en

200000...00000[-499]. Donc je redéfinis addzeros en needzeroes. Si on appelle sous la forme \XINTinFloatS, on ne fait pas l'addition de zeros.

```
\def\XINT_infloat_sp_needzeros #1.#2.#3.#4.{!#1.#2[#4]}%
```

L-P=#1.A=#2#3.P=#4.N=#5.

Ici P<L. Il va falloir arrondir. Attention si on va à la puissance de 10 suivante. En #1 on a L-P qui est >0. L'exposant final sera N+L-P, sauf dans le cas spécial, il sera alors N+L-P+1. L'ajustement final est fait par \XINT_infloat_Y.

```
\def\XINT_infloat_sp_c -#1.#2#3.#4.#5.%
{%
    \expandafter\XINT_infloat_Y
    \the\numexpr #5+#1\expandafter.%
    \romannumeral0\expandafter\XINT_infloat_sp_round
    \romannumeral0\XINT_split_fromleft
    (\xint_c_i+#4).#2#3\xint_bye2345678\xint_bye..#2%
}%
\def\XINT_infloat_sp_round #1.#2.%
{%
    \XINT_dsrr#1\xint_bye\xint_Bye3456789\xint_bye/\xint_c_x\relax.%
}%
```

General branch for A/B with B>1 inputs. It achieves correct rounding always since 1.2k (done January 2, 2017.) This branch is never taken for A=0 because \XINT_infrac will have returned B=1 then.

```
\def\XINT_infloat_fork #1%
{%
    \xint_UDsignfork
     #1\XINT_infloat_J
     -\XINT_infloat_K
    \krof #1%
}%
\def\XINT_infloat_J-{\expandafter-\romannumeral0\XINT_infloat_K }%
```

A.{P}{n}{B} avec B>1.

```
\def\XINT_infloat_K #1.#2%
{%
    \expandafter\XINT_infloat_L
    \the\numexpr\xintLength{#1}\expandafter.\the\numexpr #2+\xint_c_iv.{#1}{#2}%
}%
```

|A|.P+4.{A}{P}{n}{B}. We check if A already has length <= P+4.

```
\def\XINT_infloat_L #1.#2.%
{%
    \ifnum #1>#2
      \expandafter\XINT_infloat_Ma
    \else
      \expandafter\XINT_infloat_Mb
    \fi #1.#2.%
}%
```

|A|.P+4.{A}{P}{n}{B}. We will keep only the first P+4 digits of A, denoted A'' in what follows.
output: u=-0.A''.junk.P+4.|A|.{A}{P}{n}{B}

```
\def\XINT_infloat_Ma #1.#2.#3%
{%
    \expandafter\XINT_infloat_MtoN\expandafter-\expandafter0\expandafter.%
    \romannumeral0\XINT_split_fromleft#2.#3\xint_bye2345678\xint_bye..%
```

```
    #2.#1.{#3}%
}%
```

|A|.P+4.{A}{P}{n}{B}.
Here A is short. We set u = P+4-|A|, and A''=A (A' = 10^u A)
  output: u.A''..P+4.|A|.{A}{P}{n}{B}

```
\def\XINT_infloat_Mb #1.#2.#3%
{%
    \expandafter\XINT_infloat_MtoN\the\numexpr#2-#1.%
    #3..#2.#1.{#3}%
}%
```

input u.A''.junk.P+4.|A|.{A}{P}{n}{B}
output |B|.P+4.{B}u.A''.P.|A|.n.{A}{B}

```
\def\XINT_infloat_MtoN #1.#2.#3.#4.#5.#6#7#8#9%
{%
   \expandafter\XINT_infloat_N
   \the\numexpr\xintLength{#9}.#4.{#9}#1.#2.#7.#5.#8.{#6}{#9}%
}%
\def\XINT_infloat_N #1.#2.%
{%
    \ifnum #1>#2
      \expandafter\XINT_infloat_Oa
    \else
      \expandafter\XINT_infloat_Ob
    \fi #1.#2.%
}%
```

input |B|.P+4.{B}u.A''.P.|A|.n.{A}{B}
output v=-0.B''.junk.|B|.u.A''.P.|A|.n.{A}{B}

```
\def\XINT_infloat_Oa #1.#2.#3%
{%
    \expandafter\XINT_infloat_P\expandafter-\expandafter0\expandafter.%
    \romannumeral0\XINT_split_fromleft#2.#3\xint_bye2345678\xint_bye..%
    #1.%
}%
```

output v=P+4-|B|>=0.B''.junk.|B|.u.A''.P.|A|.n.{A}{B}

```
\def\XINT_infloat_Ob #1.#2.#3%
{%
    \expandafter\XINT_infloat_P\the\numexpr#2-#1.#3..#1.%
}%
```

input v.B''.junk.|B|.u.A''.P.|A|.n.{A}{B}
output Q1.P.|B|.|A|.n.{A}{B}
Q1 = division euclidienne de A''.10^{u-v+P+3} par B''.

Special detection of cases with A and B both having length at most P+4: this will happen when called from \xintFloatDiv as A and B (produced then via \XINTinFloatS) will have at most P digits. We then only need integer division with P+1 extra zeros, not P+3.

```
\def\XINT_infloat_P #1#2.#3.#4.#5.#6#7.#8.#9.%
{%
   \csname XINT_infloat_Q\if-#1\else\if-#6\else q\fi\fi\expandafter\endcsname
   \romannumeral0\xintiiquo
   {\romannumeral0\XINT_dsx_addzerosnofuss
      {#6#7-#1#2+#9+\xint_c_iii\if-#1\else\if-#6\else-\xint_c_ii\fi\fi}#8;}%
```

```
    {#3}.#9.#5.%
}%
```

«quick» branch.

```
\def\XINT_infloat_Qq #1.#2.%
{%
    \expandafter\XINT_infloat_Rq
    \romannumeral0\XINT_split_fromleft#2.#1\xint_bye2345678\xint_bye..#2.%
}%
\def\XINT_infloat_Rq #1.#2#3.%
{%
    \ifnum#2<\xint_c_v
         \expandafter\XINT_infloat_SEq
    \else\expandafter\XINT_infloat_SUp
    \fi
    {\if.#3.\xint_c_\else\xint_c_i\fi}#1.%
}%
```

standard branch which will have to handle undecided rounding, if too close to a mid-value.

```
\def\XINT_infloat_Q #1.#2.%
{%
    \expandafter\XINT_infloat_R
    \romannumeral0\XINT_split_fromleft#2.#1\xint_bye2345678\xint_bye..#2.%
}%
\def\XINT_infloat_R #1.#2#3#4#5.%
{%
    \if.#5.\expandafter\XINT_infloat_Sa\else\expandafter\XINT_infloat_Sb\fi
    #2#3#4#5.#1.%
}%
```

trailing digits.Q.P.|B|.|A|.n.{A}{B}
#1=trailing digits (they may have leading zeros.)

```
\def\XINT_infloat_Sa #1.%
{%
    \ifnum#1>500 \xint_dothis\XINT_infloat_SUp\fi
    \ifnum#1<499 \xint_dothis\XINT_infloat_SEq\fi
    \xint_orthat\XINT_infloat_X\xint_c_
}%
\def\XINT_infloat_Sb #1.%
{%
    \ifnum#1>5009 \xint_dothis\XINT_infloat_SUp\fi
    \ifnum#1<4990 \xint_dothis\XINT_infloat_SEq\fi
    \xint_orthat\XINT_infloat_X\xint_c_i
}%
```

epsilon #2=Q.#3=P.#4=|B|.#5=|A|.#6=n.{A}{B}
exposant final est n+|A|-|B|-P+epsilon

```
\def\XINT_infloat_SEq #1#2.#3.#4.#5.#6.#7#8%
{%
    \expandafter\XINT_infloat_SY
    \the\numexpr #6+#5-#4-#3+#1.#2.%
}%
\def\XINT_infloat_SY #1.#2.{ #2[#1]}%
```

initial digit #2 put aside to check for case of rounding up to next power of ten, which will need adjustment of mantissa and exponent.

```
\def\XINT_infloat_SUp #1#2#3.#4.#5.#6.#7.#8#9%
{%
    \expandafter\XINT_infloat_Y
    \the\numexpr#7+#6-#5-#4+#1\expandafter.%
    \romannumeral0\xintinc{#2#3}.#2%
}%
```

epsilon Q.P.|B|.|A|.n.{A}{B}

\xintDSH{-x}{U} multiplies U by 10^x. When x is negative, this means it truncates (i.e. it drops the last -x digits).

We don't try to optimize too much macro calls here, the odds are 2 per 1000 for this branch to be taken. Perhaps in future I will use higher free parameter d, which currently is set at 4.

#1=epsilon, #2#3=Q, #4=P, #5=|B|, #6=|A|, #7=n, #8=A, #9=B

```
\def\XINT_infloat_X #1#2#3.#4.#5.#6.#7.#8#9%
{%
   \expandafter\XINT_infloat_Y
   \the\numexpr #7+#6-#5-#4+#1\expandafter.%
   \romannumeral`&&@\romannumeral0\xintiiiflt
     {\xintDSH{#6-#5-#4+#1}{\xintDouble{#8}}}%
     {\xintiiMul{\xintInc{\xintDouble{#2#3}}}{#9}}%
   \xint_firstofone
   \xintinc{#2#3}.#2%
}%
```

check for rounding up to next power of ten.

```
\def\XINT_infloat_Y #1{%
\def\XINT_infloat_Y ##1.##2##3.##4%
{%
   \if##49\if##21\expandafter\expandafter\expandafter\XINT_infloat_Z\fi\fi
   #1##2##3[##1]%
}}\XINT_infloat_Y{ }%
```

#1=1, #2=0.

```
\def\XINT_infloat_Z #1#2#3[#4]%
{%
    \expandafter\XINT_infloat_ZZ\the\numexpr#4+\xint_c_i.#3.%
}%
\def\XINT_infloat_ZZ #1.#2.{ 1#2[#1]}%
```

9.79 \XINTFloatiLogTen

Added at 1.3e (2019/04/05). Le comportement pour un input nul est non encore finalisé. Il changera lorsque NaN, +Inf, -Inf existeront.

The optional argument [#1] is in fact mandatory and #1 is not pre-expanded in a \numexpr.

The return value here 2^31-2^15 is highly undecided.

```
\def\XINTFloatiLogTen {\the\numexpr\XINTfloatilogten}%
\def\XINTfloatilogten [#1]#2%
    {\expandafter\XINT_floatilogten\romannumeral0\XINT_infloat[#1]{#2}#1.}%
\def\XINTFloatiLogTendigits{\the\numexpr\XINTfloatilogten[\XINTdigits]}%
\def\XINT_floatilogten #1{%
    \if #10\xint_dothis\XINT_floatilogten_z\fi
    \if #1!\xint_dothis\XINT_floatilogten_a\fi
    \xint_orthat\XINT_floatilogten_b #1%
```

```
}%
\def\XINT_floatilogten_z 0[0]#1.{-"7FFF8000\relax}%
\def\XINT_floatilogten_a !#1.#2[#3]#4.{#3-#1+#4-\xint_c_i\relax}%
\def\XINT_floatilogten_b #1[#2]#3.{#2+#3-\xint_c_i\relax}%
```

9.80 \xintPFloat

Added at 1.1 (2014/10/28).

Modified at 1.4e (2021/05/05).

xint has not yet incorporated a general formatter as it was not a priority during development and external solutions exist (I did not check for a while but I think LaTeX3 has implemented a general formatter in the printf or Python ".format" spirit)

But when one starts using really the package, especially in an interactive way (xintsession 2021), one needs the default output to be as nice as possible.

The \xintPFloat macro was added at 1.1 as a "prettifying printer" for floats, basically influenced by Maple.

The rules were:

0. The input is float-rounded to either Digits or the optional argument
1. zero is printed as "0."
2. x.yz...eK is printed "as is" if K>5 or K<-5.
3. if -5<=K<=5, fixed point decimal notation is used.
4. in cases 2. and 3., no trimming of trailing zeroes.

1.4b added \xintPFloatE to customize whether to use e or E.

1.4e, with some hesitation, decided to make a breaking change and to modify the behaviour.

The new rules:

0. The input is float-rounded to either Digits or the optional argument
1. zero is printed as 0.0
2. x.yz...eK is printed in decimal fixed point if -4<=K<=+5 (notice the change, formerly K=-5 used fixed point notation in output) else it is printed in scientific notation
3. trailing zeros of the mantissa are trimmed always
4. in case of decimal fixed point for an integer, there is a trailing ".0"
5. in case of scientific notation with a one-digit trimmed mantissa there is an added ".0" too

Further, \xintPFloatE can now also be redefined as a macro with a parameter delimited by a full stop, with the full stop also in its ouput as terminator. It would then grab the scientific exponent K as explicit digit possibly prefixed by a minus sign. The macro must be f-expandable.

The macro \xintPFloat_wopt is only there for a micro gain as the package does

\let\xintfloatexprPrintOne\xintPFloat_wopt

as it knows it will be used always with a [P] argument in the xintexpr.sty context.

Modified at 1.4k (2022/05/18). Addition of customization via \xintPFloatZero, \xintPFloatLengthOneSuffix, \xintPFloatNoSciEmax, \xintPFloatNoSciEmin which replace formerly hard-coded behaviour.

Breaking change to not add ".0" suffix to integers (when scientific notation dropped) or to one-digit mantissas.

In my own practice I started being annoyed by the automatic trimming of zeros added at 1.4e.

This change had been influenced by using Python in interactive mode which since 3.1 prints floats (in decimal conversion) choosing the shortest string. In particular it trims trailing zeros, and it drops the scientific notation in favor of decimal notation for something like -4<= K <= 15, with K the scientific exponent.

At 1.4e I was still influenced by my experience with Maple and did for -4 <= K <= 5. Not very well thought anyhow (one may wish to use decimal notation when sending things to PostScript, so perhaps I should have kept with -5).

But, the main problem is with trimming trailing zeros: although in interactive sessions, this has its logic, as soon as one does tables with numbers, dropping a trailing zero upsets alignments or creates visual holes compared to other lines and this is in the end very annoying.

After much hesitation, I decided to slightly modifify only the former behaviour: trimming only if that removes at least 4 zeros. I had also experimented with another condition: trimmed mantissas should be at most 6 digits (for example) wide, else use no trimming.

Threshold customizable via \xintPFloatMinTrimmed.

Modified at 1.4l (2022/05/29). The 1.4k check for canceling the trimming of trailing zeros took over priority over the later check for being an integer when decimal fixed point notation was used (or being only with a one-digit trimmed mantissa). In particular if user set \xintPFloatMinTrimmed to the value of Digits (or P) to avoid trimming it also prevented recognition of some integers (but not all). Fixed at 1.4l

```
\def\xintPFloatE{e}%
\def\xintPFloatNoSciEmax{\xint_c_v}%   1e6  uses sci.not.
\def\xintPFloatNoSciEmin{-\xint_c_iv}% 1e-5 uses sci.not.
\def\xintPFloatIntSuffix{}%
\def\xintPFloatLengthOneSuffix{}%
\def\xintPFloatZero{0}%
\def\xintPFloatMinTrimmed{\xint_c_iv}%
\def\xintPFloat {\romannumeral0\xintpfloat }%
\def\xintpfloat #1{\XINT_pfloat_chkopt #1\xint:}%
\def\xintPFloat_wopt[#1]#2%
{%
    \romannumeral0\expandafter\XINT_pfloat
    \romannumeral0\XINTinfloatS[#1]{#2}#1.%
}%
\def\XINT_pfloat_chkopt #1%
{%
    \ifx [#1\expandafter\XINT_pfloat_opt
       \else\expandafter\XINT_pfloat_noopt
    \fi  #1%
}%
\def\XINT_pfloat_noopt #1\xint:%
{%
    \expandafter\XINT_pfloat\romannumeral0\XINTinfloatS[\XINTdigits]{#1}%
    \XINTdigits.%
}%
\def\XINT_pfloat_opt [\xint:{\expandafter\XINT_pfloat_opt_a\the\numexpr}%
\def\XINT_pfloat_opt_a #1]#2%
{%
    \expandafter\XINT_pfloat\romannumeral0\XINTinfloatS[#1]{#2}%
    #1.%
}%
\def\XINT_pfloat#1]%
{%
    \expandafter\XINT_pfloat_fork\romannumeral0\xintrez{#1]}%
}%
\def\XINT_pfloat_fork#1%
{%
    \xint_UDzerominusfork
       #1-\XINT_pfloat_zero
       0#1\XINT_pfloat_neg
```

```
        0-\XINT_pfloat_pos
    \krof #1%
}%
\def\XINT_pfloat_zero#1]#2.{\expanded{ \xintPFloatZero}}%
\def\XINT_pfloat_neg-{\expandafter-\romannumeral0\XINT_pfloat_pos}%
\def\XINT_pfloat_pos#1/1[#2]#3.%
{%
    \expandafter\XINT_pfloat_aa\the\numexpr\xintLength{#1}.%
    #3.#2.#1.%
}%
```

#1 est la longueur de la mantisse trimmée
#2 est Digits ou P
Si #2-#1 < MinTrimmed, on se prépare à peut-être remettre les trailing zeros
On teste pour #2=#1, car c'est le cas le plus fréquent (mais est-ce une bonne idée) car on sait qu'alors il n'y a pas de trailing zéros donc on va direct vers \XINT_pfloat_a.

```
\def\XINT_pfloat_aa #1.#2.%
{%
    \unless\ifnum\xintPFloatMinTrimmed>\numexpr#2-#1\relax
           \xint_dothis\XINT_pfloat_a\fi
    \ifnum#2>#1 \xint_dothis{\XINT_pfloat_i #2.}\fi
    \xint_orthat\XINT_pfloat_a #1.%
}%
```

Needed for \xintFracToSci, which uses old pre 1.4k interface, where the P parameter was not stored for counting how many zeros were trimmed. \xintFracToSci trims always.

```
\def\XINT_pfloat_a_fork#1%
{%
    \xint_UDzerominusfork
       #1-\XINT_pfloat_a_zero
       0#1\XINT_pfloat_a_neg
        0-\XINT_pfloat_a_pos
    \krof #1%
}%
\def\XINT_pfloat_a_zero#1]{\expanded{ \xintPFloatZero}}%
\def\XINT_pfloat_a_neg-{\expandafter-\romannumeral0\XINT_pfloat_a_pos}%
\def\XINT_pfloat_a_pos#1/1[#2]%
{%
    \expandafter\XINT_pfloat_a\the\numexpr\xintLength{#1}.#2.#1.%
}%
```

#1 est P > #2 mais peut être encore sous la forme \XINTdigits
#2 est la longueur de la mantisse trimmée
#3 est l'exposant non normalisé
#4 est la mantisse
On reconstitue les trailing zéros à remettre éventuellement.

```
\def\XINT_pfloat_i #1.#2.%#3.#4.%
{%
    \expandafter\XINT_pfloat_j\romannumeral\xintreplicate{#1-#2}0.#2.%
}%
```

#1 est les trailing zeros à remettre peut-être
#2 est la longueur de la mantisse trimmée
#3#4 est l'exposant N pour mantisse trimmée entière
#5 serait la mantisse trimmée

On calcule l'exposant scientifique.

La façon bizarre de mettre #3 est liée aux versions anciennes de la macro, héritage conservé pour minimiser effort d'adaptation.

```
\def\XINT_pfloat_j #1.#2.#3#4.%#5.
{%
    \expandafter\XINT_pfloat_b\the\numexpr#2+#3#4-\xint_c_i.%
    #3#2.#1.%
}%
```

```
#1 est la longueur de la mantisse trimmée
#2#3 est l'exposant N pour mantisse trimmée
#4 serait la mantisse
```

On calcule l'exposant scientifique. On est arrivé ici dans une branche où on n'a pas besoin de remettre les zéros trimmés donc on positionne un dernier argument vide pour \XINT_pfloat_b

```
\def\XINT_pfloat_a #1.#2#3.%#4.
{%
    \expandafter\XINT_pfloat_b\the\numexpr#1+#2#3-\xint_c_i.%
    #2#1..%
}%
```

```
#1 est l'exposant scientifique K
#2 est le signe ou premier chiffre de l'exposant N pour mantisse trimmée
#3 serait la longueur de la mantisse trimmée
#4 serait les trailing zéros
#5 serait la mantisse trimmée
```

On va vers \XINT_float_P lorsque l'on n'utilise pas la notation scientifique, mais qu'on a besoin de chiffres non nuls fractionnaires, et vers \XINT_float_Ps si on n'en a pas besoin.

On va vers \XINT_pfloat_N lorsque l'on n'utilise pas la notation scientifique et que l'exposant scientifique était strictement négatif.

```
\def\XINT_pfloat_b #1.#2%#3.#4.#5.
{%
    \ifnum \xintPFloatNoSciEmax<#1 \xint_dothis\XINT_pfloat_sci\fi
    \ifnum \xintPFloatNoSciEmin>#1 \xint_dothis\XINT_pfloat_sci\fi
    \ifnum #1<\xint_c_   \xint_dothis\XINT_pfloat_N\fi
    \if-#2\xint_dothis\XINT_pfloat_P\fi
    \xint_orthat\XINT_pfloat_Ps
    #1.%
}%
```

#1 is the scientific exponent, #2 is the length of the trimmed mantissa, #3 are the trailing zeros, #4 is the trimmed integer mantissa

\xintPFloatE can be replaced by any f-expandable macro with a dot-delimited argument which produces a dot-delimited output.

```
\def\XINT_pfloat_sci #1.#2.%
{%
    \ifnum#2=\xint_c_i\expandafter\XINT_pfloat_sci_i\expandafter\fi
    \expandafter\XINT_pfloat_sci_a\romannumeral`&&@\xintPFloatE #1.%
}%
\def\XINT_pfloat_sci_a #1.#2.#3#4.{ #3.#4#2#1}%
```

#1#2=\fi\XINT_pfloat_sci_a

1-digit mantissa, hesitation between d.0eK or deK Finally at 1.4k, \xintPFloatLengthOneSuffix for customization.

```
\def\XINT_pfloat_sci_i #1#2#3.#4.#5.{\expanded{#1 #5\xintPFloatLengthOneSuffix}#3}%
```

#1=sci.exp. K, #2=mant. wd L, #3=trailing zéros, #4=trimmed mantissa

For _N, #1 is at most -1, for _P, #1 is at least 0. For _P there will be fractional digits, and #1+1 digits before the mark.

```
\def\XINT_pfloat_N#1.#2.#3.#4.%
{%
    \expandafter\XINT_pfloat_N_e\romannumeral\xintreplicate{-#1}{0}#4#3%
}%
\def\XINT_pfloat_N_e 0{ 0.}%
```

#1=sci.exp. K, #2=mant. wd L, #3=trailing zéros, #4=trimmed mantissa

Abusive usage of internal \XINT_split_fromleft_a. It means using x = -1 - #1 in \xintDecSplit from xint.sty. We benefit also with the way \xintDecSplit is built upon \XINT_split_fromleft with a final clean-up which here we can shortcut via using terminator "\xint_bye." not "\xint_bye.."

```
\def\XINT_pfloat_P #1.#2.#3.#4.%
{%
    \expandafter\XINT_split_fromleft_a
    \the\numexpr\xint_c_vii-#1.#4\xint_bye2345678\xint_bye.#3%
}%
```

Here we have an integer so we only need to postfix the trimmed mantissa #4 with #1+1-#2 zeros (#1=sci exp., #2=trimmed mantissa width). Less cumbersome to do that with \expanded. And the trailing zeros #3 ignored here.

```
\def\XINT_pfloat_Ps #1.#2.#3.#4.%
{%
    \expanded{ #4%
    \romannumeral\xintreplicate{#1+\xint_c_i-#2}{0}\xintPFloatIntSuffix}%
}%
```

9.81 \xintFloatToDecimal

Added at 1.4k (2022/05/18).

```
\def\xintFloatToDecimal {\romannumeral0\xintfloattodecimal }%
\def\xintfloattodecimal #1{\XINT_floattodec_chkopt #1\xint:}%
\def\XINT_floattodec_chkopt #1%
{%
    \ifx [#1\expandafter\XINT_floattodec_opt
       \else\expandafter\XINT_floattodec_noopt
    \fi  #1%
}%
\def\XINT_floattodec_noopt #1\xint:%
{%
    \expandafter\XINT_floattodec\romannumeral0\XINTinfloatS[\XINTdigits]{#1}%
}%
\def\XINT_floattodec_opt [\xint:#1]%
{%
    \expandafter\XINT_floattodec\romannumeral0\XINTinfloatS[#1]%
}%
```

Temptation to try to use direct access to lower entry points from \xintREZ, but it dates back from very early days and uses old \Z delimiters (same remarks for the code jumping from \xintFracToSci to \xintrez)

```
\def\XINT_floattodec#1]%
{%
    \expandafter\XINT_dectostr\romannumeral0\xintrez{#1]}%
```

```
}%
```

9.82 \XINTinFloatFrac

Added at 1.09i (2013/12/18).
For frac function in \xintfloatexpr. This version computes exactly from the input the fractional part and then only converts it into a float with the asked-for number of digits. I will have to think it again some day, certainly.

Modified at 1.1 (2014/10/28). 1.1 removes optional argument for which there was anyhow no interface, for technical reasons having to do with \xintNewExpr.

Modified at 1.1a (2014/11/07). 1.1a renames the macro as \XINTinFloatFracdigits (from \XINTinFloatFrac) to be synchronous with the \XINTinFloatSqrt and \XINTinFloat habits related to \xintNewExpr context and issues with macro names.

Modified at 1.4e (2021/05/05). 1.4e renames it back to \XINTinFloatFrac because of all such similarly named macros also using \XINTdigits forcedly.

```
\def\XINTinFloatFrac {\romannumeral0\XINTinfloatfrac}%
\def\XINTinfloatfrac #1%
{%
    \expandafter\XINT_infloatfrac_a\expandafter {\romannumeral0\xinttfrac{#1}}%
}%
\def\XINT_infloatfrac_a {\XINTinfloat[\XINTdigits]}%
```

9.83 \xintFloatAdd, \XINTinFloatAdd

First included in release 1.07.

1.09ka improved a bit the efficiency. However the add, sub, mul, div routines were provisory and supposed to be revised soon.

Which didn't happen until 1.2f. Now, the inputs are first rounded to P digits, not P+2 as earlier.

See general introduction for important changes at 1.4e relative to the \XINTinFloat<name> macros.

```
\def\xintFloatAdd  {\romannumeral0\xintfloatadd}%
\def\xintfloatadd  #1{\XINT_fladd_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatAdd{\romannumeral0\XINTinfloatadd }%
\def\XINTinfloatadd{\XINT_fladd_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINTinFloatAdd_wopt{\romannumeral0\XINTinfloatadd_wopt}%
\def\XINTinfloatadd_wopt[#1]{\expandafter\XINT_fladd_opt_a\the\numexpr#1.\XINTinfloatS}%
\def\XINT_fladd_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_fladd_opt
       \else\expandafter\XINT_fladd_noopt
    \fi  #1#2%
}%
\def\XINT_fladd_noopt #1#2\xint:#3%
{%
    #1[\XINTdigits]%
    {\expandafter\XINT_FL_add_a
     \romannumeral0\XINTinfloat[\XINTdigits]{#2}\XINTdigits.{#3}}%
}%
\def\XINT_fladd_opt #1[\xint:#2]%#3#4%
{%
    \expandafter\XINT_fladd_opt_a\the\numexpr #2.#1%
```

```
}%
\def\XINT_fladd_opt_a #1.#2#3#4%
{%
    #2[#1]{\expandafter\XINT_FL_add_a\romannumeral0\XINTinfloat[#1]{#3}#1.{#4}}%
}%
\def\XINT_FL_add_a #1%
{%
    \xint_gob_til_zero #1\XINT_FL_add_zero 0\XINT_FL_add_b #1%
}%
\def\XINT_FL_add_zero #1.#2{#2}%[[
\def\XINT_FL_add_b #1]#2.#3%
{%
    \expandafter\XINT_FL_add_c\romannumeral0\XINTinfloat[#2]{#3}#2.#1]%
}%
\def\XINT_FL_add_c #1%
{%
    \xint_gob_til_zero #1\XINT_FL_add_zero 0\XINT_FL_add_d #1%
}%
\def\XINT_FL_add_d #1[#2]#3.#4[#5]%
{%
    \ifnum\numexpr #2-#3-#5>\xint_c_\xint_dothis\xint_firstoftwo\fi
    \ifnum\numexpr #5-#3-#2>\xint_c_\xint_dothis\xint_secondoftwo\fi
    \xint_orthat\xintAdd {#1[#2]}{#4[#5]}%
}%
```

9.84 \xintFloatSub, \XINTinFloatSub

Added at 1.07 (2013/05/25).

Modified at 1.2f (2016/03/12). Starting with 1.2f the arguments undergo an intial rounding to the target precision P not P+2.

```
\def\xintFloatSub  {\romannumeral0\xintfloatsub}%
\def\xintfloatsub  #1{\XINT_flsub_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatSub{\romannumeral0\XINTinfloatsub}%
\def\XINTinfloatsub{\XINT_flsub_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINTinFloatSub_wopt{\romannumeral0\XINTinfloatsub_wopt}%
\def\XINTinfloatsub_wopt[#1]{\expandafter\XINT_flsub_opt_a\the\numexpr#1.\XINTinfloatS}%
\def\XINT_flsub_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flsub_opt
       \else\expandafter\XINT_flsub_noopt
    \fi  #1#2%
}%
\def\XINT_flsub_noopt #1#2\xint:#3%
{%
    #1[\XINTdigits]%
    {\expandafter\XINT_FL_add_a
     \romannumeral0\XINTinfloat[\XINTdigits]{#2}\XINTdigits.{\xintOpp{#3}}}%
}%
\def\XINT_flsub_opt #1[\xint:#2]%#3#4%
{%
    \expandafter\XINT_flsub_opt_a\the\numexpr #2.#1%
}%
```

```
\def\XINT_flsub_opt_a #1.#2#3#4%
{%
    #2[#1]{\expandafter\XINT_FL_add_a\romannumeral0\XINTinfloat[#1]{#3}#1.{\xintOpp{#4}}}%
}%
```

9.85 \xintFloatMul, \XINTinFloatMul

Added at 1.07 (2013/05/25).

Modified at 1.2d (2015/11/18). Starting with 1.2f the arguments are rounded to the target precision P not P+2.

Modified at 1.2g (2016/03/19). 1.2g handles the inputs via \XINTinFloatS which will be more efficient when the precision is large and the input is for example a small constant like 2.

```
\def\xintFloatMul  {\romannumeral0\xintfloatmul}%
\def\xintfloatmul  #1{\XINT_flmul_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatMul{\romannumeral0\XINTinfloatmul}%
\def\XINTinfloatmul{\XINT_flmul_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINTinFloatMul_wopt{\romannumeral0\XINTinfloatmul_wopt}%
\def\XINTinfloatmul_wopt[#1]{\expandafter\XINT_flmul_opt_a\the\numexpr#1.\XINTinfloatS}%
\def\XINT_flmul_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flmul_opt
       \else\expandafter\XINT_flmul_noopt
    \fi  #1#2%
}%
\def\XINT_flmul_noopt #1#2\xint:#3%
{%
    #1[\XINTdigits]%
    {\expandafter\XINT_FL_mul_a
     \romannumeral0\XINTinfloatS[\XINTdigits]{#2}\XINTdigits.{#3}}%
}%
\def\XINT_flmul_opt #1[\xint:#2]%#3#4%
{%
    \expandafter\XINT_flmul_opt_a\the\numexpr #2.#1%
}%
\def\XINT_flmul_opt_a #1.#2#3#4%
{%
    #2[#1]{\expandafter\XINT_FL_mul_a\romannumeral0\XINTinfloatS[#1]{#3}#1.{#4}}%
}%
\def\XINT_FL_mul_a #1[#2]#3.#4%
{%
    \expandafter\XINT_FL_mul_b\romannumeral0\XINTinfloatS[#3]{#4}#1[#2]%
}%
\def\XINT_FL_mul_b #1[#2]#3[#4]{\xintiiMul{#3}{#1}/1[#4+#2]}%
```

9.86 \xintFloatSqr, \XINTinFloatSqr

Added at 1.4e (2021/05/05). Strangely \xintFloatSqr had never been defined so far.

An \XINTinFloatSqr{#1} was defined in xintexpr.sty directly as \XINTinFloatMul[\XINTdigits]{#1}{#1}, to support the sqr() function. The {#1}{#1} causes no problem as #1 in this context is always pre-expanded so we don't need to worry about this, and the \xintdeffloatfunc mechanism should hopefully take care to add the needed argument pre-expansion if need be.

Anyway let's do this finally properly here.

```
\def\xintFloatSqr  {\romannumeral0\xintfloatsqr}%
\def\xintfloatsqr  #1{\XINT_flsqr_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatSqr{\romannumeral0\XINTinfloatsqr}%
\def\XINTinfloatsqr{\XINT_flsqr_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINT_flsqr_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flsqr_opt
       \else\expandafter\XINT_flsqr_noopt
    \fi  #1#2%
}%
\def\XINT_flsqr_noopt #1#2\xint:
{%
    #1[\XINTdigits]%
    {\expandafter\XINT_FL_sqr_a\romannumeral0\XINTinfloatS[\XINTdigits]{#2}}%
}%
\def\XINT_flsqr_opt #1[\xint:#2]%
{%
    \expandafter\XINT_flsqr_opt_a\the\numexpr #2.#1%
}%
\def\XINT_flsqr_opt_a #1.#2#3%
{%
    #2[#1]{\expandafter\XINT_FL_sqr_a\romannumeral0\XINTinfloatS[#1]{#3}}%
}%
\def\XINT_FL_sqr_a #1[#2]{\xintiiSqr{#1}/1[#2+#2]}%
\def\XINTinFloatSqr_wopt[#1]#2{\XINTinFloatS[#1]{\expandafter\XINT_FL_sqr_a\romannumeral0\XINTinfloatS[#1]
```

9.87 \XINTinFloatInv

Added at 1.3e (2019/04/05). Added belatedly at 1.3e, to support inv() function. We use Short output, for rare inv(\xintexpr 1/3\relax) case. I need to think the whole thing out at some later date.

```
\def\XINTinFloatInv#1{\XINTinFloatS[\XINTdigits]{\xintInv{#1}}}%
\def\XINTinFloatInv_wopt[#1]#2{\XINTinFloatS[#1]{\xintInv{#2}}}%
```

9.88 \xintFloatDiv, \XINTinFloatDiv

Added at 1.07 (2013/05/25).

Modified at 1.2f (2016/03/12). Starting with 1.2f the arguments are rounded to the target precision P not P+2.

Modified at 1.2g (2016/03/19). 1.2g handles the inputs via \XINTinFloatS which will be more efficient when the precision is large and the input is for example a small constant like 2.
The actual rounding of the quotient is handled via \xintfloat (or \XINTinfloatS).

Modified at 1.2k (2017/01/06). 1.2k does the same kind of improvement in \XINT_FL_div_b as for multiplication: earlier code was unnecessarily high level.

```
\def\xintFloatDiv  {\romannumeral0\xintfloatdiv}%
\def\xintfloatdiv  #1{\XINT_fldiv_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatDiv{\romannumeral0\XINTinfloatdiv}%
\def\XINTinfloatdiv{\XINT_fldiv_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINTinFloatDiv_wopt[#1]{\romannumeral0\XINT_fldiv_opt_a#1.\XINTinfloatS}%
\def\XINT_fldiv_chkopt #1#2%
```

```
{%
    \ifx [#2\expandafter\XINT_fldiv_opt
       \else\expandafter\XINT_fldiv_noopt
    \fi  #1#2%
}%
```

1.4g adds here intercept of second argument being zero, else a low level error will arise at later stage from the the fall-back value returned by core iidivision being 0 and not having expected number of digits at \XINT_infloat_Qq and split from left returning some empty value breaking the \ifnum test in \XINT_infloat_Rq.

```
\def\XINT_fldiv_noopt #1#2\xint:#3%
{%
    #1[\XINTdigits]%
    {\expandafter\XINT_FL_div_aa
     \romannumeral0\XINTinfloatS[\XINTdigits]{#3}\XINTdigits.{#2}}%
}%
\def\XINT_FL_div_aa #1%
{%
    \xint_gob_til_zero#1\XINT_FL_div_Bzero0\XINT_FL_div_a #1%
}%
\def\XINT_FL_div_Bzero0\XINT_FL_div_a#1[#2]#3.#4%
{%
    \XINT_signalcondition{DivisionByZero}{Division by zero (#1[#2]) of #4}{}{ 0[0]}%
}%
\def\XINT_fldiv_opt #1[\xint:#2]%#3#4%
{%
    \expandafter\XINT_fldiv_opt_a\the\numexpr #2.#1%
}%
```

Also here added early check at 1.4g if divisor is zero.

```
\def\XINT_fldiv_opt_a #1.#2#3#4%
{%
    #2[#1]{\expandafter\XINT_FL_div_aa\romannumeral0\XINTinfloatS[#1]{#4}#1.{#3}}%
}%
\def\XINT_FL_div_a #1[#2]#3.#4%
{%
    \expandafter\XINT_FL_div_b\romannumeral0\XINTinfloatS[#3]{#4}/#1e#2%
}%
\def\XINT_FL_div_b #1[#2]{#1e#2}%
```

9.89 \xintFloatPow, \XINTinFloatPow

Added at 1.07 (2013/05/25).

1.09j has re-organized the core loop.

2015/12/07. I have hesitated to map ^ in expressions to \xintFloatPow rather than \xintFloatPower. But for 1.234567890123456 to the power 2145678912 with P=16, using Pow rather than Power seems to bring only about 5% gain.

This routine requires the exponent x to be compatible with \numexpr parsing.

Modified at 1.2f (2016/03/12). 1.2f has rewritten the code for better efficiency. Also, now the argument A for A^x is first rounded to P digits before switching to the increased working precision (which depends upon x).

```
\def\xintFloatPow  {\romannumeral0\xintfloatpow}%
\def\xintfloatpow  #1{\XINT_flpow_chkopt \xintfloat #1\xint:}%
```

```
\def\XINTinFloatPow{\romannumeral0\XINTinfloatpow }%
\def\XINTinfloatpow{\XINT_flpow_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINTinfloatpow_wopt[#1]{\expandafter\XINT_flpow_opt_a\the\numexpr#1.\XINTinfloatS}%
\def\XINT_flpow_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flpow_opt
      \else\expandafter\XINT_flpow_noopt
    \fi
    #1#2%
}%
\def\XINT_flpow_noopt  #1#2\xint:#3%
{%
   \expandafter\XINT_flpow_checkB_a
   \the\numexpr #3.\XINTdigits.{#2}{#1[\XINTdigits]}%
}%
\def\XINT_flpow_opt #1[\xint:#2]%
{%
   \expandafter\XINT_flpow_opt_a\the\numexpr #2.#1%
}%
\def\XINT_flpow_opt_a #1.#2#3#4%
{%
   \expandafter\XINT_flpow_checkB_a\the\numexpr #4.#1.{#3}{#2[#1]}%
}%
\def\XINT_flpow_checkB_a #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_flpow_BisZero
      0#1{\XINT_flpow_checkB_b -}%
       0-{\XINT_flpow_checkB_b {}#1}%
    \krof
}%
\def\XINT_flpow_BisZero .#1.#2#3{#3{1[0]}}%
\def\XINT_flpow_checkB_b #1#2.#3.%
{%
    \expandafter\XINT_flpow_checkB_c
    \the\numexpr\xintLength{#2}+\xint_c_iii.#3.#2.{#1}%
}%
\def\XINT_flpow_checkB_c #1.#2.%
{%
    \expandafter\XINT_flpow_checkB_d\the\numexpr#1+#2.#1.#2.%
}%
```

1.2f rounds input to P digits, first.

```
\def\XINT_flpow_checkB_d #1.#2.#3.#4.#5#6%
{%
    \expandafter \XINT_flpow_aa
    \romannumeral0\XINTinfloat [#3]{#6}{#2}{#1}{#4}{#5}%
}%
\def\XINT_flpow_aa #1[#2]#3%
{%
    \expandafter\XINT_flpow_ab\the\numexpr #2-#3\expandafter.%
    \romannumeral\XINT_rep #3\endcsname0.#1.%
}%
```

```
\def\XINT_flpow_ab #1.#2.#3.{\XINT_flpow_a #3#2[#1]}%
\def\XINT_flpow_a #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_flpow_zero
      0#1{\XINT_flpow_b \iftrue}%
       0-{\XINT_flpow_b \iffalse#1}%
    \krof
}%
\def\XINT_flpow_zero #1[#2]#3#4#5#6%
{%
    #6{\if 1#51\xint_dothis {0[0]}\fi
       \xint_orthat
       {\XINT_signalcondition{DivisionByZero}{0 raised to power -#4.}{}{ 0[0]}}%
      }%
}%
\def\XINT_flpow_b #1#2[#3]#4#5%
{%
    \XINT_flpow_loopI #5.#3.#2.#4.{#1\ifodd #5 \xint_c_i\fi\fi}%
}%
\def\XINT_flpow_truncate #1.#2.#3.%
{%
    \expandafter\XINT_flpow_truncate_a
    \romannumeral0\XINT_split_fromleft
    #3.#2\xint_bye2345678\xint_bye..#1.#3.%
}%
\def\XINT_flpow_truncate_a #1.#2.#3.{#3+\xintLength{#2}.#1.}%
\def\XINT_flpow_loopI #1.%
{%
    \ifnum #1=\xint_c_i\expandafter\XINT_flpow_ItoIII\fi
    \ifodd #1
       \expandafter\XINT_flpow_loopI_odd
    \else
       \expandafter\XINT_flpow_loopI_even
    \fi
    #1.%
}%
\def\XINT_flpow_ItoIII\ifodd #1\fi #2.#3.#4.#5.#6%
{%
    \expandafter\XINT_flpow_III\the\numexpr #6+\xint_c_.#3.#4.#5.%
}%
\def\XINT_flpow_loopI_even #1.#2.#3.%#4.%
{%
    \expandafter\XINT_flpow_loopI
    \the\numexpr #1/\xint_c_ii\expandafter.%
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr\xint_c_ii*#2\expandafter.\romannumeral0\xintiisqr{#3}.%
}%
\def\XINT_flpow_loopI_odd #1.#2.#3.#4.%
{%
    \expandafter\XINT_flpow_loopII
    \the\numexpr #1/\xint_c_ii-\xint_c_i\expandafter.%
```

```
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr\xint_c_ii*#2\expandafter.\romannumeral0\xintiisqr{#3}.#4.#2.#3.%
}%
\def\XINT_flpow_loopII #1.%
{%
    \ifnum #1 = \xint_c_i\expandafter\XINT_flpow_IItoIII\fi
    \ifodd #1
       \expandafter\XINT_flpow_loopII_odd
    \else
       \expandafter\XINT_flpow_loopII_even
    \fi
    #1.%
}%
\def\XINT_flpow_loopII_even #1.#2.#3.%#4.%
{%
    \expandafter\XINT_flpow_loopII
    \the\numexpr #1/\xint_c_ii\expandafter.%
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr\xint_c_ii*#2\expandafter.\romannumeral0\xintiisqr{#3}.%
}%
\def\XINT_flpow_loopII_odd #1.#2.#3.#4.#5.#6.%
{%
    \expandafter\XINT_flpow_loopII_odda
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr#2+#5\expandafter.\romannumeral0\xintiimul{#3}{#6}.#4.%
    #1.#2.#3.%
}%
\def\XINT_flpow_loopII_odda #1.#2.#3.#4.#5.#6.%
{%
    \expandafter\XINT_flpow_loopII
    \the\numexpr #4/\xint_c_ii-\xint_c_i\expandafter.%
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr\xint_c_ii*#5\expandafter.\romannumeral0\xintiisqr{#6}.#3.%
    #1.#2.%
}%
\def\XINT_flpow_IItoIII\ifodd #1\fi #2.#3.#4.#5.#6.#7.#8%
{%
    \expandafter\XINT_flpow_III\the\numexpr #8+\xint_c_\expandafter.%
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr#3+#6\expandafter.\romannumeral0\xintiimul{#4}{#7}.#5.%
}%
```

This ending is common with \xintFloatPower.

In the case of negative exponent we need to inverse the Q-digits mantissa. This requires no special attention now as 1.2k's \xintFloat does correct rounding of fractions hence it is easy to bound the total error. It can be checked that the algorithm after final rounding to the target precision computes a value Z whose distance to the exact theoretical will be less than 0.52 ulp(Z) (and worst cases can only be slightly worse than 0.51 ulp(Z)).

In the case of the half-integer exponent (only via the expression interface,) the computation (which proceeds via \XINTinFloatPowerH) ends with a square root. This square root extraction is done with 3 guard digits (the power operations were done with more.) Then the value is rounded to the target precision. There is thus this rounding to 3 guard digits (in the case of negative exponent the reciprocal is computed before the square-root), then the square root is (computed with exact rounding for these 3 guard digits), and then there is the final rounding of this to the target precision. The total error (for positive as well as negative exponent) has been estimated to at worst possibly exceed slightly 0.5125 ulp(Z), and at any rate it is less than 0.52 ulp(Z).

```
\def\XINT_flpow_III #1.#2.#3.#4.#5%
{%
    \expandafter\XINT_flpow_IIIend
    \xint_UDsignfork
         #5{{1/#3[-#2]}}%
         -{{#3[#2]}}%
    \krof #1%
}%
\def\XINT_flpow_IIIend #1#2#3%
    {#3{\if#21\xint_afterfi{\expandafter-\romannumeral`&&@}\fi#1}}%
```

9.90 \xintFloatPower, \XINTinFloatPower

Added at 1.07 (2013/05/25). The core loop has been re-organized in 1.09j for some slight efficiency gain. The exponent B is given to \xintNum. The ^ in expressions is mapped to this routine.

Modified at 1.2f (2016/03/12). Same modifications as in \xintFloatPow for 1.2f.

1.2f \XINTinFloatPowerH (now moved to xintlog, and renamed). It truncated the exponent to an integer of half-integer, and in the latter case use Square-root extraction. At 1.2k this was improved as 1.2f stupidly rounded to Digits before, not after the square root extraction, 1.2k kept 3 guard digits for this last step. And the initial step was changed to a rounding rather than truncating.

Modified at 1.4e (2021/05/05). Until 1.4e this \XINTinFloatPowerH was the macro for a^b in expressions, but of course it behaved strangely for b not an integer or an half-integer! At 1.4e, the non-integer, non-half-integer exponents will be handled via log10() and pow10() support macros, see xintlog. The code has now been relocated there.

```
\def\xintFloatPower  {\romannumeral0\xintfloatpower}%
\def\xintfloatpower  #1{\XINT_flpower_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatPower{\romannumeral0\XINTinfloatpower }%
\def\XINTinfloatpower{\XINT_flpower_opt_a\XINTdigits.\XINTinfloatS}%
```

Start of macro. Check for optional argument.

```
\def\XINT_flpower_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flpower_opt
       \else\expandafter\XINT_flpower_noopt
    \fi
    #1#2%
}%
\def\XINT_flpower_noopt  #1#2\xint:#3%
{%
   \expandafter\XINT_flpower_checkB_a
   \romannumeral0\xintnum{#3}.\XINTdigits.{#2}{#1[\XINTdigits]}%
}%
\def\XINT_flpower_opt #1[\xint:#2]%
{%
   \expandafter\XINT_flpower_opt_a\the\numexpr #2.#1%
}%
\def\XINT_flpower_opt_a #1.#2#3#4%
{%
```

```
   \expandafter\XINT_flpower_checkB_a
   \romannumeral0\xintnum{#4}.#1.{#3}{#2[#1]}%
}%
\def\XINT_flpower_checkB_a #1%
{%
    \xint_UDzerominusfork
      #1-{\XINT_flpower_BisZero 0}%
      0#1{\XINT_flpower_checkB_b -}%
       0-{\XINT_flpower_checkB_b {}#1}%
    \krof
}%
\def\XINT_flpower_BisZero 0.#1.#2#3{#3{1[0]}}%
\def\XINT_flpower_checkB_b #1#2.#3.%
{%
    \expandafter\XINT_flpower_checkB_c
    \the\numexpr\xintLength{#2}+\xint_c_iii.#3.#2.{#1}%
}%
\def\XINT_flpower_checkB_c #1.#2.%
{%
    \expandafter\XINT_flpower_checkB_d\the\numexpr#1+#2.#1.#2.%
}%
\def\XINT_flpower_checkB_d #1.#2.#3.#4.#5#6%
{%
    \expandafter \XINT_flpower_aa
    \romannumeral0\XINTinfloat [#3]{#6}{#2}{#1}{#4}{#5}%
}%
\def\XINT_flpower_aa #1[#2]#3%
{%
    \expandafter\XINT_flpower_ab\the\numexpr #2-#3\expandafter.%
    \romannumeral\XINT_rep #3\endcsname0.#1.%
}%
\def\XINT_flpower_ab #1.#2.#3.{\XINT_flpower_a #3#2[#1]}%
\def\XINT_flpower_a #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_flpow_zero
      0#1{\XINT_flpower_b \iftrue}%
       0-{\XINT_flpower_b \iffalse#1}%
    \krof
}%
\def\XINT_flpower_b #1#2[#3]#4#5%
{%
    \XINT_flpower_loopI #5.#3.#2.#4.{#1\xintiiOdd{#5}\fi}%
}%
\def\XINT_flpower_loopI #1.%
{%
    \if1\XINT_isOne {#1}\xint_dothis\XINT_flpower_ItoIII\fi
    \ifodd\xintLDg{#1} %<- intentional space
       \xint_dothis{\expandafter\XINT_flpower_loopI_odd}\fi
    \xint_orthat{\expandafter\XINT_flpower_loopI_even}%
    \romannumeral0\XINT_half
    #1\xint_bye\xint_Bye345678\xint_bye
```

```
    *\xint_c_v+\xint_c_v)/\xint_c_x-\xint_c_i\relax.%
}%
\def\XINT_flpower_ItoIII #1.#2.#3.#4.#5%
{%
    \expandafter\XINT_flpow_III\the\numexpr #5+\xint_c_.#2.#3.#4.%
}%
\def\XINT_flpower_loopI_even #1.#2.#3.#4.%
{%
    \expandafter\XINT_flpower_toloopI
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr\xint_c_ii*#2\expandafter.\romannumeral0\xintiisqr{#3}.#4.#1.%
}%
\def\XINT_flpower_toloopI #1.#2.#3.#4.{\XINT_flpower_loopI #4.#1.#2.#3.}%
\def\XINT_flpower_loopI_odd #1.#2.#3.#4.%
{%
    \expandafter\XINT_flpower_toloopII
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr\xint_c_ii*#2\expandafter.\romannumeral0\xintiisqr{#3}.#4.%
    #1.#2.#3.%
}%
\def\XINT_flpower_toloopII #1.#2.#3.#4.{\XINT_flpower_loopII #4.#1.#2.#3.}%
\def\XINT_flpower_loopII #1.%
{%
    \if1\XINT_isOne{#1}\xint_dothis\XINT_flpower_IItoIII\fi
    \ifodd\xintLDg{#1} %<- intentional space
        \xint_dothis{\expandafter\XINT_flpower_loopII_odd}\fi
    \xint_orthat{\expandafter\XINT_flpower_loopII_even}%
    \romannumeral0\XINT_half#1\xint_bye\xint_Bye345678\xint_bye
    *\xint_c_v+\xint_c_v)/\xint_c_x-\xint_c_i\relax.%
}%
\def\XINT_flpower_loopII_even #1.#2.#3.#4.%
{%
    \expandafter\XINT_flpower_toloopII
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr\xint_c_ii*#2\expandafter.\romannumeral0\xintiisqr{#3}.#4.#1.%
}%
\def\XINT_flpower_loopII_odd #1.#2.#3.#4.#5.#6.%
{%
    \expandafter\XINT_flpower_loopII_odda
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr#2+#5\expandafter.\romannumeral0\xintiimul{#3}{#6}.#4.%
    #1.#2.#3.%
}%
\def\XINT_flpower_loopII_odda #1.#2.#3.#4.#5.#6.%
{%
    \expandafter\XINT_flpower_toloopII
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr\xint_c_ii*#5\expandafter.\romannumeral0\xintiisqr{#6}.#3.%
    #4.#1.#2.%
}%
\def\XINT_flpower_IItoIII #1.#2.#3.#4.#5.#6.#7%
{%
```

```
    \expandafter\XINT_flpow_III\the\numexpr #7+\xint_c_\expandafter.%
    \the\numexpr\expandafter\XINT_flpow_truncate
    \the\numexpr#2+#5\expandafter.\romannumeral0\xintiimul{#3}{#6}.#4.%
}%
```

9.91 \xintFloatFac, \XINTFloatFac

Added at 1.2 (2015/10/10).

```
\def\xintFloatFac  {\romannumeral0\xintfloatfac}%
\def\xintfloatfac  #1{\XINT_flfac_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatFac{\romannumeral0\XINTinfloatfac}%
\def\XINTinfloatfac[#1]{\expandafter\XINT_flfac_opt_a\the\numexpr#1.\XINTinfloatS}%
\def\XINTinFloatFacdigits{\romannumeral0\XINT_flfac_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINT_flfac_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flfac_opt
       \else\expandafter\XINT_flfac_noopt
    \fi
     #1#2%
}%
\def\XINT_flfac_noopt  #1#2\xint:
{%
   \expandafter\XINT_FL_fac_fork_a
   \the\numexpr \xintNum{#2}.\xint_c_i \XINTdigits\XINT_FL_fac_out{#1[\XINTdigits]}%
}%
\def\XINT_flfac_opt #1[\xint:#2]%
{%
   \expandafter\XINT_flfac_opt_a\the\numexpr #2.#1%
}%
\def\XINT_flfac_opt_a #1.#2#3%
{%
   \expandafter\XINT_FL_fac_fork_a\the\numexpr \xintNum{#3}.\xint_c_i {#1}\XINT_FL_fac_out{#2[#1]}%
}%
\def\XINT_FL_fac_fork_a #1%
{%
     \xint_UDzerominusfork
     #1-\XINT_FL_fac_iszero
     0#1\XINT_FL_fac_isneg
      0-{\XINT_FL_fac_fork_b #1}%
    \krof
}%
\def\XINT_FL_fac_iszero #1.#2#3#4#5{#5{1[0]}}%
```

1.2f XINT_FL_fac_isneg returns 0, earlier versions used 1 here.

```
\def\XINT_FL_fac_isneg  #1.#2#3#4#5%
{%
    #5{\XINT_signalcondition{InvalidOperation}
                     {Factorial argument is negative: -#1.}{}{ 0[0]}}%
}%
\def\XINT_FL_fac_fork_b #1.%
{%
    \ifnum #1>\xint_c_x^viii_mone\xint_dothis\XINT_FL_fac_toobig\fi
    \ifnum #1>\xint_c_x^iv\xint_dothis\XINT_FL_fac_vbig \fi
```

```
    \ifnum #1>465  \xint_dothis\XINT_FL_fac_big\fi
    \ifnum #1>101  \xint_dothis\XINT_FL_fac_med\fi
                   \xint_orthat\XINT_FL_fac_small
    #1.%
}%
\def\XINT_FL_fac_toobig #1.#2#3#4#5%
{%
    #5{\XINT_signalcondition{InvalidOperation}
                     {Factorial argument is too large: #1>=10^8.}{}{ 0[0]}}%
}%
```

Computations are done with Q blocks of eight digits. When a multiplication has a carry, hence creates Q+1 blocks, the least significant one is dropped. The goal is to compute an approximate value X' to the exact value X, such that the final relative error (X-X')/X will be at most 10^{-P-1} with P the desired precision. Then, when we round X' to X'' with P significant digits, we can prove that the absolute error |X-X''| is bounded (strictly) by 0.6 ulp(X''). (ulp= unit in the last (significant) place). Let N be the number of such operations, the formula for Q deduces from the previous explanations is that 8Q should be at least P+9+k, with k the number of digits of N (in base 10). Note that 1.2 version used P+10+k, for 1.2f I reduced to P+9+k. Also, k should be the number of digits of the number N of multiplications done, hence for n<=10000 we can take N=n/2, or N/3, or N/4. This is rounded above by numexpr and always an overestimate of the actual number of approximate multiplications done (the first ones are exact). (vérifier ce que je raconte, j'ai la flemme là).

We then want ceil((P+k+n)/8). Using \numexpr rounding division (ARRRRRGGGHHHH), if m is a positive integer, ceil(m/8) can be computed as (m+3)/8. Thus with m=P+10+k, this gives Q<-(P+13+k)/8. The routine actually computes 8(Q-1) for use in \XINT_FL_fac_addzeros.

With 1.2f the formula is m=P+9+k, Q<-(P+12+k)/8, and we use now 4=12-8 rather than the earlier 5=13-8. Whatever happens, the value computed in \XINT_FL_fac_increaseP is at least 8. There will always be an extra block.

Note: with Digits:=32; Maple gives for 200!:
> factorial(200.);
375
0.78865786736479050355236321393218 10
My 1.2f routine (and also 1.2) outputs:
7.8865786736479050355236321393219e374
and this is the correct rounding because for 40 digits it computes
7.886578673647905035523632139321850622951e374
Maple's result (contrarily to xint) is thus not the correct rounding but still it is less than 0.6 ulp wrong.

```
\def\XINT_FL_fac_vbig
   {\expandafter\XINT_FL_fac_vbigloop_a
    \the\numexpr \XINT_FL_fac_increaseP \xint_c_i   }%
\def\XINT_FL_fac_big
   {\expandafter\XINT_FL_fac_bigloop_a
    \the\numexpr \XINT_FL_fac_increaseP \xint_c_ii  }%
\def\XINT_FL_fac_med
   {\expandafter\XINT_FL_fac_medloop_a
    \the\numexpr \XINT_FL_fac_increaseP \xint_c_iii }%
\def\XINT_FL_fac_small
   {\expandafter\XINT_FL_fac_smallloop_a
    \the\numexpr \XINT_FL_fac_increaseP \xint_c_iv  }%
\def\XINT_FL_fac_increaseP #1#2.#3#4%
{%
```

```
    #2\expandafter.\the\numexpr\xint_c_viii*%
    ((\xint_c_iv+#4+\expandafter\XINT_FL_fac_countdigits
                   \the\numexpr #2/(#1*#3)\relax 87654321\Z)/\xint_c_viii).%
}%
\def\XINT_FL_fac_countdigits #1#2#3#4#5#6#7#8{\XINT_FL_fac_countdone }%
\def\XINT_FL_fac_countdone   #1#2\Z {#1}%
\def\XINT_FL_fac_out #1;![#2]#3%
    {#3{\romannumeral0\XINT_mul_out
         #1;!1\R!1\R!1\R!1\R!%
                   1\R!1\R!1\R!1\R!\W [#2]}}%
\def\XINT_FL_fac_vbigloop_a #1.#2.%
{%
    \XINT_FL_fac_bigloop_a \xint_c_x^iv.#2.%
    {\expandafter\XINT_FL_fac_vbigloop_loop\the\numexpr 100010001\expandafter.%
     \the\numexpr \xint_c_x^viii+#1.}%
}%
\def\XINT_FL_fac_vbigloop_loop #1.#2.%
{%
    \ifnum #1>#2 \expandafter\XINT_FL_fac_loop_exit\fi
    \expandafter\XINT_FL_fac_vbigloop_loop
    \the\numexpr #1+\xint_c_i\expandafter.%
    \the\numexpr #2\expandafter.\the\numexpr\XINT_FL_fac_mul #1!%
}%
\def\XINT_FL_fac_bigloop_a #1.%
{%
    \expandafter\XINT_FL_fac_bigloop_b \the\numexpr
    #1+\xint_c_i-\xint_c_ii*((#1-464)/\xint_c_ii).#1.%
}%
\def\XINT_FL_fac_bigloop_b #1.#2.#3.%
{%
    \expandafter\XINT_FL_fac_medloop_a
        \the\numexpr #1-\xint_c_i.#3.{\XINT_FL_fac_bigloop_loop #1.#2.}%
}%
\def\XINT_FL_fac_bigloop_loop #1.#2.%
{%
    \ifnum #1>#2 \expandafter\XINT_FL_fac_loop_exit\fi
    \expandafter\XINT_FL_fac_bigloop_loop
    \the\numexpr #1+\xint_c_ii\expandafter.%
    \the\numexpr #2\expandafter.\the\numexpr\XINT_FL_fac_bigloop_mul #1!%
}%
\def\XINT_FL_fac_bigloop_mul #1!%
{%
    \expandafter\XINT_FL_fac_mul
        \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)!%
}%
\def\XINT_FL_fac_medloop_a #1.%
{%
    \expandafter\XINT_FL_fac_medloop_b
        \the\numexpr #1+\xint_c_i-\xint_c_iii*((#1-100)/\xint_c_iii).#1.%
}%
\def\XINT_FL_fac_medloop_b #1.#2.#3.%
{%
```

```
    \expandafter\XINT_FL_fac_smallloop_a
        \the\numexpr #1-\xint_c_i.#3.{\XINT_FL_fac_medloop_loop #1.#2.}%
}%
\def\XINT_FL_fac_medloop_loop #1.#2.%
{%
    \ifnum #1>#2 \expandafter\XINT_FL_fac_loop_exit\fi
    \expandafter\XINT_FL_fac_medloop_loop
    \the\numexpr #1+\xint_c_iii\expandafter.%
    \the\numexpr #2\expandafter.\the\numexpr\XINT_FL_fac_medloop_mul #1!%
}%
\def\XINT_FL_fac_medloop_mul #1!%
{%
    \expandafter\XINT_FL_fac_mul
    \the\numexpr
        \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_FL_fac_smallloop_a #1.%
{%
    \csname
      XINT_FL_fac_smallloop_\the\numexpr #1-\xint_c_iv*(#1/\xint_c_iv)\relax
    \endcsname #1.%
}%
\expandafter\def\csname XINT_FL_fac_smallloop_1\endcsname #1.#2.%
{%
    \XINT_FL_fac_addzeros #2.100000001!.{2.#1.}{#2}%
}%
\expandafter\def\csname XINT_FL_fac_smallloop_-2\endcsname #1.#2.%
{%
    \XINT_FL_fac_addzeros #2.100000002!.{3.#1.}{#2}%
}%
\expandafter\def\csname XINT_FL_fac_smallloop_-1\endcsname #1.#2.%
{%
    \XINT_FL_fac_addzeros #2.100000006!.{4.#1.}{#2}%
}%
\expandafter\def\csname XINT_FL_fac_smallloop_0\endcsname #1.#2.%
{%
    \XINT_FL_fac_addzeros #2.100000024!.{5.#1.}{#2}%
}%
\def\XINT_FL_fac_addzeros #1.%
{%
    \ifnum #1=\xint_c_viii \expandafter\XINT_FL_fac_addzeros_exit\fi
    \expandafter\XINT_FL_fac_addzeros
    \the\numexpr #1-\xint_c_viii.100000000!%
}%
```

We will manipulate by successive *small* multiplications Q blocks 1<8d>!, terminated by 1;!. We need a custom small multiplication which tells us when it has create a new block, and the least significant one should be dropped.

```
\def\XINT_FL_fac_addzeros_exit #1.#2.#3#4{\XINT_FL_fac_smallloop_loop #3#21;![-#4]}%
\def\XINT_FL_fac_smallloop_loop #1.#2.%
{%
    \ifnum #1>#2 \expandafter\XINT_FL_fac_loop_exit\fi
    \expandafter\XINT_FL_fac_smallloop_loop
```

```
    \the\numexpr #1+\xint_c_iv\expandafter.%
    \the\numexpr #2\expandafter.\romannumeral0\XINT_FL_fac_smallloop_mul #1!%
}%
\def\XINT_FL_fac_smallloop_mul #1!%
{%
    \expandafter\XINT_FL_fac_mul
    \the\numexpr
        \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%[[
\def\XINT_FL_fac_loop_exit #1!#2]#3{#3#2]}%
\def\XINT_FL_fac_mul 1#1!%
   {\expandafter\XINT_FL_fac_mul_a\the\numexpr\XINT_FL_fac_smallmul 10!{#1}}%
\def\XINT_FL_fac_mul_a #1-#2%
{%
    \if#21\xint_afterfi{\expandafter\space\xint_gob_til_exclam}\else
    \expandafter\space\fi #11;!%
}%
\def\XINT_FL_fac_minimulwc_a #1#2#3#4#5!#6#7#8#9%
{%
    \XINT_FL_fac_minimulwc_b {#1#2#3#4}{#5}{#6#7#8#9}%
}%
\def\XINT_FL_fac_minimulwc_b #1#2#3#4!#5%
{%
    \expandafter\XINT_FL_fac_minimulwc_c
    \the\numexpr \xint_c_x^ix+#5+#2*#4!{{#1}{#2}{#3}{#4}}%
}%
\def\XINT_FL_fac_minimulwc_c 1#1#2#3#4#5#6!#7%
{%
    \expandafter\XINT_FL_fac_minimulwc_d {#1#2#3#4#5}#7{#6}%
}%
\def\XINT_FL_fac_minimulwc_d #1#2#3#4#5%
{%
    \expandafter\XINT_FL_fac_minimulwc_e
    \the\numexpr \xint_c_x^ix+#1+#2*#5+#3*#4!{#2}{#4}%
}%
\def\XINT_FL_fac_minimulwc_e 1#1#2#3#4#5#6!#7#8#9%
{%
    1#6#9\expandafter!%
    \the\numexpr\expandafter\XINT_FL_fac_smallmul
    \the\numexpr \xint_c_x^viii+#1#2#3#4#5+#7*#8!%
}%
\def\XINT_FL_fac_smallmul 1#1!#21#3!%
{%
    \xint_gob_til_sc #3\XINT_FL_fac_smallmul_end;%
    \XINT_FL_fac_minimulwc_a #2!#3!{#1}{#2}%
}%
```

This is the crucial ending. I note that I used here an \ifnum test rather than the gob_til_eightzeroes thing. Actually for eight digits there is much less difference than for only four.

The "carry" situation is marked by a final !-1 rather than !-2 for no-carry. (a \numexpr muste be stopped, and leaving a - as delimiter is good as it will not arise earlier.)

```
\def\XINT_FL_fac_smallmul_end;\XINT_FL_fac_minimulwc_a #1!;!#2#3[#4]%
{%
```

```
   \ifnum #2=\xint_c_
       \expandafter\xint_firstoftwo\else
       \expandafter\xint_secondoftwo
   \fi
   {-2\relax[#4]}%
   {1#2\expandafter!\expandafter-\expandafter1\expandafter
                  [\the\numexpr #4+\xint_c_viii]}%
}%
```

9.92 \xintFloatPFactorial, \XINTinFloatPFactorial

Added at 1.2f (2016/03/12) [on 2015/11/29]. Partial factorial pfactorial(a,b)=(a+1)...b, only for non-negative integers with a<=b<10^8.

Modified at 1.2h (2016/11/20). Now avoids raising \xintError:OutOfRangePFac if the condition 0<=a<=b<10^8 is violated. Same as for \xintiiPFactorial.

Modified at 1.4e (2021/05/05). 1.4e extends the precision in floating point context adding some overhead but well.

```
\def\xintFloatPFactorial  {\romannumeral0\xintfloatpfactorial}%
\def\xintfloatpfactorial  #1{\XINT_flpfac_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatPFactorial{\romannumeral0\XINTinfloatpfactorial }%
\def\XINTinfloatpfactorial{\XINT_flpfac_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINT_flpfac_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flpfac_opt
       \else\expandafter\XINT_flpfac_noopt
    \fi
     #1#2%
}%
\def\XINT_flpfac_noopt  #1#2\xint:#3%
{%
   \expandafter\XINT_FL_pfac_fork
   \the\numexpr \xintNum{#2}\expandafter.%
   \the\numexpr \xintNum{#3}.\xint_c_i{\XINTdigits}{#1[\XINTdigits]}%
}%
\def\XINT_flpfac_opt #1[\xint:#2]%
{%
   \expandafter\XINT_flpfac_opt_a\the\numexpr #2.#1%
}%
\def\XINT_flpfac_opt_a #1.#2#3#4%
{%
   \expandafter\XINT_FL_pfac_fork
   \the\numexpr \xintNum{#3}\expandafter.%
   \the\numexpr \xintNum{#4}.\xint_c_i{#1}{#2[#1]}%
}%
\def\XINT_FL_pfac_fork #1#2.#3#4.%
{%
    \unless\ifnum #1#2<#3#4 \xint_dothis\XINT_FL_pfac_one\fi
    \if-#3\xint_dothis\XINT_FL_pfac_neg \fi
    \if-#1\xint_dothis\XINT_FL_pfac_zero\fi
    \ifnum #3#4>\xint_c_x^viii_mone\xint_dothis\XINT_FL_pfac_outofrange\fi
    \xint_orthat \XINT_FL_pfac_increaseP #1#2.#3#4.%
}%
```

```
\def\XINT_FL_pfac_outofrange #1.#2.#3#4#5%
{%
    #5{\XINT_signalcondition{InvalidOperation}
                     {pFactorial with too large argument: #2 >= 10^8.}{}{ 0[0]}}%
}%
\def\XINT_FL_pfac_one  #1.#2.#3#4#5{#5{1[0]}}%
\def\XINT_FL_pfac_zero #1.#2.#3#4#5{#5{0[0]}}%
\def\XINT_FL_pfac_neg -#1.-#2.%
{%
    \ifnum #1>\xint_c_x^viii\xint_dothis\XINT_FL_pfac_outofrange\fi
    \xint_orthat {%
    \ifodd\numexpr#2-#1\relax\xint_afterfi{\expandafter-\romannumeral`&&@}\fi
    \expandafter\XINT_FL_pfac_increaseP}%
    \the\numexpr #2-\xint_c_i\expandafter.\the\numexpr#1-\xint_c_i.%
}%
```

See the comments for \XINT_FL_pfac_increaseP. Case of b=a+1 should be filtered out perhaps. We only needed here to copy the \xintPFactorial macros and re-use \XINT_FL_fac_mul/\XINT_FL_fac_out. Had to modify a bit \XINT_FL_pfac_addzeroes. We can enter here directly with #3 equal to specify the precision (the calculated value before final rounding has a relative error less than #3.10^{-#4-1}), and #5 would hold the macro doing the final rounding (or truncating, if I make a FloatTrunc available) to a given number of digits, possibly not #4. By default the #3 is 1, but FloatBinomial calls it with #3=4.

```
\def\XINT_FL_pfac_increaseP #1.#2.#3#4%
{%
    \expandafter\XINT_FL_pfac_a
    \the\numexpr \xint_c_viii*((\xint_c_iv+#4+\expandafter
                 \XINT_FL_fac_countdigits\the\numexpr (#2-#1-\xint_c_i)%
                    /\ifnum #2>\xint_c_x^iv #3\else(#3*\xint_c_ii)\fi\relax
                 87654321\Z)/\xint_c_viii).#1.#2.%
}%
\def\XINT_FL_pfac_a #1.#2.#3.%
{%
    \expandafter\XINT_FL_pfac_b\the\numexpr \xint_c_i+#2\expandafter.%
    \the\numexpr#3\expandafter.%
    \romannumeral0\XINT_FL_pfac_addzeroes #1.100000001!1;![-#1]%
}%
\def\XINT_FL_pfac_addzeroes #1.%
{%
    \ifnum #1=\xint_c_viii \expandafter\XINT_FL_pfac_addzeroes_exit\fi
    \expandafter\XINT_FL_pfac_addzeroes\the\numexpr #1-\xint_c_viii.100000000!%
}%
\def\XINT_FL_pfac_addzeroes_exit #1.{ }%
\def\XINT_FL_pfac_b #1.%
{%
    \ifnum #1>9999 \xint_dothis\XINT_FL_pfac_vbigloop \fi
    \ifnum #1>463  \xint_dothis\XINT_FL_pfac_bigloop   \fi
    \ifnum #1>98   \xint_dothis\XINT_FL_pfac_medloop   \fi
                   \xint_orthat\XINT_FL_pfac_smallloop #1.%
}%
\def\XINT_FL_pfac_smallloop #1.#2.%
{%
    \ifcase\numexpr #2-#1\relax
```

```
        \expandafter\XINT_FL_pfac_end_
    \or \expandafter\XINT_FL_pfac_end_i
    \or \expandafter\XINT_FL_pfac_end_ii
    \or \expandafter\XINT_FL_pfac_end_iii
    \else\expandafter\XINT_FL_pfac_smallloop_a
    \fi #1.#2.%
}%
\def\XINT_FL_pfac_smallloop_a #1.#2.%
{%
    \expandafter\XINT_FL_pfac_smallloop_b
    \the\numexpr #1+\xint_c_iv\expandafter.%
    \the\numexpr #2\expandafter.%
    \romannumeral0\expandafter\XINT_FL_fac_mul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_FL_pfac_smallloop_b #1.%
{%
    \ifnum #1>98  \expandafter\XINT_FL_pfac_medloop   \else
                  \expandafter\XINT_FL_pfac_smallloop \fi #1.%
}%
\def\XINT_FL_pfac_medloop #1.#2.%
{%
    \ifcase\numexpr #2-#1\relax
        \expandafter\XINT_FL_pfac_end_
    \or \expandafter\XINT_FL_pfac_end_i
    \or \expandafter\XINT_FL_pfac_end_ii
    \else\expandafter\XINT_FL_pfac_medloop_a
    \fi #1.#2.%
}%
\def\XINT_FL_pfac_medloop_a #1.#2.%
{%
    \expandafter\XINT_FL_pfac_medloop_b
    \the\numexpr #1+\xint_c_iii\expandafter.%
    \the\numexpr #2\expandafter.%
    \romannumeral0\expandafter\XINT_FL_fac_mul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_FL_pfac_medloop_b #1.%
{%
    \ifnum #1>463 \expandafter\XINT_FL_pfac_bigloop   \else
                  \expandafter\XINT_FL_pfac_medloop   \fi #1.%
}%
\def\XINT_FL_pfac_bigloop #1.#2.%
{%
    \ifcase\numexpr #2-#1\relax
        \expandafter\XINT_FL_pfac_end_
    \or \expandafter\XINT_FL_pfac_end_i
    \else\expandafter\XINT_FL_pfac_bigloop_a
    \fi #1.#2.%
}%
\def\XINT_FL_pfac_bigloop_a #1.#2.%
{%
```

```
    \expandafter\XINT_FL_pfac_bigloop_b
    \the\numexpr #1+\xint_c_ii\expandafter.%
    \the\numexpr #2\expandafter.%
    \romannumeral0\expandafter\XINT_FL_fac_mul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)!%
}%
\def\XINT_FL_pfac_bigloop_b #1.%
{%
    \ifnum #1>9999 \expandafter\XINT_FL_pfac_vbigloop  \else
                   \expandafter\XINT_FL_pfac_bigloop   \fi #1.%
}%
\def\XINT_FL_pfac_vbigloop #1.#2.%
{%
    \ifnum #2=#1
        \expandafter\XINT_FL_pfac_end_
    \else\expandafter\XINT_FL_pfac_vbigloop_a
    \fi #1.#2.%
}%
\def\XINT_FL_pfac_vbigloop_a #1.#2.%
{%
    \expandafter\XINT_FL_pfac_vbigloop
    \the\numexpr #1+\xint_c_i\expandafter.%
    \the\numexpr #2\expandafter.%
    \romannumeral0\expandafter\XINT_FL_fac_mul
    \the\numexpr\xint_c_x^viii+#1!%
}%
\def\XINT_FL_pfac_end_iii #1.#2.%
{%
    \expandafter\XINT_FL_fac_out
    \romannumeral0\expandafter\XINT_FL_fac_mul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)*(#1+\xint_c_iii)!%
}%
\def\XINT_FL_pfac_end_ii #1.#2.%
{%
    \expandafter\XINT_FL_fac_out
    \romannumeral0\expandafter\XINT_FL_fac_mul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)*(#1+\xint_c_ii)!%
}%
\def\XINT_FL_pfac_end_i #1.#2.%
{%
    \expandafter\XINT_FL_fac_out
    \romannumeral0\expandafter\XINT_FL_fac_mul
    \the\numexpr \xint_c_x^viii+#1*(#1+\xint_c_i)!%
}%
\def\XINT_FL_pfac_end_ #1.#2.%
{%
    \expandafter\XINT_FL_fac_out
    \romannumeral0\expandafter\XINT_FL_fac_mul
    \the\numexpr \xint_c_x^viii+#1!%
}%
```

9.93 \xintFloatBinomial, \XINTinFloatBinomial

Added at 1.2f (2016/03/12) [on 2015/12/01]. We compute binomial(x,y) as pfac(x-y,x)/y!, where the numerator and denominator are computed with a relative error at most 4.10^{-P-2}, then rounded (once I have a float truncation, I will use truncation rather) to P+3 digits, and finally the quotient is correctly rounded to P digits. This will guarantee that the exact value X differs from the computed one Y by at most 0.6 ulp(Y).

Modified at 1.2h (2016/11/20). As for \xintiiBinomial, hard to understand why last year I coded this to raise an error if y<0 or y>x ! The question of the Gamma function is for another occasion, here x and y must be (small) integers.

1.4e: same remarks as for factorial and partial factorial about added overhead due to extra guard digits.

```
\def\xintFloatBinomial  {\romannumeral0\xintfloatbinomial}%
\def\xintfloatbinomial  #1{\XINT_flbinom_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatBinomial{\romannumeral0\XINTinfloatbinomial }%
\def\XINTinfloatbinomial{\XINT_flbinom_opt\XINTinfloatS[\xint:\XINTdigits]}%
\def\XINT_flbinom_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flbinom_opt
       \else\expandafter\XINT_flbinom_noopt
    \fi  #1#2%
}%
\def\XINT_flbinom_noopt #1#2\xint:#3%
{%
    \expandafter\XINT_FL_binom_a
    \the\numexpr\xintNum{#2}\expandafter.\the\numexpr\xintNum{#3}.\XINTdigits.#1%
}%
\def\XINT_flbinom_opt #1[\xint:#2]#3#4%
{%
    \expandafter\XINT_FL_binom_a
    \the\numexpr\xintNum{#3}\expandafter.\the\numexpr\xintNum{#4}\expandafter.%
    \the\numexpr #2.#1%
}%
\def\XINT_FL_binom_a #1.#2.%
{%
    \expandafter\XINT_FL_binom_fork \the\numexpr #1-#2.#2.#1.%
}%
\def\XINT_FL_binom_fork #1#2.#3#4.#5#6.%
{%
    \if-#5\xint_dothis \XINT_FL_binom_neg\fi
    \if-#1\xint_dothis \XINT_FL_binom_zero\fi
    \if-#3\xint_dothis \XINT_FL_binom_zero\fi
    \if0#1\xint_dothis \XINT_FL_binom_one\fi
    \if0#3\xint_dothis \XINT_FL_binom_one\fi
    \ifnum #5#6>\xint_c_x^viii_mone \xint_dothis\XINT_FL_binom_toobig\fi
    \ifnum #1#2>#3#4  \xint_dothis\XINT_FL_binom_ab \fi
                      \xint_orthat\XINT_FL_binom_aa
    #1#2.#3#4.#5#6.%
}%
\def\XINT_FL_binom_neg #1.#2.#3.#4.#5%
{%
    #5[#4]{\XINT_signalcondition{InvalidOperation}
```

```
                          {Binomial with negative argument: #3.}{}{ 0[0]}}%
}%
\def\XINT_FL_binom_toobig #1.#2.#3.#4.#5%
{%
    #5[#4]{\XINT_signalcondition{InvalidOperation}
                          {Binomial with too large argument: #3 >= 10^8.}{}{ 0[0]}}%
}%
\def\XINT_FL_binom_one  #1.#2.#3.#4.#5{#5[#4]{1[0]}}%
\def\XINT_FL_binom_zero #1.#2.#3.#4.#5{#5[#4]{0[0]}}%
\def\XINT_FL_binom_aa  #1.#2.#3.#4.#5%
{%
    #5[#4]{\xintDiv{\XINT_FL_pfac_increaseP
           #2.#3.\xint_c_iv{#4+\xint_c_i}{\XINTinfloat[#4+\xint_c_iii]}}%
           {\XINT_FL_fac_fork_b
           #1.\xint_c_iv{#4+\xint_c_i}\XINT_FL_fac_out{\XINTinfloat[#4+\xint_c_iii]}}}%
}%
\def\XINT_FL_binom_ab  #1.#2.#3.#4.#5%
{%
    #5[#4]{\xintDiv{\XINT_FL_pfac_increaseP
           #1.#3.\xint_c_iv{#4+\xint_c_i}{\XINTinfloat[#4+\xint_c_iii]}}%
           {\XINT_FL_fac_fork_b
           #2.\xint_c_iv{#4+\xint_c_i}\XINT_FL_fac_out{\XINTinfloat[#4+\xint_c_iii]}}}%
}%
```

9.94 \xintFloatSqrt, \XINTinFloatSqrt

Added at 1.08 (2013/06/07).

Modified at 1.2f (2016/03/12).

The float version was developed at the same time as the integer one and even a bit earlier. As a result the integer variant had some sub-optimal parts. Anyway, for 1.2f I have rewritten the integer variant, and the float variant delegates all preparatory wrok for it until the last step. In particular the very low precisions are not penalized anymore from doing computations for at least 17 or 18 digits. Both the large and small precisions give quite shorter computation times.

Also, after examining more closely the achieved precision I decided to extend the float version in order for it to obtain the correct rounding (for inputs already of at most P digits with P the precision) of the theoretical exact value.

Beyond about 500 digits of precision the efficiency decreases swiftly, as is the case generally speaking with xintcore/xint/xintfrac arithmetic macros.

Final note: with 1.2f the input is always first rounded to P significant places.

```
\def\xintFloatSqrt   {\romannumeral0\xintfloatsqrt}%
\def\xintfloatsqrt  #1{\XINT_flsqrt_chkopt \xintfloat #1\xint:}%
\def\XINTinFloatSqrt{\romannumeral0\XINTinfloatsqrt}%
\def\XINTinfloatsqrt[#1]{\expandafter\XINT_flsqrt_opt_a\the\numexpr#1.\XINTinfloatS}%
\def\XINTinFloatSqrtdigits{\romannumeral0\XINT_flsqrt_opt_a\XINTdigits.\XINTinfloatS}%
\def\XINT_flsqrt_chkopt #1#2%
{%
    \ifx [#2\expandafter\XINT_flsqrt_opt
       \else\expandafter\XINT_flsqrt_noopt
    \fi  #1#2%
}%
\def\XINT_flsqrt_noopt #1#2\xint:%
{%
```

```
    \expandafter\XINT_FL_sqrt_a
                \romannumeral0\XINTinfloat[\XINTdigits]{#2}\XINTdigits.#1%
}%
\def\XINT_flsqrt_opt #1[\xint:#2]%#3%
{%
    \expandafter\XINT_flsqrt_opt_a\the\numexpr #2.#1%
}%
\def\XINT_flsqrt_opt_a #1.#2#3%
{%
    \expandafter\XINT_FL_sqrt_a\romannumeral0\XINTinfloat[#1]{#3}#1.#2%
}%
\def\XINT_FL_sqrt_a #1%
{%
    \xint_UDzerominusfork
     #1-\XINT_FL_sqrt_iszero
     0#1\XINT_FL_sqrt_isneg
      0-{\XINT_FL_sqrt_pos #1}%
    \krof
}%[
\def\XINT_FL_sqrt_iszero #1]#2.#3{#3[#2]{0[0]}}%
\def\XINT_FL_sqrt_isneg #1]#2.#3%
{%
   #3[#2]{\XINT_signalcondition{InvalidOperation}
                         {Square root of negative: -#1].}{}{ 0[0]}}%
}%
\def\XINT_FL_sqrt_pos #1[#2]#3.%
{%
    \expandafter\XINT_flsqrt
    \the\numexpr #3\ifodd #2 \xint_dothis {+\xint_c_iii.(#2+\xint_c_i).0}\fi
    \xint_orthat {+\xint_c_ii.#2.{}}#100.#3.%
}%
\def\XINT_flsqrt #1.#2.%
{%
    \expandafter\XINT_flsqrt_a
    \the\numexpr #2/\xint_c_ii-(#1-\xint_c_i)/\xint_c_ii.#1.%
}%
\def\XINT_flsqrt_a #1.#2.#3#4.#5.%
{%
    \expandafter\XINT_flsqrt_b
    \the\numexpr (#2-\xint_c_i)/\xint_c_ii\expandafter.%
    \romannumeral0\XINT_sqrt_start #2.#4#3.#5.#2.#4#3.#5.#1.%
}%

\def\XINT_flsqrt_b #1.#2#3%
{%
   \expandafter\XINT_flsqrt_c
   \romannumeral0\xintiisub
    {\XINT_dsx_addzeros {#1}#2;}%
    {\xintiiDivRound{\XINT_dsx_addzeros {#1}#3;}%
                    {\XINT_dbl#2\xint_bye2345678\xint_bye*\xint_c_ii\relax}}.%
}%
\def\XINT_flsqrt_c #1.#2.%
{%
```

```
    \expandafter\XINT_flsqrt_d
    \romannumeral0\XINT_split_fromleft#2.#1\xint_bye2345678\xint_bye..%
}%
\def\XINT_flsqrt_d #1.#2#3.%
{%
    \ifnum #2=\xint_c_v
    \expandafter\XINT_flsqrt_f\else\expandafter\XINT_flsqrt_finish\fi
    #2#3.#1.%
}%
\def\XINT_flsqrt_finish #1#2.#3.#4.#5.#6.#7.#8{#8[#6]{#3#1[#7]}}%
\def\XINT_flsqrt_f 5#1.%
   {\expandafter\XINT_flsqrt_g\romannumeral0\xintinum{#1}\relax.}%
\def\XINT_flsqrt_g #1#2#3.{\if\relax#2\xint_dothis{\XINT_flsqrt_h #1}\fi
                          \xint_orthat{\XINT_flsqrt_finish 5.}}%
\def\XINT_flsqrt_h #1{\ifnum #1<\xint_c_iii\xint_dothis{\XINT_flsqrt_again}\fi
                      \xint_orthat{\XINT_flsqrt_finish 5.}}%
\def\XINT_flsqrt_again #1.#2.%
{%
    \expandafter\XINT_flsqrt_again_a\the\numexpr #2+\xint_c_viii.%
}%
\def\XINT_flsqrt_again_a #1.#2.#3.%
{%
    \expandafter\XINT_flsqrt_b
    \the\numexpr (#1-\xint_c_i)/\xint_c_ii\expandafter.%
    \romannumeral0\XINT_sqrt_start #1.#200000000.#3.%
                                  #1.#200000000.#3.%
}%
```

9.95 \xintFloatE, \XINTinFloatE

Added at 1.07 (2013/05/25). The fraction is the first argument contrarily to \xintTrunc and \xintRound.

Attention to \XINTinFloatE: it is for use by xintexpr. With input 0 it produces on output an 0[N], not 0[0].

```
\def\xintFloatE   {\romannumeral0\xintfloate }%
\def\xintfloate #1{\XINT_floate_chkopt #1\xint:}%
\def\XINT_floate_chkopt #1%
{%
    \ifx [#1\expandafter\XINT_floate_opt
       \else\expandafter\XINT_floate_noopt
    \fi  #1%
}%
\def\XINT_floate_noopt #1\xint:%
{%
    \expandafter\XINT_floate_post
    \romannumeral0\XINTinfloat[\XINTdigits]{#1}\XINTdigits.%
}%
\def\XINT_floate_opt [\xint:#1]%
{%
    \expandafter\XINT_floate_opt_a\the\numexpr #1.%
}%
\def\XINT_floate_opt_a #1.#2%
```

```
{%
    \expandafter\XINT_floate_post
    \romannumeral0\XINTinfloat[#1]{#2}#1.%
}%
\def\XINT_floate_post #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_floate_zero
       0#1\XINT_floate_neg
       0-\XINT_floate_pos
    \krof #1%
}%[
\def\XINT_floate_zero #1]#2.#3{ 0.e0}%
\def\XINT_floate_neg-{\expandafter-\romannumeral0\XINT_floate_pos}%
\def\XINT_floate_pos #1#2[#3]#4.#5%
{%
    \expandafter\XINT_float_pos_done\the\numexpr#3+#4+#5-\xint_c_i.#1.#2;%
}%
\def\XINTinFloatE {\romannumeral0\XINTinfloate }%
\def\XINTinfloate
   {\expandafter\XINT_infloate\romannumeral0\XINTinfloat[\XINTdigits]}%
\def\XINT_infloate #1[#2]#3%
   {\expandafter\XINT_infloate_end\the\numexpr #3+#2.{#1}}%
\def\XINT_infloate_end #1.#2{ #2[#1]}%
```

9.96 \XINTinFloatMod

Added at 1.1 (2014/10/28). Pour emploi dans xintexpr. Code shortened at 1.2p.

```
\def\XINTinFloatMod {\romannumeral0\XINTinfloatmod [\XINTdigits]}%
\def\XINTinfloatmod [#1]#2#3%
{%
    \XINTinfloat[#1]{\xintMod
        {\romannumeral0\XINTinfloat[#1]{#2}}%
        {\romannumeral0\XINTinfloat[#1]{#3}}}%
}%
```

9.97 \XINTinFloatDivFloor

Added at 1.2p (2017/12/05). Formerly // and /: in \xintfloatexpr used \xintDivFloor and \xintMod, hence did not round their operands to float precision beforehand.

```
\def\XINTinFloatDivFloor {\romannumeral0\XINTinfloatdivfloor [\XINTdigits]}%
\def\XINTinfloatdivfloor [#1]#2#3%
{%
    \xintdivfloor
          {\romannumeral0\XINTinfloat[#1]{#2}}%
          {\romannumeral0\XINTinfloat[#1]{#3}}%
}%
```

9.98 \XINTinFloatDivMod

Added at 1.2p (2017/12/05). Pour emploi dans xintexpr, donc je ne prends pas la peine de faire l'expansion du modulo, qui se produira dans le \csname.

Hésitation sur le quotient, faut-il l'arrondir immédiatement ? Finalement non, le produire comme un integer.

Breaking change at 1.4 as output format is not comma separated anymore. Attention also that it uses \expanded.

No time now at the time of completion of the big 1.4 rewrite of xintexpr to test whether code efficiency here can be improved to expand the second item of output.

```
\def\XINTinFloatDivMod {\romannumeral0\XINTinfloatdivmod [\XINTdigits]}%
\def\XINTinfloatdivmod [#1]#2#3%
{%
    \expandafter\XINT_infloatdivmod
    \romannumeral0\xintdivmod
          {\romannumeral0\XINTinfloat[#1]{#2}}%
          {\romannumeral0\XINTinfloat[#1]{#3}}%
    {#1}%
}%
\def\XINT_infloatdivmod #1#2#3{\expanded{{#1}{\XINTinFloat[#3]{#2}}}}%
```

9.99 \xintifFloatInt

Added at 1.3a (2018/03/07). For ifint() function in \xintfloatexpr.

```
\def\xintifFloatInt {\romannumeral0\xintiffloatint}%
\def\xintiffloatint #1{\expandafter\XINT_iffloatint
                        \romannumeral0\xintrez{\XINTinFloatS[\XINTdigits]{#1}}}%
\def\XINT_iffloatint #1#2/1[#3]%
{%
   \if 0#1\xint_dothis\xint_stop_atfirstoftwo\fi
   \ifnum#3<\xint_c_\xint_dothis\xint_stop_atsecondoftwo\fi
   \xint_orthat\xint_stop_atfirstoftwo
}%
```

9.100 \xintFloatIsInt

Added at 1.3d (2019/01/06). For isint() function in \xintfloatexpr.

```
\def\xintFloatIsInt {\romannumeral0\xintfloatisint}%
\def\xintfloatisint #1{\expandafter\XINT_iffloatint
     \romannumeral0\xintrez{\XINTinFloatS[\XINTdigits]{#1}}10}%
```

9.101 \xintFloatIntType

Added at 1.4e (2021/05/05). For fractional powers. Expands to \xint_c_mone if argument is not an integer, to \xint_c_ if it is an even integer and to \xint_c_i if it is an odd integer.

```
\def\xintFloatIntType {\romannumeral`&&@\xintfloatinttype}%
\def\xintfloatinttype #1%
{%
    \expandafter\XINT_floatinttype
    \romannumeral0\xintrez{\XINTinFloatS[\XINTdigits]{#1}}%
}%
\def\XINT_floatinttype #1#2/1[#3]%
{%
    \if 0#1\xint_dothis\xint_c_\fi
    \ifnum#3<\xint_c_\xint_dothis\xint_c_mone\fi
```

```
    \ifnum#3>\xint_c_\xint_dothis\xint_c_\fi
    \ifodd\xintLDg{#1#2} \xint_dothis\xint_c_i\fi
    \xint_orthat\xint_c_
}%
```

9.102 \XINTinFloatdigits, \XINTinFloatSdigits

```
\def\XINTinFloatdigits {\XINTinFloat [\XINTdigits]}%
\def\XINTinFloatSdigits{\XINTinFloatS[\XINTdigits]}%
```

9.103 (WIP) \XINTinRandomFloatS, \XINTinRandomFloatSdigits

Added at 1.3b (2018/05/18). Support for random() function.

Thus as it is a priori only for xintexpr usage, it expands inside \csname context, but as we need to get rid of initial zeros we use \xintRandomDigits not \xintXRandomDigits (\expanded would have a use case here).

And anyway as we want to be able to use random() in \xintdeffunc/\xintNewExpr, it is good to have f-expandable macros, so we add the small overhead to make it f-expandable.

We don't have to be very efficient in removing leading zeroes, as there is only 10% chance for each successive one. Besides we use (current) internal storage format of the type A[N], where A is not required to be with \xintDigits digits, so N will simply be -\xintDigits and needs no adjustment.

In case we use in future with #1 something else than \xintDigits we do the 0-(#1) construct.

I had some qualms about doing a random float like this which means that when there are leading zeros in the random digits the (virtual) mantissa ends up with trailing zeros. That did not feel right but I checked random() in Python (which of course uses radix 2), and indeed this is what happens there.

```
\def\XINTinRandomFloatS{\romannumeral0\XINTinrandomfloatS}%
\def\XINTinRandomFloatSdigits{\XINTinRandomFloatS[\XINTdigits]}%
\def\XINTinrandomfloatS[#1]%
{%
    \expandafter\XINT_inrandomfloatS\the\numexpr\xint_c_-(#1)\xint:
}%
\def\XINT_inrandomfloatS-#1\xint:
{%
    \expandafter\XINT_inrandomfloatS_a
    \romannumeral0\xintrandomdigits{#1}[-#1]%
}%
```

We add one macro to handle a tiny bit faster 90% of cases, after all we also use one extra macro for the completely improbable all 0 case.

```
\def\XINT_inrandomfloatS_a#1%
{%
    \if#10\xint_dothis{\XINT_inrandomfloatS_b}\fi
    \xint_orthat{ #1}%
}%[
\def\XINT_inrandomfloatS_b#1%
{%
    \if#1[\xint_dothis{\XINT_inrandomfloatS_zero}\fi% ]
    \if#10\xint_dothis{\XINT_inrandomfloatS_b}\fi
    \xint_orthat{ #1}%
}%[
\def\XINT_inrandomfloatS_zero#1]{ 0[0]}%
```

9.104 (WIP) \XINTinRandomFloatSixteen

Added at 1.3b (2018/05/18). Support for qrand() function.

```
\def\XINTinRandomFloatSixteen%
{%
    \romannumeral0\expandafter\XINT_inrandomfloatS_a
    \romannumeral`&&@\expandafter\XINT_eightrandomdigits
                \romannumeral`&&@\XINT_eightrandomdigits[-16]%
}%
\let\XINTinFloatMaxof\XINT_Maxof
\let\XINTinFloatMinof\XINT_Minof
\let\XINTinFloatSum\XINT_Sum
\let\XINTinFloatPrd\XINT_Prd
\XINTrestorecatcodesendinput%
```

10 Package xintseries implementation

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The commenting is currently (2022/06/11) very sparse.

10.1 Catcodes, ε-TEX and reload detection

The code for reload detection was initially copied from Heiko Oberdiek's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5     % ^^M
  \endlinechar=13 %
  \catcode123=1    % {
  \catcode125=2    % }
  \catcode64=11    % @
  \catcode44=12    % ,
  \catcode46=12    % .
  \catcode58=12    % :
  \catcode94=7     % ^
  \def\empty{}\def\space{ }\newlinechar10
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xintseries.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
  \expandafter\ifx\csname numexpr\endcsname\relax
    \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
      \immediate\write128{^^JPackage xintseries Warning:^^J%
                          \space\space\space\space
                          \numexpr not available, aborting input.^^J}%
    \else
      \PackageWarningNoLine{xintseries}{\numexpr not available, aborting input}%
    \fi
    \def\z{\endgroup\endinput}%
  \else
    \ifx\x\relax   % plain-TeX, first loading of xintseries.sty
      \ifx\w\relax % but xintfrac.sty not yet loaded.
         \def\z{\endgroup\input xintfrac.sty\relax}%
      \fi
    \else
      \ifx\x\empty % LaTeX, first loading,
      % variable is initialized, but \ProvidesPackage not yet seen
          \ifx\w\relax % xintfrac.sty not yet loaded.
            \def\z{\endgroup\RequirePackage{xintfrac}}%
          \fi
      \else
        \def\z{\endgroup\endinput}% xintseries already loaded.
      \fi
    \fi
```

```
  \fi
\z%
\XINTsetupcatcodes% defined in xintkernel.sty
```

10.2 Package identification

```
\XINT_providespackage
\ProvidesPackage{xintseries}%
  [2022/06/10 v1.4m Expandable partial sums with xint package (JFB)]%
```

10.3 \xintSeries

```
\def\xintSeries {\romannumeral0\xintseries }%
\def\xintseries #1#2%
{%
    \expandafter\XINT_series\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
}%
\def\XINT_series #1#2#3%
{%
   \ifnum #2<#1
      \xint_afterfi { 0/1[0]}%
   \else
      \xint_afterfi {\XINT_series_loop {#1}{0}{#2}{#3}}%
   \fi
}%
\def\XINT_series_loop #1#2#3#4%
{%
    \ifnum #3>#1 \else \XINT_series_exit \fi
    \expandafter\XINT_series_loop\expandafter
    {\the\numexpr #1+1\expandafter }\expandafter
    {\romannumeral0\xintadd {#2}{#4{#1}}}%
    {#3}{#4}%
}%
\def\XINT_series_exit \fi #1#2#3#4#5#6#7#8%
{%
    \fi\xint_gobble_ii #6%
}%
```

10.4 \xintiSeries

```
\def\xintiSeries {\romannumeral0\xintiseries }%
\def\xintiseries #1#2%
{%
    \expandafter\XINT_iseries\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
}%
\def\XINT_iseries #1#2#3%
{%
   \ifnum #2<#1
      \xint_afterfi { 0}%
   \else
      \xint_afterfi {\XINT_iseries_loop {#1}{0}{#2}{#3}}%
```

```
  \fi
}%
\def\XINT_iseries_loop #1#2#3#4%
{%
    \ifnum #3>#1 \else \XINT_iseries_exit \fi
    \expandafter\XINT_iseries_loop\expandafter
    {\the\numexpr #1+1\expandafter }\expandafter
    {\romannumeral0\xintiiadd {#2}{#4{#1}}}%
    {#3}{#4}%
}%
\def\XINT_iseries_exit \fi #1#2#3#4#5#6#7#8%
{%
    \fi\xint_gobble_ii #6%
}%
```

10.5 \xintPowerSeries

The 1.03 version was very lame and created a build-up of denominators. (this was at a time \xintAdd always multiplied denominators, by the way) The Horner scheme for polynomial evaluation is used in 1.04, this cures the denominator problem and drastically improves the efficiency of the macro. Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```
\def\xintPowerSeries {\romannumeral0\xintpowerseries }%
\def\xintpowerseries #1#2%
{%
    \expandafter\XINT_powseries\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
}%
\def\XINT_powseries #1#2#3#4%
{%
  \ifnum #2<#1
     \xint_afterfi { 0/1[0]}%
  \else
     \xint_afterfi
     {\XINT_powseries_loop_i {#3{#2}}{#1}{#2}{#3}{#4}}%
  \fi
}%
\def\XINT_powseries_loop_i #1#2#3#4#5%
{%
    \ifnum #3>#2 \else\XINT_powseries_exit_i\fi
    \expandafter\XINT_powseries_loop_ii\expandafter
    {\the\numexpr #3-1\expandafter}\expandafter
    {\romannumeral0\xintmul {#1}{#5}}{#2}{#4}{#5}%
}%
\def\XINT_powseries_loop_ii #1#2#3#4%
{%
  \expandafter\XINT_powseries_loop_i\expandafter
  {\romannumeral0\xintadd {#4{#1}}{#2}}{#3}{#1}{#4}%
}%
\def\XINT_powseries_exit_i\fi #1#2#3#4#5#6#7#8#9%
{%
```

```
    \fi \XINT_powseries_exit_ii  #6{#7}%
}%
\def\XINT_powseries_exit_ii #1#2#3#4#5#6%
{%
    \xintmul{\xintPow {#5}{#6}}{#4}%
}%
```

10.6 \xintPowerSeriesX

Same as \xintPowerSeries except for the initial expansion of the x parameter. Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```
\def\xintPowerSeriesX {\romannumeral0\xintpowerseriesx }%
\def\xintpowerseriesx #1#2%
{%
    \expandafter\XINT_powseriesx\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
}%
\def\XINT_powseriesx #1#2#3#4%
{%
   \ifnum #2<#1
      \xint_afterfi { 0/1[0]}%
   \else
      \xint_afterfi
      {\expandafter\XINT_powseriesx_pre\expandafter
                   {\romannumeral`&&@#4}{#1}{#2}{#3}%
      }%
   \fi
}%
\def\XINT_powseriesx_pre #1#2#3#4%
{%
    \XINT_powseries_loop_i {#4{#3}}{#2}{#3}{#4}{#1}%
}%
```

10.7 \xintRationalSeries

This computes F(a)+...+F(b) on the basis of the value of F(a) and the ratios F(n)/F(n-1). As in \xintPowerSeries we use an iterative scheme which has the great advantage to avoid denominator build-up. This makes exact computations possible with exponential type series, which would be completely inaccessible to \xintSeries. #1=a, #2=b, #3=F(a), #4=ratio function Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```
\def\xintRationalSeries {\romannumeral0\xintratseries }%
\def\xintratseries #1#2%
{%
    \expandafter\XINT_ratseries\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
}%
\def\XINT_ratseries #1#2#3#4%
{%
```

```
    \ifnum #2<#1
       \xint_afterfi { 0/1[0]}%
    \else
       \xint_afterfi
       {\XINT_ratseries_loop {#2}{1}{#1}{#4}{#3}}%
    \fi
}%
\def\XINT_ratseries_loop #1#2#3#4%
{%
    \ifnum #1>#3 \else\XINT_ratseries_exit_i\fi
    \expandafter\XINT_ratseries_loop\expandafter
    {\the\numexpr #1-1\expandafter}\expandafter
    {\romannumeral0\xintadd {1}{\xintMul {#2}{#4{#1}}}}{#3}{#4}%
}%
\def\XINT_ratseries_exit_i\fi #1#2#3#4#5#6#7#8%
{%
    \fi \XINT_ratseries_exit_ii  #6%
}%
\def\XINT_ratseries_exit_ii #1#2#3#4#5%
{%
    \XINT_ratseries_exit_iii #5%
}%
\def\XINT_ratseries_exit_iii #1#2#3#4%
{%
    \xintmul{#2}{#4}%
}%
```

10.8 \xintRationalSeriesX

a,b,initial,ratiofunction,x
This computes F(a,x)+...+F(b,x) on the basis of the value of F(a,x) and the ratios F(n,x)/F(n-1,x). The argument x is first expanded and it is the value resulting from this which is used then throughout. The initial term F(a,x) must be defined as one-parameter macro which will be given x. Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```
\def\xintRationalSeriesX {\romannumeral0\xintratseriesx }%
\def\xintratseriesx #1#2%
{%
    \expandafter\XINT_ratseriesx\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
}%
\def\XINT_ratseriesx #1#2#3#4#5%
{%
    \ifnum #2<#1
       \xint_afterfi { 0/1[0]}%
    \else
       \xint_afterfi
       {\expandafter\XINT_ratseriesx_pre\expandafter
                    {\romannumeral`&&@#5}{#2}{#1}{#4}{#3}%
       }%
    \fi
```

```
}%
\def\XINT_ratseriesx_pre #1#2#3#4#5%
{%
    \XINT_ratseries_loop {#2}{1}{#3}{#4{#1}}{#5{#1}}%
}%
```

10.9 \xintFxPtPowerSeries

I am not two happy with this piece of code. Will make it more economical another day. Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a: forgot last time some optimization from the change to \numexpr.

```
\def\xintFxPtPowerSeries {\romannumeral0\xintfxptpowerseries }%
\def\xintfxptpowerseries #1#2%
{%
    \expandafter\XINT_fppowseries\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
}%
\def\XINT_fppowseries #1#2#3#4#5%
{%
   \ifnum #2<#1
      \xint_afterfi { 0}%
   \else
      \xint_afterfi
        {\expandafter\XINT_fppowseries_loop_pre\expandafter
           {\romannumeral0\xinttrunc {#5}{\xintPow {#4}{#1}}}%
          {#1}{#4}{#2}{#3}{#5}%
        }%
   \fi
}%
\def\XINT_fppowseries_loop_pre #1#2#3#4#5#6%
{%
    \ifnum #4>#2 \else\XINT_fppowseries_dont_i \fi
    \expandafter\XINT_fppowseries_loop_i\expandafter
    {\the\numexpr #2+\xint_c_i\expandafter}\expandafter
    {\romannumeral0\xintitrunc {#6}{\xintMul {#5{#2}}{#1}}}%
    {#1}{#3}{#4}{#5}{#6}%
}%
\def\XINT_fppowseries_dont_i \fi\expandafter\XINT_fppowseries_loop_i
    {\fi \expandafter\XINT_fppowseries_dont_ii }%
\def\XINT_fppowseries_dont_ii #1#2#3#4#5#6#7{\xinttrunc {#7}{#2[-#7]}}%
\def\XINT_fppowseries_loop_i #1#2#3#4#5#6#7%
{%
    \ifnum #5>#1 \else \XINT_fppowseries_exit_i \fi
    \expandafter\XINT_fppowseries_loop_ii\expandafter
    {\romannumeral0\xinttrunc {#7}{\xintMul {#3}{#4}}}%
    {#1}{#4}{#2}{#5}{#6}{#7}%
}%
\def\XINT_fppowseries_loop_ii #1#2#3#4#5#6#7%
{%
    \expandafter\XINT_fppowseries_loop_i\expandafter
    {\the\numexpr #2+\xint_c_i\expandafter}\expandafter
```

```
    {\romannumeral0\xintiiadd {#4}{\xintiTrunc {#7}{\xintMul {#6{#2}}{#1}}}}%
    {#1}{#3}{#5}{#6}{#7}%
}%
\def\XINT_fppowseries_exit_i\fi\expandafter\XINT_fppowseries_loop_ii
    {\fi \expandafter\XINT_fppowseries_exit_ii }%
\def\XINT_fppowseries_exit_ii #1#2#3#4#5#6#7%
{%
    \xinttrunc {#7}
    {\xintiiadd {#4}{\xintiTrunc {#7}{\xintMul {#6{#2}}{#1}}}[-#7]}%
}%
```

10.10 \xintFxPtPowerSeriesX

a,b,coeff,x,D

Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```
\def\xintFxPtPowerSeriesX {\romannumeral0\xintfxptpowerseriesx }%
\def\xintfxptpowerseriesx #1#2%
{%
    \expandafter\XINT_fppowseriesx\expandafter
    {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
}%
\def\XINT_fppowseriesx #1#2#3#4#5%
{%
   \ifnum #2<#1
      \xint_afterfi { 0}%
   \else
      \xint_afterfi
        {\expandafter \XINT_fppowseriesx_pre \expandafter
         {\romannumeral`&&@#4}{#1}{#2}{#3}{#5}%
        }%
   \fi
}%
\def\XINT_fppowseriesx_pre #1#2#3#4#5%
{%
    \expandafter\XINT_fppowseries_loop_pre\expandafter
       {\romannumeral0\xinttrunc {#5}{\xintPow {#1}{#2}}}%
       {#2}{#1}{#3}{#4}{#5}%
}%
```

10.11 \xintFloatPowerSeries

1.08a. I still have to re-visit \xintFxPtPowerSeries; temporarily I just adapted the code to the case of floats.

Usage of new names \XINTinfloatpow_wopt \XINTinfloatmul_wopt, \XINTinfloatadd_wopt to track xintfrac.sty changes at 1.4e.

```
\def\xintFloatPowerSeries {\romannumeral0\xintfloatpowerseries }%
\def\xintfloatpowerseries #1{\XINT_flpowseries_chkopt #1\xint:}%
\def\XINT_flpowseries_chkopt #1%
{%
    \ifx [#1\expandafter\XINT_flpowseries_opt
```

```
      \else\expandafter\XINT_flpowseries_noopt
    \fi
    #1%
}%
\def\XINT_flpowseries_noopt  #1\xint:#2%
{%
    \expandafter\XINT_flpowseries\expandafter
    {\the\numexpr #1\expandafter}\expandafter
    {\the\numexpr #2}\XINTdigits
}%
\def\XINT_flpowseries_opt [\xint:#1]#2#3%
{%
    \expandafter\XINT_flpowseries\expandafter
    {\the\numexpr #2\expandafter}\expandafter
    {\the\numexpr #3\expandafter}{\the\numexpr #1}%
}%
\def\XINT_flpowseries #1#2#3#4#5%
{%
   \ifnum #2<#1
      \xint_afterfi { 0.e0}%
   \else
      \xint_afterfi
        {\expandafter\XINT_flpowseries_loop_pre\expandafter
           {\romannumeral0\XINTinfloatpow_wopt[#3]{#5}{#1}}%
          {#1}{#5}{#2}{#4}{#3}%
        }%
   \fi
}%
\def\XINT_flpowseries_loop_pre #1#2#3#4#5#6%
{%
    \ifnum #4>#2 \else\XINT_flpowseries_dont_i \fi
    \expandafter\XINT_flpowseries_loop_i\expandafter
    {\the\numexpr #2+\xint_c_i\expandafter}\expandafter
    {\romannumeral0\XINTinfloatmul_wopt[#6]{#5{#2}}{#1}}%
    {#1}{#3}{#4}{#5}{#6}%
}%
\def\XINT_flpowseries_dont_i \fi\expandafter\XINT_flpowseries_loop_i
    {\fi \expandafter\XINT_flpowseries_dont_ii }%
\def\XINT_flpowseries_dont_ii #1#2#3#4#5#6#7{\xintfloat [#7]{#2}}%
\def\XINT_flpowseries_loop_i #1#2#3#4#5#6#7%
{%
    \ifnum #5>#1 \else \XINT_flpowseries_exit_i \fi
    \expandafter\XINT_flpowseries_loop_ii\expandafter
    {\romannumeral0\XINTinfloatmul_wopt[#7]{#3}{#4}}%
    {#1}{#4}{#2}{#5}{#6}{#7}%
}%
\def\XINT_flpowseries_loop_ii #1#2#3#4#5#6#7%
{%
    \expandafter\XINT_flpowseries_loop_i\expandafter
    {\the\numexpr #2+\xint_c_i\expandafter}\expandafter
    {\romannumeral0\XINTinfloatadd_wopt[#7]{#4}%
                        {\XINTinfloatmul_wopt[#7]{#6{#2}}{#1}}}%
```

```
    {#1}{#3}{#5}{#6}{#7}%
}%
\def\XINT_flpowseries_exit_i\fi\expandafter\XINT_flpowseries_loop_ii
    {\fi \expandafter\XINT_flpowseries_exit_ii }%
\def\XINT_flpowseries_exit_ii #1#2#3#4#5#6#7%
{%
    \xintfloatadd[#7]{#4}{\XINTinfloatmul_wopt[#7]{#6{#2}}{#1}}%
}%
```

10.12 \xintFloatPowerSeriesX

1.08a

See \xintFloatPowerSeries for 1.4e comments.

```
\def\xintFloatPowerSeriesX {\romannumeral0\xintfloatpowerseriesx }%
\def\xintfloatpowerseriesx #1{\XINT_flpowseriesx_chkopt #1\xint:}%
\def\XINT_flpowseriesx_chkopt #1%
{%
    \ifx [#1\expandafter\XINT_flpowseriesx_opt
       \else\expandafter\XINT_flpowseriesx_noopt
    \fi
    #1%
}%
\def\XINT_flpowseriesx_noopt  #1\xint:#2%
{%
    \expandafter\XINT_flpowseriesx\expandafter
    {\the\numexpr #1\expandafter}\expandafter
    {\the\numexpr #2}\XINTdigits
}%
\def\XINT_flpowseriesx_opt [\xint:#1]#2#3%
{%
    \expandafter\XINT_flpowseriesx\expandafter
    {\the\numexpr #2\expandafter}\expandafter
    {\the\numexpr #3\expandafter}{\the\numexpr #1}%
}%
\def\XINT_flpowseriesx #1#2#3#4#5%
{%
   \ifnum #2<#1
      \xint_afterfi { 0.e0}%
   \else
      \xint_afterfi
        {\expandafter \XINT_flpowseriesx_pre \expandafter
         {\romannumeral`&&@#5}{#1}{#2}{#4}{#3}%
        }%
   \fi
}%
\def\XINT_flpowseriesx_pre #1#2#3#4#5%
{%
    \expandafter\XINT_flpowseries_loop_pre\expandafter
       {\romannumeral0\XINTinfloatpow_wopt[#5]{#1}{#2}}%
       {#2}{#1}{#3}{#4}{#5}%
}%
\XINTrestorecatcodesendinput%
```

11 Package xintcfrac implementation

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The commenting is currently (2022/06/11) very sparse. Release 1.09m (2014/02/26) has modified a few things: \xintFtoCs and \xintCntoCs insert spaces after the commas, \xintCstoF and \xintCstoCv authorize spaces in the input also before the commas, \xintCntoCs does not brace the produced coefficients, new macros \xintFtoC, \xintCtoF, \xintCtoCv, \xintFGtoC, and \xintGGCFrac.

There is partial dependency on xinttools due to \xintCstoF and \xintCsToCv.

11.1 Catcodes, ε-TEX and reload detection

The code for reload detection was initially copied from HEIKO OBERDIEK's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5     % ^^M
  \endlinechar=13 %
  \catcode123=1    % {
  \catcode125=2    % }
  \catcode64=11    % @
  \catcode44=12    % ,
  \catcode46=12    % .
  \catcode58=12    % :
  \catcode94=7     % ^
  \def\empty{}\def\space{ }\newlinechar10
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xintcfrac.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
  \expandafter\ifx\csname numexpr\endcsname\relax
    \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
      \immediate\write128{^^JPackage xintcfrac Warning:^^J%
                          \space\space\space\space
                          \numexpr not available, aborting input.^^J}%
    \else
      \PackageWarningNoLine{xintcfrac}{\numexpr not available, aborting input}%
    \fi
    \def\z{\endgroup\endinput}%
  \else
    \ifx\x\relax   % plain-TeX, first loading of xintcfrac.sty
```

```
      \ifx\w\relax % but xintfrac.sty not yet loaded.
         \def\z{\endgroup\input xintfrac.sty\relax}%
      \fi
    \else
      \ifx\x\empty % LaTeX, first loading,
      % variable is initialized, but \ProvidesPackage not yet seen
          \ifx\w\relax % xintfrac.sty not yet loaded.
            \def\z{\endgroup\RequirePackage{xintfrac}}%
          \fi
      \else
        \def\z{\endgroup\endinput}% xintcfrac already loaded.
      \fi
    \fi
  \fi
\z%
\XINTsetupcatcodes% defined in xintkernel.sty
```

11.2 Package identification

```
\XINT_providespackage
\ProvidesPackage{xintcfrac}%
  [2022/06/10 v1.4m Expandable continued fractions with xint package (JFB)]%
```

11.3 \xintCFrac

```
\def\xintCFrac {\romannumeral0\xintcfrac }%
\def\xintcfrac #1%
{%
    \XINT_cfrac_opt_a #1\xint:
}%
\def\XINT_cfrac_opt_a #1%
{%
    \ifx[#1\XINT_cfrac_opt_b\fi \XINT_cfrac_noopt #1%
}%
\def\XINT_cfrac_noopt #1\xint:
{%
    \expandafter\XINT_cfrac_A\romannumeral0\xintrawwithzeros {#1}\Z
    \relax\relax
}%
\def\XINT_cfrac_opt_b\fi\XINT_cfrac_noopt [\xint:#1]%
{%
    \fi\csname XINT_cfrac_opt#1\endcsname
}%
\def\XINT_cfrac_optl #1%
{%
    \expandafter\XINT_cfrac_A\romannumeral0\xintrawwithzeros {#1}\Z
    \relax\hfill
}%
\def\XINT_cfrac_optc #1%
{%
    \expandafter\XINT_cfrac_A\romannumeral0\xintrawwithzeros {#1}\Z
    \relax\relax
}%
```

```
\def\XINT_cfrac_optr #1%
{%
    \expandafter\XINT_cfrac_A\romannumeral0\xintrawwithzeros {#1}\Z
    \hfill\relax
}%
\def\XINT_cfrac_A #1/#2\Z
{%
    \expandafter\XINT_cfrac_B\romannumeral0\xintiidivision {#1}{#2}{#2}%
}%
\def\XINT_cfrac_B #1#2%
{%
    \XINT_cfrac_C #2\Z {#1}%
}%
\def\XINT_cfrac_C #1%
{%
    \xint_gob_til_zero #1\XINT_cfrac_integer 0\XINT_cfrac_D #1%
}%
\def\XINT_cfrac_integer 0\XINT_cfrac_D 0#1\Z #2#3#4#5{ #2}%
\def\XINT_cfrac_D #1\Z #2#3{\XINT_cfrac_loop_a {#1}{#3}{#1}{{#2}}}%
\def\XINT_cfrac_loop_a
{%
    \expandafter\XINT_cfrac_loop_d\romannumeral0\XINT_div_prepare
}%
\def\XINT_cfrac_loop_d #1#2%
{%
    \XINT_cfrac_loop_e #2.{#1}%
}%
\def\XINT_cfrac_loop_e #1%
{%
    \xint_gob_til_zero #1\xint_cfrac_loop_exit0\XINT_cfrac_loop_f #1%
}%
\def\XINT_cfrac_loop_f #1.#2#3#4%
{%
    \XINT_cfrac_loop_a {#1}{#3}{#1}{{#2}#4}%
}%
\def\xint_cfrac_loop_exit0\XINT_cfrac_loop_f #1.#2#3#4#5#6%
   {\XINT_cfrac_T #5#6{#2}#4\Z }%
\def\XINT_cfrac_T #1#2#3#4%
{%
  \xint_gob_til_Z #4\XINT_cfrac_end\Z\XINT_cfrac_T #1#2{#4+\cfrac{#11#2}{#3}}%
}%
\def\XINT_cfrac_end\Z\XINT_cfrac_T #1#2#3%
{%
    \XINT_cfrac_end_b #3%
}%
\def\XINT_cfrac_end_b \Z+\cfrac#1#2{ #2}%
```

11.4 \xintGCFrac

Updated at 1.4g to follow-up on renaming of \xintFrac into \xintTeXFrac.

```
\def\xintGCFrac {\romannumeral0\xintgcfrac }%
\def\xintgcfrac #1{\XINT_gcfrac_opt_a #1\xint:}%
```

```
\def\XINT_gcfrac_opt_a #1%
{%
    \ifx[#1\XINT_gcfrac_opt_b\fi \XINT_gcfrac_noopt #1%
}%
\def\XINT_gcfrac_noopt #1\xint:%
{%
    \XINT_gcfrac #1+!/\relax\relax
}%
\def\XINT_gcfrac_opt_b\fi\XINT_gcfrac_noopt [\xint:#1]%
{%
    \fi\csname XINT_gcfrac_opt#1\endcsname
}%
\def\XINT_gcfrac_optl #1%
{%
    \XINT_gcfrac #1+!/\relax\hfill
}%
\def\XINT_gcfrac_optc #1%
{%
    \XINT_gcfrac #1+!/\relax\relax
}%
\def\XINT_gcfrac_optr #1%
{%
    \XINT_gcfrac #1+!/\hfill\relax
}%
\def\XINT_gcfrac
{%
    \expandafter\XINT_gcfrac_enter\romannumeral`&&@%
}%
\def\XINT_gcfrac_enter {\XINT_gcfrac_loop {}}%
\def\XINT_gcfrac_loop #1#2+#3/%
{%
    \xint_gob_til_exclam #3\XINT_gcfrac_endloop!%
    \XINT_gcfrac_loop {{#3}{#2}#1}%
}%
\def\XINT_gcfrac_endloop!\XINT_gcfrac_loop #1#2#3%
{%
    \XINT_gcfrac_T #2#3#1!!%
}%
\def\XINT_gcfrac_T #1#2#3#4{\XINT_gcfrac_U #1#2{\xintTeXFrac{#4}}}%
\def\XINT_gcfrac_U #1#2#3#4#5%
{%
    \xint_gob_til_exclam #5\XINT_gcfrac_end!\XINT_gcfrac_U
              #1#2{\xintTeXFrac{#5}%
               \ifcase\xintSgn{#4}
               +\or+\else-\fi
               \cfrac{#1\xintTeXFrac{\xintAbs{#4}}#2}{#3}}%
}%
\def\XINT_gcfrac_end!\XINT_gcfrac_U #1#2#3%
{%
    \XINT_gcfrac_end_b #3%
}%
\def\XINT_gcfrac_end_b #1\cfrac#2#3{ #3}%
```

11.5 \xintGGCFrac

New with 1.09m

```
\def\xintGGCFrac {\romannumeral0\xintggcfrac }%
\def\xintggcfrac #1{\XINT_ggcfrac_opt_a #1\xint:}%
\def\XINT_ggcfrac_opt_a #1%
{%
    \ifx[#1\XINT_ggcfrac_opt_b\fi \XINT_ggcfrac_noopt #1%
}%
\def\XINT_ggcfrac_noopt #1\xint:
{%
    \XINT_ggcfrac #1+!/\relax\relax
}%
\def\XINT_ggcfrac_opt_b\fi\XINT_ggcfrac_noopt [\xint:#1]%
{%
    \fi\csname XINT_ggcfrac_opt#1\endcsname
}%
\def\XINT_ggcfrac_optl #1%
{%
    \XINT_ggcfrac #1+!/\relax\hfill
}%
\def\XINT_ggcfrac_optc #1%
{%
    \XINT_ggcfrac #1+!/\relax\relax
}%
\def\XINT_ggcfrac_optr #1%
{%
    \XINT_ggcfrac #1+!/\hfill\relax
}%
\def\XINT_ggcfrac
{%
    \expandafter\XINT_ggcfrac_enter\romannumeral`&&@%
}%
\def\XINT_ggcfrac_enter {\XINT_ggcfrac_loop {}}%
\def\XINT_ggcfrac_loop #1#2+#3/%
{%
    \xint_gob_til_exclam #3\XINT_ggcfrac_endloop!%
    \XINT_ggcfrac_loop {{#3}{#2}#1}%
}%
\def\XINT_ggcfrac_endloop!\XINT_ggcfrac_loop #1#2#3%
{%
    \XINT_ggcfrac_T #2#3#1!!%
}%
\def\XINT_ggcfrac_T #1#2#3#4{\XINT_ggcfrac_U #1#2{#4}}%
\def\XINT_ggcfrac_U #1#2#3#4#5%
{%
    \xint_gob_til_exclam #5\XINT_ggcfrac_end!\XINT_ggcfrac_U
              #1#2{#5+\cfrac{#1#4#2}{#3}}%
}%
\def\XINT_ggcfrac_end!\XINT_ggcfrac_U #1#2#3%
{%
    \XINT_ggcfrac_end_b #3%
}%
```

```
\def\XINT_ggcfrac_end_b #1\cfrac#2#3{ #3}%
```

11.6 \xintGCtoGCx

```
\def\xintGCtoGCx {\romannumeral0\xintgctogcx }%
\def\xintgctogcx #1#2#3%
{%
    \expandafter\XINT_gctgcx_start\expandafter {\romannumeral`&&@#3}{#1}{#2}%
}%
\def\XINT_gctgcx_start #1#2#3{\XINT_gctgcx_loop_a {}{#2}{#3}#1+!/}%
\def\XINT_gctgcx_loop_a #1#2#3#4+#5/%
{%
    \xint_gob_til_exclam #5\XINT_gctgcx_end!%
    \XINT_gctgcx_loop_b {#1{#4}}{#2{#5}#3}{#2}{#3}%
}%
\def\XINT_gctgcx_loop_b #1#2%
{%
    \XINT_gctgcx_loop_a {#1#2}%
}%
\def\XINT_gctgcx_end!\XINT_gctgcx_loop_b #1#2#3#4{ #1}%
```

11.7 \xintFtoCs

Modified in 1.09m: a space is added after the inserted commas.

```
\def\xintFtoCs {\romannumeral0\xintftocs }%
\def\xintftocs #1%
{%
    \expandafter\XINT_ftc_A\romannumeral0\xintrawwithzeros {#1}\Z
}%
\def\XINT_ftc_A #1/#2\Z
{%
    \expandafter\XINT_ftc_B\romannumeral0\xintiidivision {#1}{#2}{#2}%
}%
\def\XINT_ftc_B #1#2%
{%
    \XINT_ftc_C #2.{#1}%
}%
\def\XINT_ftc_C #1%
{%
    \xint_gob_til_zero #1\XINT_ftc_integer 0\XINT_ftc_D #1%
}%
\def\XINT_ftc_integer 0\XINT_ftc_D 0#1.#2#3{ #2}%
\def\XINT_ftc_D #1.#2#3{\XINT_ftc_loop_a {#1}{#3}{#1}{#2, }}% 1.09m adds a space
\def\XINT_ftc_loop_a
{%
    \expandafter\XINT_ftc_loop_d\romannumeral0\XINT_div_prepare
}%
\def\XINT_ftc_loop_d #1#2%
{%
    \XINT_ftc_loop_e #2.{#1}%
}%
\def\XINT_ftc_loop_e #1%
{%
```

```
    \xint_gob_til_zero #1\xint_ftc_loop_exit0\XINT_ftc_loop_f #1%
}%
\def\XINT_ftc_loop_f #1.#2#3#4%
{%
    \XINT_ftc_loop_a {#1}{#3}{#1}{#4#2, }% 1.09m has an added space here
}%
\def\xint_ftc_loop_exit0\XINT_ftc_loop_f #1.#2#3#4{ #4#2}%
```

11.8 \xintFtoCx

```
\def\xintFtoCx {\romannumeral0\xintftocx }%
\def\xintftocx #1#2%
{%
    \expandafter\XINT_ftcx_A\romannumeral0\xintrawwithzeros {#2}\Z {#1}%
}%
\def\XINT_ftcx_A #1/#2\Z
{%
    \expandafter\XINT_ftcx_B\romannumeral0\xintiidivision {#1}{#2}{#2}%
}%
\def\XINT_ftcx_B #1#2%
{%
    \XINT_ftcx_C #2.{#1}%
}%
\def\XINT_ftcx_C #1%
{%
    \xint_gob_til_zero #1\XINT_ftcx_integer 0\XINT_ftcx_D #1%
}%
\def\XINT_ftcx_integer 0\XINT_ftcx_D 0#1.#2#3#4{ #2}%
\def\XINT_ftcx_D #1.#2#3#4{\XINT_ftcx_loop_a {#1}{#3}{#1}{{#2}#4}{#4}}%
\def\XINT_ftcx_loop_a
{%
    \expandafter\XINT_ftcx_loop_d\romannumeral0\XINT_div_prepare
}%
\def\XINT_ftcx_loop_d #1#2%
{%
    \XINT_ftcx_loop_e #2.{#1}%
}%
\def\XINT_ftcx_loop_e #1%
{%
    \xint_gob_til_zero #1\xint_ftcx_loop_exit0\XINT_ftcx_loop_f #1%
}%
\def\XINT_ftcx_loop_f #1.#2#3#4#5%
{%
    \XINT_ftcx_loop_a {#1}{#3}{#1}{#4{#2}#5}{#5}%
}%
\def\xint_ftcx_loop_exit0\XINT_ftcx_loop_f #1.#2#3#4#5{ #4{#2}}%
```

11.9 \xintFtoC

New in 1.09m: this is the same as \xintFtoCx with empty separator. I had temporarily during preparation of 1.09m removed braces from \xintFtoCx, but I recalled later why that was useful (see doc), thus let's just here do \xintFtoCx {}

```
\def\xintFtoC {\romannumeral0\xintftoc }%
```

```
\def\xintftoc {\xintftocx {}}%
```

11.10 \xintFtoGC

```
\def\xintFtoGC {\romannumeral0\xintftogc }%
\def\xintftogc {\xintftocx {+1/}}%
```

11.11 \xintFGtoC

New with 1.09m of 2014/02/26. Computes the common initial coefficients for the two fractions f and g, and outputs them as a sequence of braced items.

```
\def\xintFGtoC {\romannumeral0\xintfgtoc}%
\def\xintfgtoc#1%
{%
    \expandafter\XINT_fgtc_a\romannumeral0\xintrawwithzeros {#1}\Z
}%
\def\XINT_fgtc_a #1/#2\Z #3%
{%
    \expandafter\XINT_fgtc_b\romannumeral0\xintrawwithzeros {#3}\Z #1/#2\Z { }%
}%
\def\XINT_fgtc_b #1/#2\Z
{%
    \expandafter\XINT_fgtc_c\romannumeral0\xintiidivision {#1}{#2}{#2}%
}%
\def\XINT_fgtc_c #1#2#3#4/#5\Z
{%
    \expandafter\XINT_fgtc_d\romannumeral0\xintiidivision
                                              {#4}{#5}{#5}{#1}{#2}{#3}%
}%
\def\XINT_fgtc_d #1#2#3#4%#5#6#7%
{%
    \xintifEq {#1}{#4}{\XINT_fgtc_da {#1}{#2}{#3}{#4}}%
                      {\xint_thirdofthree}%
}%
\def\XINT_fgtc_da #1#2#3#4#5#6#7%
{%
     \XINT_fgtc_e {#2}{#5}{#3}{#6}{#7{#1}}%
}%
\def\XINT_fgtc_e #1%
{%
    \xintiiifZero {#1}{\expandafter\xint_firstofone\xint_gobble_iii}%
                    {\XINT_fgtc_f {#1}}%
}%
\def\XINT_fgtc_f #1#2%
{%
   \xintiiifZero {#2}{\xint_thirdofthree}{\XINT_fgtc_g {#1}{#2}}%
}%
\def\XINT_fgtc_g #1#2#3%
{%
    \expandafter\XINT_fgtc_h\romannumeral0\XINT_div_prepare {#1}{#3}{#1}{#2}%
}%
\def\XINT_fgtc_h #1#2#3#4#5%
{%
```

```
    \expandafter\XINT_fgtc_d\romannumeral0\XINT_div_prepare
                       {#4}{#5}{#4}{#1}{#2}{#3}%
}%
```

11.12 \xintFtoCC

```
\def\xintFtoCC {\romannumeral0\xintftocc }%
\def\xintftocc #1%
{%
    \expandafter\XINT_ftcc_A\expandafter {\romannumeral0\xintrawwithzeros {#1}}%
}%
\def\XINT_ftcc_A #1%
{%
    \expandafter\XINT_ftcc_B
    \romannumeral0\xintrawwithzeros {\xintAdd {1/2[0]}{#1[0]}}\Z {#1[0]}%
}%
\def\XINT_ftcc_B #1/#2\Z
{%
    \expandafter\XINT_ftcc_C\expandafter {\romannumeral0\xintiiquo {#1}{#2}}%
}%
\def\XINT_ftcc_C #1#2%
{%
    \expandafter\XINT_ftcc_D\romannumeral0\xintsub {#2}{#1}\Z {#1}%
}%
\def\XINT_ftcc_D #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_ftcc_integer
      0#1\XINT_ftcc_En
       0-{\XINT_ftcc_Ep #1}%
    \krof
}%
\def\XINT_ftcc_Ep #1\Z #2%
{%
    \expandafter\XINT_ftcc_loop_a\expandafter
    {\romannumeral0\xintdiv {1[0]}{#1}}{#2+1/}%
}%
\def\XINT_ftcc_En #1\Z #2%
{%
    \expandafter\XINT_ftcc_loop_a\expandafter
    {\romannumeral0\xintdiv {1[0]}{#1}}{#2+-1/}%
}%
\def\XINT_ftcc_integer #1\Z #2{ #2}%
\def\XINT_ftcc_loop_a #1%
{%
    \expandafter\XINT_ftcc_loop_b
    \romannumeral0\xintrawwithzeros {\xintAdd {1/2[0]}{#1}}\Z {#1}%
}%
\def\XINT_ftcc_loop_b #1/#2\Z
{%
    \expandafter\XINT_ftcc_loop_c\expandafter
    {\romannumeral0\xintiiquo {#1}{#2}}%
}%
```

```
\def\XINT_ftcc_loop_c #1#2%
{%
    \expandafter\XINT_ftcc_loop_d
    \romannumeral0\xintsub {#2}{#1[0]}\Z {#1}%
}%
\def\XINT_ftcc_loop_d #1%
{%
    \xint_UDzerominusfork
      #1-\XINT_ftcc_end
      0#1\XINT_ftcc_loop_N
       0-{\XINT_ftcc_loop_P #1}%
    \krof
}%
\def\XINT_ftcc_end #1\Z #2#3{ #3#2}%
\def\XINT_ftcc_loop_P #1\Z #2#3%
{%
    \expandafter\XINT_ftcc_loop_a\expandafter
    {\romannumeral0\xintdiv {1[0]}{#1}}{#3#2+1/}%
}%
\def\XINT_ftcc_loop_N #1\Z #2#3%
{%
    \expandafter\XINT_ftcc_loop_a\expandafter
    {\romannumeral0\xintdiv {1[0]}{#1}}{#3#2+-1/}%
}%
```

11.13 \xintCtoF, \xintCstoF

1.09m uses \xintCSVtoList on the argument of \xintCstoF to allow spaces also before the commas. And the original \xintCstoF code became the one of the new \xintCtoF dealing with a braced rather than comma separated list.

```
\def\xintCstoF {\romannumeral0\xintcstof }%
\def\xintcstof #1%
{%
    \expandafter\XINT_ctf_prep \romannumeral0\xintcsvtolist{#1}!%
}%
\def\xintCtoF {\romannumeral0\xintctof }%
\def\xintctof #1%
{%
    \expandafter\XINT_ctf_prep \romannumeral`&&@#1!%
}%
\def\XINT_ctf_prep
{%
    \XINT_ctf_loop_a 1001%
}%
\def\XINT_ctf_loop_a #1#2#3#4#5%
{%
    \xint_gob_til_exclam #5\XINT_ctf_end!%
    \expandafter\XINT_ctf_loop_b
    \romannumeral0\xintrawwithzeros {#5}.{#1}{#2}{#3}{#4}%
}%
\def\XINT_ctf_loop_b #1/#2.#3#4#5#6%
{%
```

```
    \expandafter\XINT_ctf_loop_c\expandafter
    {\romannumeral0\XINT_mul_fork #2\xint:#4\xint:}%
    {\romannumeral0\XINT_mul_fork #2\xint:#3\xint:}%
    {\romannumeral0\xintiiadd {\XINT_mul_fork #2\xint:#6\xint:}%
                              {\XINT_mul_fork #1\xint:#4\xint:}}%
    {\romannumeral0\xintiiadd {\XINT_mul_fork #2\xint:#5\xint:}%
                              {\XINT_mul_fork #1\xint:#3\xint:}}%
}%
\def\XINT_ctf_loop_c #1#2%
{%
    \expandafter\XINT_ctf_loop_d\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_ctf_loop_d #1#2%
{%
    \expandafter\XINT_ctf_loop_e\expandafter {\expandafter{#2}#1}%
}%
\def\XINT_ctf_loop_e #1#2%
{%
    \expandafter\XINT_ctf_loop_a\expandafter{#2}#1%
}%
\def\XINT_ctf_end #1.#2#3#4#5{\xintrawwithzeros {#2/#3}}% 1.09b removes [0]
```

11.14 \xintiCstoF

```
\def\xintiCstoF {\romannumeral0\xinticstof }%
\def\xinticstof #1%
{%
    \expandafter\XINT_icstf_prep \romannumeral`&&@#1,!,%
}%
\def\XINT_icstf_prep
{%
    \XINT_icstf_loop_a 1001%
}%
\def\XINT_icstf_loop_a #1#2#3#4#5,%
{%
    \xint_gob_til_exclam #5\XINT_icstf_end!%
    \expandafter
    \XINT_icstf_loop_b \romannumeral`&&@#5.{#1}{#2}{#3}{#4}%
}%
\def\XINT_icstf_loop_b #1.#2#3#4#5%
{%
    \expandafter\XINT_icstf_loop_c\expandafter
    {\romannumeral0\xintiiadd {#5}{\XINT_mul_fork #1\xint:#3\xint:}}%
    {\romannumeral0\xintiiadd {#4}{\XINT_mul_fork #1\xint:#2\xint:}}%
    {#2}{#3}%
}%
\def\XINT_icstf_loop_c #1#2%
{%
    \expandafter\XINT_icstf_loop_a\expandafter {#2}{#1}%
}%
\def\XINT_icstf_end#1.#2#3#4#5{\xintrawwithzeros {#2/#3}}% 1.09b removes [0]
```

11.15 \xintGCtoF

```
\def\xintGCtoF {\romannumeral0\xintgctof }%
\def\xintgctof #1%
{%
    \expandafter\XINT_gctf_prep \romannumeral`&&@#1+!/%
}%
\def\XINT_gctf_prep
{%
    \XINT_gctf_loop_a 1001%
}%
\def\XINT_gctf_loop_a #1#2#3#4#5+%
{%
    \expandafter\XINT_gctf_loop_b
    \romannumeral0\xintrawwithzeros {#5}.{#1}{#2}{#3}{#4}%
}%
\def\XINT_gctf_loop_b #1/#2.#3#4#5#6%
{%
    \expandafter\XINT_gctf_loop_c\expandafter
    {\romannumeral0\XINT_mul_fork #2\xint:#4\xint:}%
    {\romannumeral0\XINT_mul_fork #2\xint:#3\xint:}%
    {\romannumeral0\xintiiadd {\XINT_mul_fork #2\xint:#6\xint:}%
                              {\XINT_mul_fork #1\xint:#4\xint:}}%
    {\romannumeral0\xintiiadd {\XINT_mul_fork #2\xint:#5\xint:}%
                              {\XINT_mul_fork #1\xint:#3\xint:}}%
}%
\def\XINT_gctf_loop_c #1#2%
{%
    \expandafter\XINT_gctf_loop_d\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_gctf_loop_d #1#2%
{%
    \expandafter\XINT_gctf_loop_e\expandafter {\expandafter{#2}#1}%
}%
\def\XINT_gctf_loop_e #1#2%
{%
    \expandafter\XINT_gctf_loop_f\expandafter {\expandafter{#2}#1}%
}%
\def\XINT_gctf_loop_f #1#2/%
{%
    \xint_gob_til_exclam #2\XINT_gctf_end!%
    \expandafter\XINT_gctf_loop_g
    \romannumeral0\xintrawwithzeros {#2}.#1%
}%
\def\XINT_gctf_loop_g #1/#2.#3#4#5#6%
{%
    \expandafter\XINT_gctf_loop_h\expandafter
    {\romannumeral0\XINT_mul_fork #1\xint:#6\xint:}%
    {\romannumeral0\XINT_mul_fork #1\xint:#5\xint:}%
    {\romannumeral0\XINT_mul_fork #2\xint:#4\xint:}%
    {\romannumeral0\XINT_mul_fork #2\xint:#3\xint:}%
}%
\def\XINT_gctf_loop_h #1#2%
```

```
{%
    \expandafter\XINT_gctf_loop_i\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_gctf_loop_i #1#2%
{%
    \expandafter\XINT_gctf_loop_j\expandafter {\expandafter{#2}#1}%
}%
\def\XINT_gctf_loop_j #1#2%
{%
    \expandafter\XINT_gctf_loop_a\expandafter {#2}#1%
}%
\def\XINT_gctf_end #1.#2#3#4#5{\xintrawwithzeros {#2/#3}}% 1.09b removes [0]
```

11.16 \xintiGCtoF

```
\def\xintiGCtoF {\romannumeral0\xintigctof }%
\def\xintigctof #1%
{%
    \expandafter\XINT_igctf_prep \romannumeral`&&@#1+!/%
}%
\def\XINT_igctf_prep
{%
    \XINT_igctf_loop_a 1001%
}%
\def\XINT_igctf_loop_a #1#2#3#4#5+%
{%
    \expandafter\XINT_igctf_loop_b
    \romannumeral`&&@#5.{#1}{#2}{#3}{#4}%
}%
\def\XINT_igctf_loop_b #1.#2#3#4#5%
{%
    \expandafter\XINT_igctf_loop_c\expandafter
    {\romannumeral0\xintiiadd {#5}{\XINT_mul_fork #1\xint:#3\xint:}}%
    {\romannumeral0\xintiiadd {#4}{\XINT_mul_fork #1\xint:#2\xint:}}%
    {#2}{#3}%
}%
\def\XINT_igctf_loop_c #1#2%
{%
    \expandafter\XINT_igctf_loop_f\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_igctf_loop_f #1#2#3#4/%
{%
    \xint_gob_til_exclam #4\XINT_igctf_end!%
    \expandafter\XINT_igctf_loop_g
    \romannumeral`&&@#4.{#2}{#3}#1%
}%
\def\XINT_igctf_loop_g #1.#2#3%
{%
    \expandafter\XINT_igctf_loop_h\expandafter
    {\romannumeral0\XINT_mul_fork #1\xint:#3\xint:}%
    {\romannumeral0\XINT_mul_fork #1\xint:#2\xint:}%
}%
\def\XINT_igctf_loop_h #1#2%
```

```
{%
    \expandafter\XINT_igctf_loop_i\expandafter {#2}{#1}%
}%
\def\XINT_igctf_loop_i #1#2#3#4%
{%
    \XINT_igctf_loop_a {#3}{#4}{#1}{#2}%
}%
\def\XINT_igctf_end #1.#2#3#4#5{\xintrawwithzeros {#4/#5}}% 1.09b removes [0]
```

11.17 \xintCtoCv, \xintCstoCv

1.09m uses \xintCSVtoList on the argument of \xintCstoCv to allow spaces also before the commas. The original \xintCstoCv code became the one of the new \xintCtoF dealing with a braced rather than comma separated list.

```
\def\xintCstoCv {\romannumeral0\xintcstocv }%
\def\xintcstocv #1%
{%
    \expandafter\XINT_ctcv_prep\romannumeral0\xintcsvtolist{#1}!%
}%
\def\xintCtoCv {\romannumeral0\xintctocv }%
\def\xintctocv #1%
{%
    \expandafter\XINT_ctcv_prep\romannumeral`&&@#1!%
}%
\def\XINT_ctcv_prep
{%
    \XINT_ctcv_loop_a {}1001%
}%
\def\XINT_ctcv_loop_a #1#2#3#4#5#6%
{%
    \xint_gob_til_exclam #6\XINT_ctcv_end!%
    \expandafter\XINT_ctcv_loop_b
    \romannumeral0\xintrawwithzeros {#6}.{#2}{#3}{#4}{#5}{#1}%
}%
\def\XINT_ctcv_loop_b #1/#2.#3#4#5#6%
{%
    \expandafter\XINT_ctcv_loop_c\expandafter
    {\romannumeral0\XINT_mul_fork #2\xint:#4\xint:}%
    {\romannumeral0\XINT_mul_fork #2\xint:#3\xint:}%
    {\romannumeral0\xintiiadd {\XINT_mul_fork #2\xint:#6\xint:}%
                              {\XINT_mul_fork #1\xint:#4\xint:}}%
    {\romannumeral0\xintiiadd {\XINT_mul_fork #2\xint:#5\xint:}%
                              {\XINT_mul_fork #1\xint:#3\xint:}}%
}%
\def\XINT_ctcv_loop_c #1#2%
{%
    \expandafter\XINT_ctcv_loop_d\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_ctcv_loop_d #1#2%
{%
    \expandafter\XINT_ctcv_loop_e\expandafter {\expandafter{#2}#1}%
}%
```

```
\def\XINT_ctcv_loop_e #1#2%
{%
    \expandafter\XINT_ctcv_loop_f\expandafter{#2}#1%
}%
\def\XINT_ctcv_loop_f #1#2#3#4#5%
{%
    \expandafter\XINT_ctcv_loop_g\expandafter
    {\romannumeral0\xintrawwithzeros {#1/#2}}{#5}{#1}{#2}{#3}{#4}%
}%
\def\XINT_ctcv_loop_g #1#2{\XINT_ctcv_loop_a {#2{#1}}}% 1.09b removes [0]
\def\XINT_ctcv_end #1.#2#3#4#5#6{ #6}%
```

11.18 \xintiCstoCv

```
\def\xintiCstoCv {\romannumeral0\xinticstocv }%
\def\xinticstocv #1%
{%
    \expandafter\XINT_icstcv_prep \romannumeral`&&@#1,!,%
}%
\def\XINT_icstcv_prep
{%
    \XINT_icstcv_loop_a {}1001%
}%
\def\XINT_icstcv_loop_a #1#2#3#4#5#6,%
{%
    \xint_gob_til_exclam #6\XINT_icstcv_end!%
    \expandafter
    \XINT_icstcv_loop_b \romannumeral`&&@#6.{#2}{#3}{#4}{#5}{#1}%
}%
\def\XINT_icstcv_loop_b #1.#2#3#4#5%
{%
    \expandafter\XINT_icstcv_loop_c\expandafter
    {\romannumeral0\xintiiadd {#5}{\XINT_mul_fork #1\xint:#3\xint:}}%
    {\romannumeral0\xintiiadd {#4}{\XINT_mul_fork #1\xint:#2\xint:}}%
    {{#2}{#3}}%
}%
\def\XINT_icstcv_loop_c #1#2%
{%
    \expandafter\XINT_icstcv_loop_d\expandafter {#2}{#1}%
}%
\def\XINT_icstcv_loop_d #1#2%
{%
    \expandafter\XINT_icstcv_loop_e\expandafter
    {\romannumeral0\xintrawwithzeros {#1/#2}}{{#1}{#2}}%
}%
\def\XINT_icstcv_loop_e #1#2#3#4{\XINT_icstcv_loop_a {#4{#1}}#2#3}%
\def\XINT_icstcv_end #1.#2#3#4#5#6{ #6}%  1.09b removes [0]
```

11.19 \xintGCtoCv

```
\def\xintGCtoCv {\romannumeral0\xintgctocv }%
\def\xintgctocv #1%
{%
```

```
    \expandafter\XINT_gctcv_prep \romannumeral`&&@#1+!/%
}%
\def\XINT_gctcv_prep
{%
    \XINT_gctcv_loop_a {}1001%
}%
\def\XINT_gctcv_loop_a #1#2#3#4#5#6+%
{%
    \expandafter\XINT_gctcv_loop_b
    \romannumeral0\xintrawwithzeros {#6}.{#2}{#3}{#4}{#5}{#1}%
}%
\def\XINT_gctcv_loop_b #1/#2.#3#4#5#6%
{%
    \expandafter\XINT_gctcv_loop_c\expandafter
    {\romannumeral0\XINT_mul_fork #2\xint:#4\xint:}%
    {\romannumeral0\XINT_mul_fork #2\xint:#3\xint:}%
    {\romannumeral0\xintiiadd {\XINT_mul_fork #2\xint:#6\xint:}%
                              {\XINT_mul_fork #1\xint:#4\xint:}}%
    {\romannumeral0\xintiiadd {\XINT_mul_fork #2\xint:#5\xint:}%
                              {\XINT_mul_fork #1\xint:#3\xint:}}%
}%
\def\XINT_gctcv_loop_c #1#2%
{%
    \expandafter\XINT_gctcv_loop_d\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_gctcv_loop_d #1#2%
{%
    \expandafter\XINT_gctcv_loop_e\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_gctcv_loop_e #1#2%
{%
    \expandafter\XINT_gctcv_loop_f\expandafter {#2}#1%
}%
\def\XINT_gctcv_loop_f #1#2%
{%
    \expandafter\XINT_gctcv_loop_g\expandafter
    {\romannumeral0\xintrawwithzeros {#1/#2}}{{#1}{#2}}%
}%
\def\XINT_gctcv_loop_g #1#2#3#4%
{%
    \XINT_gctcv_loop_h {#4{#1}}{#2#3}% 1.09b removes [0]
}%
\def\XINT_gctcv_loop_h #1#2#3/%
{%
    \xint_gob_til_exclam #3\XINT_gctcv_end!%
    \expandafter\XINT_gctcv_loop_i
    \romannumeral0\xintrawwithzeros {#3}.#2{#1}%
}%
\def\XINT_gctcv_loop_i #1/#2.#3#4#5#6%
{%
    \expandafter\XINT_gctcv_loop_j\expandafter
    {\romannumeral0\XINT_mul_fork #1\xint:#6\xint:}%
```

```
    {\romannumeral0\XINT_mul_fork #1\xint:#5\xint:}%
    {\romannumeral0\XINT_mul_fork #2\xint:#4\xint:}%
    {\romannumeral0\XINT_mul_fork #2\xint:#3\xint:}%
}%
\def\XINT_gctcv_loop_j #1#2%
{%
    \expandafter\XINT_gctcv_loop_k\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_gctcv_loop_k #1#2%
{%
    \expandafter\XINT_gctcv_loop_l\expandafter {\expandafter{#2}#1}%
}%
\def\XINT_gctcv_loop_l #1#2%
{%
    \expandafter\XINT_gctcv_loop_m\expandafter {\expandafter{#2}#1}%
}%
\def\XINT_gctcv_loop_m #1#2{\XINT_gctcv_loop_a {#2}#1}%
\def\XINT_gctcv_end #1.#2#3#4#5#6{ #6}%
```

11.20 \xintiGCtoCv

```
\def\xintiGCtoCv {\romannumeral0\xintigctocv }%
\def\xintigctocv #1%
{%
    \expandafter\XINT_igctcv_prep \romannumeral`&&@#1+!/%
}%
\def\XINT_igctcv_prep
{%
    \XINT_igctcv_loop_a {}1001%
}%
\def\XINT_igctcv_loop_a #1#2#3#4#5#6+%
{%
    \expandafter\XINT_igctcv_loop_b
    \romannumeral`&&@#6.{#2}{#3}{#4}{#5}{#1}%
}%
\def\XINT_igctcv_loop_b #1.#2#3#4#5%
{%
    \expandafter\XINT_igctcv_loop_c\expandafter
    {\romannumeral0\xintiiadd {#5}{\XINT_mul_fork #1\xint:#3\xint:}}%
    {\romannumeral0\xintiiadd {#4}{\XINT_mul_fork #1\xint:#2\xint:}}%
    {{#2}{#3}}%
}%
\def\XINT_igctcv_loop_c #1#2%
{%
    \expandafter\XINT_igctcv_loop_f\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_igctcv_loop_f #1#2#3#4/%
{%
    \xint_gob_til_exclam #4\XINT_igctcv_end_a!%
    \expandafter\XINT_igctcv_loop_g
    \romannumeral`&&@#4.#1#2{#3}%
}%
\def\XINT_igctcv_loop_g #1.#2#3#4#5%
```

```
{%
    \expandafter\XINT_igctcv_loop_h\expandafter
    {\romannumeral0\XINT_mul_fork #1\xint:#5\xint:}%
    {\romannumeral0\XINT_mul_fork #1\xint:#4\xint:}%
    {{#2}{#3}}%
}%
\def\XINT_igctcv_loop_h #1#2%
{%
    \expandafter\XINT_igctcv_loop_i\expandafter {\expandafter{#2}{#1}}%
}%
\def\XINT_igctcv_loop_i #1#2{\XINT_igctcv_loop_k #2{#2#1}}%
\def\XINT_igctcv_loop_k #1#2%
{%
    \expandafter\XINT_igctcv_loop_l\expandafter
    {\romannumeral0\xintrawwithzeros {#1/#2}}%
}%
\def\XINT_igctcv_loop_l #1#2#3{\XINT_igctcv_loop_a {#3{#1}}#2}%1.09i removes [0]
\def\XINT_igctcv_end_a #1.#2#3#4#5%
{%
    \expandafter\XINT_igctcv_end_b\expandafter
    {\romannumeral0\xintrawwithzeros {#2/#3}}%
}%
\def\XINT_igctcv_end_b #1#2{ #2{#1}}% 1.09b removes [0]
```

11.21 \xintFtoCv

Still uses \xinticstocv \xintFtoCs rather than \xintctocv \xintFtoC.

```
\def\xintFtoCv {\romannumeral0\xintftocv }%
\def\xintftocv #1%
{%
    \xinticstocv {\xintFtoCs {#1}}%
}%
```

11.22 \xintFtoCCv

```
\def\xintFtoCCv {\romannumeral0\xintftoccv }%
\def\xintftoccv #1%
{%
    \xintigctocv {\xintFtoCC {#1}}%
}%
```

11.23 \xintCntoF

Modified in 1.06 to give the N first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

```
\def\xintCntoF {\romannumeral0\xintcntof }%
\def\xintcntof #1%
{%
    \expandafter\XINT_cntf\expandafter {\the\numexpr #1}%
}%
\def\XINT_cntf #1#2%
{%
```

```
  \ifnum #1>\xint_c_
     \xint_afterfi {\expandafter\XINT_cntf_loop\expandafter
                    {\the\numexpr #1-1\expandafter}\expandafter
                    {\romannumeral`&&@#2{#1}}{#2}}%
  \else
     \xint_afterfi
        {\ifnum #1=\xint_c_
             \xint_afterfi {\expandafter\space \romannumeral`&&@#2{0}}%
         \else \xint_afterfi { }% 1.09m now returns nothing.
         \fi}%
  \fi
}%
\def\XINT_cntf_loop #1#2#3%
{%
    \ifnum #1>\xint_c_ \else \XINT_cntf_exit \fi
    \expandafter\XINT_cntf_loop\expandafter
    {\the\numexpr #1-1\expandafter }\expandafter
    {\romannumeral0\xintadd {\xintDiv {1[0]}{#2}}{#3{#1}}}%
    {#3}%
}%
\def\XINT_cntf_exit \fi
    \expandafter\XINT_cntf_loop\expandafter
    #1\expandafter #2#3%
{%
    \fi\xint_gobble_ii #2%
}%
```

11.24 \xintGCntoF

Modified in 1.06 to give the N argument first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

```
\def\xintGCntoF {\romannumeral0\xintgcntof }%
\def\xintgcntof #1%
{%
    \expandafter\XINT_gcntf\expandafter {\the\numexpr #1}%
}%
\def\XINT_gcntf #1#2#3%
{%
  \ifnum #1>\xint_c_
     \xint_afterfi {\expandafter\XINT_gcntf_loop\expandafter
                    {\the\numexpr #1-1\expandafter}\expandafter
                    {\romannumeral`&&@#2{#1}}{#2}{#3}}%
  \else
     \xint_afterfi
        {\ifnum #1=\xint_c_
             \xint_afterfi {\expandafter\space\romannumeral`&&@#2{0}}%
         \else \xint_afterfi { }% 1.09m now returns nothing rather than 0/1[0]
         \fi}%
  \fi
}%
\def\XINT_gcntf_loop #1#2#3#4%
{%
```

```
    \ifnum #1>\xint_c_ \else \XINT_gcntf_exit \fi
    \expandafter\XINT_gcntf_loop\expandafter
    {\the\numexpr #1-1\expandafter }\expandafter
    {\romannumeral0\xintadd {\xintDiv {#4{#1}}{#2}}{#3{#1}}}%
    {#3}{#4}%
}%
\def\XINT_gcntf_exit \fi
    \expandafter\XINT_gcntf_loop\expandafter
    #1\expandafter #2#3#4%
{%
    \fi\xint_gobble_ii #2%
}%
```

11.25 \xintCntoCs

Modified in 1.09m: added spaces after the commas in the produced list. Moreover the coefficients are not braced anymore. A slight induced limitation is that the macro argument should not contain some explicit comma (cf. \XINT_cntcs_exit_b), hence \xintCntoCs {\macro,} with \def\macro,#1{<stuff>} would crash. Not a very serious limitation, I believe.

```
\def\xintCntoCs {\romannumeral0\xintcntocs }%
\def\xintcntocs #1%
{%
    \expandafter\XINT_cntcs\expandafter {\the\numexpr #1}%
}%
\def\XINT_cntcs #1#2%
{%
   \ifnum #1<0
      \xint_afterfi { }% 1.09i: a 0/1[0] was here, now the macro returns nothing
   \else
      \xint_afterfi {\expandafter\XINT_cntcs_loop\expandafter
                     {\the\numexpr #1-\xint_c_i\expandafter}\expandafter
                     {\romannumeral`&&@#2{#1}}{#2}}% produced coeff not braced
   \fi
}%
\def\XINT_cntcs_loop #1#2#3%
{%
    \ifnum #1>-\xint_c_i \else \XINT_cntcs_exit \fi
    \expandafter\XINT_cntcs_loop\expandafter
    {\the\numexpr #1-\xint_c_i\expandafter}\expandafter
    {\romannumeral`&&@#3{#1}, #2}{#3}% space added, 1.09m
}%
\def\XINT_cntcs_exit \fi
    \expandafter\XINT_cntcs_loop\expandafter
    #1\expandafter #2#3%
{%
    \fi\XINT_cntcs_exit_b #2%
}%
\def\XINT_cntcs_exit_b #1,{}% romannumeral stopping space already there
```

11.26 \xintCntoGC

Modified in 1.06 to give the N first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

1.09m maintains the braces, as the coeff are allowed to be fraction and the slash can not be naked in the GC format, contrarily to what happens in \xintCntoCs. Also the separators given to \xintGCtoGCx may then fetch the coefficients as argument, as they are braced.

```
\def\xintCntoGC {\romannumeral0\xintcntogc }%
\def\xintcntogc #1%
{%
    \expandafter\XINT_cntgc\expandafter {\the\numexpr #1}%
}%
\def\XINT_cntgc #1#2%
{%
   \ifnum #1<0
      \xint_afterfi { }% 1.09i there was as strange 0/1[0] here, removed
   \else
      \xint_afterfi {\expandafter\XINT_cntgc_loop\expandafter
                     {\the\numexpr #1-\xint_c_i\expandafter}\expandafter
                     {\expandafter{\romannumeral`&&@#2{#1}}}{#2}}%
   \fi
}%
\def\XINT_cntgc_loop #1#2#3%
{%
    \ifnum #1>-\xint_c_i \else \XINT_cntgc_exit \fi
    \expandafter\XINT_cntgc_loop\expandafter
    {\the\numexpr #1-\xint_c_i\expandafter }\expandafter
    {\expandafter{\romannumeral`&&@#3{#1}}+1/#2}{#3}%
}%
\def\XINT_cntgc_exit \fi
    \expandafter\XINT_cntgc_loop\expandafter
    #1\expandafter #2#3%
{%
    \fi\XINT_cntgc_exit_b #2%
}%
\def\XINT_cntgc_exit_b #1+1/{ }%
```

11.27 \xintGCntoGC

Modified in 1.06 to give the N first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

```
\def\xintGCntoGC {\romannumeral0\xintgcntogc }%
\def\xintgcntogc #1%
{%
    \expandafter\XINT_gcntgc\expandafter {\the\numexpr #1}%
}%
\def\XINT_gcntgc #1#2#3%
{%
   \ifnum #1<0
      \xint_afterfi { }% 1.09i now returns nothing
   \else
      \xint_afterfi {\expandafter\XINT_gcntgc_loop\expandafter
                     {\the\numexpr #1-\xint_c_i\expandafter}\expandafter
                     {\expandafter{\romannumeral`&&@#2{#1}}}{#2}{#3}}%
   \fi
}%
```

```
\def\XINT_gcntgc_loop #1#2#3#4%
{%
    \ifnum #1>-\xint_c_i \else \XINT_gcntgc_exit \fi
    \expandafter\XINT_gcntgc_loop_b\expandafter
    {\expandafter{\romannumeral`&&@#4{#1}}/#2}{#3{#1}}{#1}{#3}{#4}%
}%
\def\XINT_gcntgc_loop_b #1#2#3%
{%
    \expandafter\XINT_gcntgc_loop\expandafter
    {\the\numexpr #3-\xint_c_i \expandafter}\expandafter
    {\expandafter{\romannumeral`&&@#2}+#1}%
}%
\def\XINT_gcntgc_exit \fi
    \expandafter\XINT_gcntgc_loop_b\expandafter #1#2#3#4#5%
{%
    \fi\XINT_gcntgc_exit_b #1%
}%
\def\XINT_gcntgc_exit_b #1/{ }%
```

11.28 \xintCstoGC

```
\def\xintCstoGC {\romannumeral0\xintcstogc }%
\def\xintcstogc #1%
{%
    \expandafter\XINT_cstc_prep \romannumeral`&&@#1,!,%
}%
\def\XINT_cstc_prep #1,{\XINT_cstc_loop_a {{#1}}}%
\def\XINT_cstc_loop_a #1#2,%
{%
    \xint_gob_til_exclam #2\XINT_cstc_end!%
    \XINT_cstc_loop_b {#1}{#2}%
}%
\def\XINT_cstc_loop_b #1#2{\XINT_cstc_loop_a {#1+1/{#2}}}%
\def\XINT_cstc_end!\XINT_cstc_loop_b #1#2{ #1}%
```

11.29 \xintGCtoGC

```
\def\xintGCtoGC {\romannumeral0\xintgctogc }%
\def\xintgctogc #1%
{%
    \expandafter\XINT_gctgc_start \romannumeral`&&@#1+!/%
}%
\def\XINT_gctgc_start {\XINT_gctgc_loop_a {}}%
\def\XINT_gctgc_loop_a #1#2+#3/%
{%
    \xint_gob_til_exclam #3\XINT_gctgc_end!%
    \expandafter\XINT_gctgc_loop_b\expandafter
    {\romannumeral`&&@#2}{#3}{#1}%
}%
\def\XINT_gctgc_loop_b #1#2%
{%
    \expandafter\XINT_gctgc_loop_c\expandafter
    {\romannumeral`&&@#2}{#1}%
```

```
}%
\def\XINT_gctgc_loop_c #1#2#3%
{%
    \XINT_gctgc_loop_a {#3{#2}+{#1}/}%
}%
\def\XINT_gctgc_end!\expandafter\XINT_gctgc_loop_b
{%
    \expandafter\XINT_gctgc_end_b
}%
\def\XINT_gctgc_end_b #1#2#3{ #3{#1}}%
\XINTrestorecatcodesendinput%
```

12 Package xintexpr implementation

This is release 1.4m of 2022/06/10.

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12.1 READ ME! Important warnings and explanations relative to the status of the code source at the time of the 1.4 release

At release 1.4 the csname encapsulation of intermediate evaluations during parsing of expressions is dropped, and xintexpr requires the \expanded primitive. This means that there is no more impact on the string pool. And as internal storage now uses simply core \TeX{} syntax with braces rather than comma separated items inside a csname dummy control sequence, it became much easier to let the [...] syntax be associated to a true internal type of «tuple» or «list».

The output of \xintexpr (after \romannumeral0 or \romannumeral-`0 triggered expansion or double expansion) is thus modified at 1.4. It now looks like this:

\XINTfstop \XINTexprprint .{{<number>}} in simplest case

\XINTfstop \XINTexprprint .{{...}...{...}} in general case

where ... stands for nested braces ultimately ending in {<num. rep.>} leaves. The <num. rep.> stands for some internal representation of numeric data. It may be empty, and currently as well as probably in future uses only catcode 12 tokens (no spaces currently).

{{}} corresponds (in input as in output) to []. The external TeX braces also serve as set-theoretical braces. The comma is concatenation, so for example [], [] will become {{}{}}, or rather {}{} if sub-unit of something else.

The associated vocabulary is explained in the user manual and we avoid too much duplication here. xintfrac numerical macros receiving an empty argument usually handle it as being 0, but this is not the case of the xintcore macros supporting \xintiiexpr, they usually break if exercised on some empty argument.

The above expansion result \XINTfstop \XINTexprprint .{{<num1>}{<num2}...} uses only normal catcodes: the backslash, regular braces, and catcode 12 characters. Scientific notation is internally converted to raw xintfrac representation [N].

Additional data may be located before the dot; this is the case only for \xintfloatexpr currently. As xintexpr actually defines three parsers \xintexpr, \xintiiexpr and \xintfloatexpr but tries to share as much code as possible, some overhead is induced to fit all into the same mold.

\XINTfstop stops \romannumeral-`0 (or 0) type spanned expansion, and is invariant under \edef, but simply disappears in typesetting context. It is thus now legal to use \xintexpr directly in typesetting flow.

\XINTexprprint is \protected.

The f-expansion of an \xintexpr <expression>\relax is a complete expansion, i.e. one whose result remains invariant under \edef. But if exposed to finitely many expansion steps (at least two) there is a «blinking» \noexpand upfront depending on parity of number of steps.

\xintthe\xintexpr <expression>\relax or \xinteval{<expression>} serve as formerly to deliver the explicit digits, or more exactly some prettifying view of the actual <internal number representation>.

Nested contents like this

{{1}{{2}{3}{{4}{5}{6}}}{9}}

will get delivered using nested square brackets like that

1, [2, 3, [4, 5, 6]], 9

and as conversely \xintexpr 1, [2, 3, [4, 5, 6]], 9\relax expands to

\XINTfstop \XINTexprprint .{{1}{{2}{3}{{4}{5}{6}}}{9}}

we obtain the gratifying result that

\xinteval{1, [2, 3, [4, 5, 6]], 9}

expands to

1, [2, 3, [4, 5, 6]], 9

See user manual for explanations on the plasticity of \xintexpr syntax regarding functions with multiple arguments, and the 1.4 «unpacking» Python-like * prefix operator.

> I have suppressed (from the public dtx) many big chunks of comments. Some became obsolete and need to be updated, others are currently of value only to the author as a historical record.
>
> ATTENTION! As the removal process itself took too much time, I ended up leaving as is many comments which are obsoleted and wrong to various degrees after the 1.4 release. Precedence levels of operators have all been doubled to make room for new constructs
>
> Even comments added during 1.4 developement may now be obsolete because the preparation of 1.4 took a few weeks and that's enough of duration to provide the author many chances to contradict in the code what has been already commented upon.
>
> Thus don't believe (fully) anything which is said here!

Warning: in text below and also in left-over old comments I may refer to «until» and «op» macros; due to the change of data storage at 1.4, I needed to refactor a bit the way expansion is controlled, and the situation now is mainly governed by «op», «exec», «check-» and «checkp» macros the latter three replacing the two «until_a» and «until_b» of former code. This allows to diminish the number of times an accumulated result will be grabbed in order to propagate expansion to its right. Formerly this was not an issue because such things were only a single token! I do not describe here how this is all articulated but it is not hard to see it from the code (the hardest thing in all such matter was in 2013 to actually write how the expansion would be initially launched because to do that one basically has to understand the mechanism in its whole and such things are not easy to develop piecemeal). Another thing to keep in mind is that operators in truth have a left precedence (i.e. the precedence they show to operators arising earlier) and a right precedence (which determines how they react to operators coming after them from the right). Only the first one is usually encapsulated in a chardef, the second one is most of the times identical to the first one and if not it is only virtual but implemented via \ifcase of \ifnum branching. A final remark is that some things are achieved by special «op» macros, which are a favorite tool to hack into the normal regular flow of things, via injection of special syntax elements. I did not rename these macros for avoiding too large git diffs, and besides the nice thing is that the 1.4 refactoring minimally had to modify them, and all hacky things using them kept on working with not a single modification. And a post-scriptum is that advanced features crucially exploit injecting sub-\xintexpr-essions, as all is expandable there is no real «context» (only a minimal one) which one would have to perhaps store and restore and doing this sub-expression injection is rather cheap and efficient operation.

12.2 Old comments

These general comments were last updated at the end of the 1.09x series in 2014. The principles remain in place to this day but refer to CHANGES.html for some significant evolutions since.

The first version was released in June 2013. I was greatly helped in this task of writing an expandable parser of infix operations by the comments provided in l3fp-parse.dtx (in its version as available in April-May 2013). One will recognize in particular the idea of the `until' macros; I have not looked into the actual l3fp code beyond the very useful comments provided in its documentation.

A main worry was that my data has no a priori bound on its size; to keep the code reasonably efficient, I experimented with a technique of storing and retrieving data expandably as *names* of control sequences. Intermediate computation results are stored as control sequences \.=a/b[n].

Roughly speaking, the parser mechanism is as follows: at any given time the last found ``operator'' has its associated until macro awaiting some news from the token flow; first getnext expands forward in the hope to construct some number, which may come from a parenthesized sub-expression, from some braced material, or from a digit by digit scan. After this number has been formed the next operator is looked for by the getop macro. Once getop has finished its job, until is presented with three tokens: the first one is the precedence level of the new found operator (which may be an end of expression marker), the second is the operator character token (earlier versions had here already some macro name, but in order to keep as much common code to expr and floatexpr common as possible, this was modified) of the new found operator, and the third one is the newly found number (which was encountered just before the new operator).

The until macro of the earlier operator examines the precedence level of the new found one, and either executes the earlier operator (in the case of a binary operation, with the found number and a previously stored one) or it delays execution, giving the hand to the until macro of the operator having been found of higher precedence.

A minus sign acting as prefix gets converted into a (unary) operator inheriting the precedence level of the previous operator.

Once the end of the expression is found (it has to be marked by a \relax) the final result is output as four tokens (five tokens since 1.09j) the first one a catcode 11 exclamation mark, the second one an error generating macro, the third one is a protection mechanism, the fourth one a printing macro and the fifth is \.=a/b[n]. The prefix \xintthe makes the output printable by killing the first three tokens.

12.3 Catcodes, ε-TEX and reload detection

The code for reload detection was initially copied from Heiko Oberdiek's packages, then modified.

The method for catcodes was also initially directly inspired by these packages.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5     % ^^M
  \endlinechar=13 %
  \catcode123=1    % {
  \catcode125=2    % }
  \catcode64=11    % @
  \catcode44=12    % ,
  \catcode46=12    % .
  \catcode58=12    % :
  \catcode94=7     % ^
  \def\empty{}\def\space{ }\newlinechar10
  \def\z{\endgroup}%
  \expandafter\let\expandafter\x\csname ver@xintexpr.sty\endcsname
  \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
  \expandafter\let\expandafter\t\csname ver@xinttools.sty\endcsname
```

```
 % I don't think engine exists providing \expanded but not \numexpr
 \expandafter\ifx\csname expanded\endcsname\relax
   \expandafter\ifx\csname PackageWarningNoLine\endcsname\relax
     \immediate\write128{^^JPackage xintexpr Warning:^^J%
                         \space\space\space\space
                         \expanded not available, aborting input.^^J}%
   \else
     \PackageWarningNoLine{xintexpr}{\expanded not available, aborting input}%
   \fi
   \def\z{\endgroup\endinput}%
 \else
   \ifx\x\relax   % plain-TeX (possibly with miniltx!), first loading of xintexpr.sty
     \ifx\w\relax % but xintfrac.sty not yet loaded (made miniltx robust 2022/06/09)
        \expandafter\def\expandafter\z\expandafter
                   {\z\input xintfrac.sty\relax}%
     \fi
     \ifx\t\relax % but xinttools.sty not yet loaded.
        \expandafter\def\expandafter\z\expandafter
                   {\z\input xinttools.sty\relax}%
     \fi
   \else
     \ifx\x\empty % LaTeX, first loading,
     % variable is initialized, but \ProvidesPackage not yet seen
         \ifx\w\relax % xintfrac.sty not yet loaded.
           \expandafter\def\expandafter\z\expandafter
                         {\z\RequirePackage{xintfrac}}%
         \fi
         \ifx\t\relax % xinttools.sty not yet loaded.
           \expandafter\def\expandafter\z\expandafter
                         {\z\RequirePackage{xinttools}}%
         \fi
     \else
       \def\z{\endgroup\endinput}% xintexpr already loaded.
     \fi
   \fi
 \fi
\z%
\XINTsetupcatcodes%
```

12.4 Package identification

\XINT_Cmp alias for \xintiiCmp needed for some forgotten reason related to \xintNewExpr (FIX THIS!)

```
\XINT_providespackage
\ProvidesPackage{xintexpr}%
  [2022/06/10 v1.4m Expandable expression parser (JFB)]%
\catcode`! 11
\let\XINT_Cmp \xintiiCmp
\def\XINTfstop{\noexpand\XINTfstop}%
```

12.5 \xintDigits*, \xintSetDigits*, \xintreloadscilibs

1.3f. 1.4e added some \xintGuardDigits and \XINTdigitsx mechanism but it was finally removed, due to pending issues of user interface, functionality, and documentation (the worst part) for whose resolution no time was left.

```
\def\xintreloadscilibs{\xintreloadxintlog\xintreloadxinttrig}%
\def\xintDigits {\futurelet\XINT_token\xintDigits_i}%
\def\xintDigits_i#1={\afterassignment\xintDigits_j\mathchardef\XINT_digits=}%
\def\xintDigits_j#1%
{%
    \let\XINTdigits=\XINT_digits
    \ifx*\XINT_token\expandafter\xintreloadscilibs\fi
}%
\let\xintfracSetDigits\xintSetDigits
\def\xintSetDigits#1#{\if\relax\detokenize{#1}\relax\expandafter\xintfracSetDigits
                      \else\expandafter\xintSetDigits_a\fi}%
\def\xintSetDigits_a#1%
{%
    \mathchardef\XINT_digits=\numexpr#1\relax
    \let\XINTdigits\XINT_digits
    \xintreloadscilibs
}%
```

12.6 \XINTdigitsormax

1.4f. To not let xintlog and xinttrig work with, and produce, long mantissas exceeeding the supported range for accuracy of the math functions. The official maximal value is 62, let's set the cut-off at 64.

A priori, no need for \expandafter, always ends up expanded in \numexpr (I saw also in an \edef in xinttrig as argument to \xintReplicate prior to its \numexpr).

```
\def\XINTdigitsormax{\ifnum\XINTdigits>\xint_c_ii^vi\xint_c_ii^vi\else\XINTdigits\fi}%
```

12.7 Support for output and transform of nested braced contents as core data type

New at 1.4, of course. The former \csname.=...\endcsname encapsulation technique made very difficult implementation of nested structures.

12.7.1 Bracketed list rendering with prettifying of leaves from nested braced contents

Added at 1.4 (2020/01/31). The braces in \XINT:expr:toblistwith are there because there is an \expanded trigger.

Modified at 1.4d (2021/03/29). Add support for the polexpr 0.8 polynomial type. See \XINT:expr:toblist_a.

Modified at 1.4l (2022/05/29). Let \XINT:expr:toblist_b use #1{#2} with regular { and } in case macro #1 is \protected and things are output to external file where former #1<#2> would end up with catcode 12 < and >.

```
\def\XINT:expr:toblistwith#1#2%
{%
    {\expandafter\XINT:expr:toblist_checkempty
     \expanded{\noexpand#1!\expandafter}\detokenize{#2}^}%
}%
```

```
\def\XINT:expr:toblist_checkempty #1!#2%
{%
    \if ^#2\expandafter\xint_gob_til_^\else\expandafter\XINT:expr:toblist_a\fi
    #1!#2%
}%
\catcode`< 1 \catcode`> 2 \catcode`{ 12 \catcode`} 12
\def\XINT:expr:toblist_a #1{#2%
<%
    \if{#2\xint_dothis<[\XINT:expr:toblist_a>\fi
    \if P#2\xint_dothis<\XINT:expr:toblist_pol>\fi
    \xint_orthat\XINT:expr:toblist_b #1#2%
>%
\def\XINT:expr:toblist_pol #1!#2.{#3}}%
<%
    pol([\XINT:expr:toblist_b #1!#3}^])\XINT:expr:toblist_c #1!}%
>%
\catcode`{ 1 \catcode`} 2
\def\XINT:expr:toblist_b #1{%
\def\XINT:expr:toblist_b ##1!##2#1%
{%
    \if\relax##2\relax\xintexprEmptyItem\else##1{##2}\fi\XINT:expr:toblist_c ##1!#1%
}}\catcode`{ 12 \catcode`} 12 \XINT:expr:toblist_b<}>%
\def\XINT:expr:toblist_c #1}#2%
<%
    \if ^#2\xint_dothis<\xint_gob_til_^>\fi
    \if{#2\xint_dothis<, \XINT:expr:toblist_a>\fi
    \xint_orthat<]\XINT:expr:toblist_c>#1#2%
>%
\catcode`{ 1 \catcode`} 2 \catcode`< 12 \catcode`> 12
```

12.7.2 Flattening nested braced contents

1.4b I hesitated whether using this technique or some variation of the method of the ListSel macros. I chose this one which I downscaled from toblistwith, I will revisit later. I only have a few minutes right now.

Call form is \expanded\XINT:expr:flatten

See \XINT_expr_func_flat. I hesitated with «flattened», but short names are faster parsed.

```
\def\XINT:expr:flatten#1%
{%
   {{\expandafter\XINT:expr:flatten_checkempty\detokenize{#1}^}}%
}%
\def\XINT:expr:flatten_checkempty #1%
{%
    \if ^#1\expandafter\xint_gobble_i\else\expandafter\XINT:expr:flatten_a\fi
    #1%
}%
\begingroup
\catcode`[ 1 \catcode`] 2 \lccode`[`{ \lccode`]`}
\catcode`< 1 \catcode`> 2 \catcode`{ 12 \catcode`} 12
\lowercase<\endgroup
\def\XINT:expr:flatten_a {#1%
<%
    \if{#1\xint_dothis<\XINT:expr:flatten_a>\fi
```

```
    \xint_orthat\XINT:expr:flatten_b #1%
>%
\def\XINT:expr:flatten_b #1}%
<%
    [#1]\XINT:expr:flatten_c }%
>%
\def\XINT:expr:flatten_c }#1%
<%
    \if ^#1\xint_dothis<\xint_gobble_i>\fi
    \if{#1\xint_dothis<\XINT:expr:flatten_a>\fi
    \xint_orthat<\XINT:expr:flatten_c>#1%
>%
>% back to normal catcodes
```

12.7.3 Braced contents rendering via a TEX alignment with prettifying of leaves

1.4.

Breaking change at 1.4a as helper macros were renamed and their meanings refactored: no more \xintexpraligntab nor \xintexpralignninnercomma or \xintexpralignoutercomma but \xintexpralignninnersep, etc...

At 1.4c I remove the \protected from \xintexpralignend. I had made note a year ago that it served nothing. Let's trust myself on this one (risky one year later!).

```
\catcode`& 4
\protected\def\xintexpralignbegin      {\halign\bgroup\tabskip2ex\hfil##&&##\hfil\cr}%
\def\xintexpralignend                  {\crcr\egroup}%
\protected\def\xintexpralignlinesep    {,\cr}%
\protected\def\xintexpralignleftbracket {[}%
\protected\def\xintexpralignrightbracket{]}%
\protected\def\xintexpralignleftsep    {&}%
\protected\def\xintexpralignrightsep   {&}%
\protected\def\xintexpralignninnersep  {,&}%
\catcode`& 7
\def\XINT:expr:toalignwith#1#2%
{%
    {\expandafter\XINT:expr:toalign_checkempty
     \expanded{\noexpand#1!\expandafter}\detokenize{#2}^\expandafter}%
    \xintexpralignend
}%
\def\XINT:expr:toalign_checkempty #1!#2%
{%
    \if ^#2\expandafter\xint_gob_til_^\else\expandafter\XINT:expr:toalign_a\fi
    #1!#2%
}%
\catcode`< 1 \catcode`> 2 \catcode`{ 12 \catcode`} 12
\def\XINT:expr:toalign_a #1{#2%
<%
    \if{#2\xint_dothis<\xintexpralignleftbracket\XINT:expr:toalign_a>\fi
    \xint_orthat<\xintexpralignleftsep\XINT:expr:toalign_b>#1#2%
>%
\def\XINT:expr:toalign_b #1!#2}%
<%
    \if\relax#2\relax\xintexprEmptyItem\else#1<#2>\fi\XINT:expr:toalign_c #1!}%
>%
```

```
\def\XINT:expr:toalign_c #1}#2%
<%
    \if ^#2\xint_dothis<\xint_gob_til_^>\fi
    \if {#2\xint_dothis<\xintexpraligninnersep\XINT:expr:toalign_A>\fi
    \xint_orthat<\xintexpralignrightsep\xintexpralignrightbracket\XINT:expr:toalign_C>#1#2%
>%
\def\XINT:expr:toalign_A #1{#2%
<%
    \if{#2\xint_dothis<\xintexpralignleftbracket\XINT:expr:toalign_A>\fi
    \xint_orthat\XINT:expr:toalign_b #1#2%
>%
\def\XINT:expr:toalign_C #1}#2%
<%
    \if ^#2\xint_dothis<\xint_gob_til_^>\fi
    \if {#2\xint_dothis<\xintexpralignlinesep\XINT:expr:toalign_a>\fi
    \xint_orthat<\xintexpralignrightbracket\XINT:expr:toalign_C>#1#2%
>%
\catcode`{ 1 \catcode`} 2 \catcode`< 12 \catcode`> 12
```

12.7.4 Transforming all leaves within nested braced contents

1.4. Leaves must be of catcode 12... This is currently not a constraint (or rather not a new constraint) for xintexpr because formerly anyhow all data went through csname encapsulation and extraction via string.

In order to share code with the functioning of universal functions, which will be allowed to transform a number into an ople, the applied macro is supposed to apply one level of bracing to its ouput. Thus to apply this with an xintfrac macro such as \xintiRound{0} one needs first to define a wrapper which will expand it inside an added brace pair:

\def\foo#1{{\xintiRound{0}{#1}}}

As the things will expand inside expanded, propagating expansion is not an issue.

This code is used by \xintiexpr and \xintfloatexpr in case of optional argument and by the «Universal functions».

Comment at 1.4l: this seems to be used only at private package level, else I should modify \XINT:expr:mapwithin_b like I did with \XINT:expr:toblist_b to use regular braces in case the applied macro is \protected and things end up in external file.

```
\def\XINT:expr:mapwithin#1#2%
{%
    {{\expandafter\XINT:expr:mapwithin_checkempty
      \expanded{\noexpand#1!\expandafter}\detokenize{#2}^}}%
}%
\def\XINT:expr:mapwithin_checkempty #1!#2%
{%
    \if ^#2\expandafter\xint_gob_til_^\else\expandafter\XINT:expr:mapwithin_a\fi
    #1!#2%
}%
\begingroup
\catcode`[ 1 \catcode`] 2 \lccode`[`{ \lccode`]`}
\catcode`< 1 \catcode`> 2 \catcode`{ 12 \catcode`} 12
\lowercase<\endgroup
\def\XINT:expr:mapwithin_a #1{#2%
<%
    \if{#2\xint_dothis<[\iffalse]\fi\XINT:expr:mapwithin_a>\fi%
    \xint_orthat\XINT:expr:mapwithin_b #1#2%
```

```
>%
\def\XINT:expr:mapwithin_b #1!#2}%
<%
    #1<#2>\XINT:expr:mapwithin_c #1!}%
>%
\def\XINT:expr:mapwithin_c #1}#2%
<%
    \if ^#2\xint_dothis<\xint_gob_til_^>\fi
    \if{#2\xint_dothis<\XINT:expr:mapwithin_a>\fi%
    \xint_orthat<\iffalse[\fi]\XINT:expr:mapwithin_c>#1#2%
>%
>% back to normal catcodes
```

12.8 Top level user TEX interface: \xinteval, \xintfloateval, \xintiieval

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12.8.1 \xintexpr, \xintiexpr, \xintfloatexpr, \xintiiexpr

\xintiexpr and \xintfloatexpr have an optional argument since 1.1.

ATTENTION! 1.3d renamed \xinteval to \xintexpro etc...

Usage of \xintiRound{0} for \xintiexpr without optional [D] means that \xintiexpr ... \relax wrapper can be used to insert rounded-to-integers values in \xintiiexpr context: no post-fix [0] which would break it.

1.4a add support for the optional argument [D] for \xintiexpr being negative D, with same meaning as the 1.4a modified \xintRound from xintfrac.sty.

\xintiexpr mechanism was refactored at 1.4e so that rounding due to [D] optional argument uses raw format, not fixed point format on output, delegating fixed point conversion to an \XINTiexprprint now separated from \XINTexprprint.

In case of negative [D], \xintiexpr [D]...\relax internally has the [0] post-fix so it can not be inserted as sub-expression in \xintiiexpr without a num() or \xintiexpr ...\relax (extra) wrapper.

```
\def\xintexpr       {\romannumeral0\xintexpro      }%
\def\xintiexpr      {\romannumeral0\xintiexpro     }%
\def\xintfloatexpr  {\romannumeral0\xintfloatexpro }%
\def\xintiiexpr     {\romannumeral0\xintiiexpro    }%
\def\xintexpro   {\expandafter\XINT_expr_wrap\romannumeral0\xintbareeval }%
\def\xintiiexpro {\expandafter\XINT_iiexpr_wrap\romannumeral0\xintbareiieval }%
\def\xintiexpro #1%
```

```
{%
    \ifx [#1\expandafter\XINT_iexpr_withopt\else\expandafter\XINT_iexpr_noopt
    \fi #1%
}%
\def\XINT_iexpr_noopt
{%
    \expandafter\XINT_iexpr_iiround\romannumeral0\xintbareeval
}%
\def\XINT_iexpr_iiround
{%
    \expandafter\XINT_expr_wrap
    \expanded
    \XINT:NEhook:x:mapwithin\XINT:expr:mapwithin{\XINTiRoundzero_braced}%
}%
\def\XINTiRoundzero_braced#1{{\xintiRound{0}{#1}}}%
\def\XINT_iexpr_withopt [#1]%
{%
    \expandafter\XINT_iexpr_round
    \the\numexpr \xint_zapspaces #1 \xint_gobble_i\expandafter.%
    \romannumeral0\xintbareeval
}%
\def\XINT_iexpr_round #1.%
{%
    \ifnum#1=\xint_c_\xint_dothis{\XINT_iexpr_iiround}\fi
    \xint_orthat{\XINT_iexpr_round_a #1.}%
}%
\def\XINT_iexpr_round_a #1.%
{%
    \expandafter\XINT_iexpr_wrap
    \expanded
    \XINT:NEhook:x:mapwithin\XINT:expr:mapwithin{\XINTiRound_braced{#1}}%
}%
\def\XINTiRound_braced#1#2%
  {{\xintiRound{#1}{#2}[\the\numexpr\ifnum#1<\xint_c_i0\else-#1\fi]}}%
\def\xintfloatexpro #1%
{%
    \ifx [#1\expandafter\XINT_flexpr_withopt\else\expandafter\XINT_flexpr_noopt
    \fi #1%
}%
\def\XINT_flexpr_noopt
{%
    \expandafter\XINT_flexpr_wrap\the\numexpr\XINTdigits\expandafter.%
    \romannumeral0\xintbarefloateval
}%
\def\XINT_flexpr_withopt [#1]%
{%
    \expandafter\XINT_flexpr_withopt_a
    \the\numexpr\xint_zapspaces #1 \xint_gobble_i\expandafter.%
    \romannumeral0\xintbarefloateval
}%
\def\XINT_flexpr_withopt_a #1#2.%
{%
```

```
    \expandafter\XINT_flexpr_withopt_b\the\numexpr\if#1-\XINTdigits\fi#1#2.%
}%
\def\XINT_flexpr_withopt_b #1.%
{%
    \expandafter\XINT_flexpr_wrap
    \the\numexpr#1\expandafter.%
    \expanded
    \XINT:NEhook:x:mapwithin\XINT:expr:mapwithin{\XINTinFloat_braced[#1]}%
}%
\def\XINTinFloat_braced[#1]#2{{\XINTinFloat[#1]{#2}}}%
```

12.8.2 \XINT_expr_wrap, \XINT_iiexpr_wrap, \XINT_flexpr_wrap

1.3e removes some leading space tokens which served nothing. There is no \XINT_iexpr_wrap, because \XINT_expr_wrap is used directly.

1.4e has \XINT_iexpr_wrap separated from \XINT_expr_wrap, thus simplifying internal matters as output printer for \xintexpr will not have to handle fixed point input but only extended-raw type input (i.e. A, A/B, A[N] or A/B[N]).

```
\def\XINT_expr_wrap   {\XINTfstop\XINTexprprint.}%
\def\XINT_iexpr_wrap  {\XINTfstop\XINTiexprprint.}%
\def\XINT_iiexpr_wrap {\XINTfstop\XINTiiexprprint.}%
\def\XINT_flexpr_wrap {\XINTfstop\XINTflexprprint}%
```

12.8.3 \XINTexprprint, \XINTiexprprint, \XINTiiexprprint, \XINTflexprprint

Modified at 1.4 (2020/01/31). Requires \expanded.

Modified at 1.4e (2021/05/05). 1.4e has a breaking change of \XINTflexprprint and \xintfloatexprPrintOne which now requires \xintfloatexprPrintOne[D]{x} syntax, with first argument in brackets.

Modified at 1.4l (2022/05/29). The code does \let\xintexprPrintOne\xint_FracToSci_x but the latter is not yet defined so this is delayed until \xint_FracToSci_x definition.

Modified at 1.4m (2022/06/10). \xintboolexprPrintOne outputs true or false, not True or False. By the way (undocumented) all four keywords true, false, True, False are recognized as genuine variables since 1.4i.

```
\protected\def\XINTexprprint.%
    {\XINT:NEhook:x:toblist\XINT:expr:toblistwith\xintexprPrintOne}%
\protected\def\XINTiexprprint.%
    {\XINT:NEhook:x:toblist\XINT:expr:toblistwith\xintiexprPrintOne}%
\let\xintiexprPrintOne\xintDecToString
\def\xintexprEmptyItem{[]}%
\protected\def\XINTiiexprprint.%
    {\XINT:NEhook:x:toblist\XINT:expr:toblistwith\xintiiexprPrintOne}%
\let\xintiiexprPrintOne\xint_firstofone
\protected\def\XINTflexprprint #1.%
    {\XINT:NEhook:x:toblist\XINT:expr:toblistwith{\xintfloatexprPrintOne[#1]}}%
\let\xintfloatexprPrintOne\xintPFloat_wopt
\protected\def\XINTboolexprprint.%
    {\XINT:NEhook:x:toblist\XINT:expr:toblistwith\xintboolexprPrintOne}%
\def\xintboolexprPrintOne#1{\xintiiifNotZero{#1}{true}{false}}%
```

12.8.4 \xintthe, \xintthealign, \xinttheexpr, \xinttheiexpr, \xintthefloatexpr, \xinttheiiexpr

The reason why \xinttheiexpr et \xintthefloatexpr are handled differently is that they admit an optional argument which acts via a custom «printing» stage.

We exploit here that \expanded expands forward until finding an implicit or explicit brace, and that this expansion overrules \protected macros, forcing them to expand, similarly as \romannumeral expands \protected macros, and contrarily to what happens *within* the actual \expanded scope. I discovered this fact by testing (with pdftex) and I don't know where this is documented apart from the source code of the relevant engines. This is useful to us because there are contexts where we will want to apply a complete expansion before printing, but in purely numerical context this is not needed (if I converted correctly after dropping at 1.4 the \csname governed expansions; however I rely at various places on the fact that the xint macros are f-expandable, so I have tried to not use zillions of expanded all over the place), hence it is not needed to add the expansion overhead by default. But the \expanded here will allow \xintNewExpr to create macro with suitable modification or the printing step, via some hook rather than having to duplicate all macros here with some new «NE» meaning (aliasing does not work or causes big issues due to desire to support \xinteval also in «NE» context as sub-constituent. The \XINT:NEhook:x:toblist is something else which serves to achieve this support of *sub* \xinteval, it serves nothing for the actual produced macros. For \xintdeffunc, things are simpler, but still we support the [N] optional argument of \xintiexpr and \xintfloatexpr, which required some work...

The \expanded upfront ensures \xintthe mechanism does expand completely in two steps.

```
\def\xintthe      #1{\expanded\expandafter\xint_gobble_i\romannumeral`&&@#1}%
\def\xintthealign #1{\expandafter\xintexpralignbegin
                     \expanded\expandafter\XINT:expr:toalignwith
                     \romannumeral0\expandafter\expandafter\expandafter\expandafter
                                   \expandafter\expandafter\expandafter\xint_gob_andstop_ii
                     \expandafter\xint_gobble_i\romannumeral`&&@#1}%
\def\xinttheexpr
   {\expanded\expandafter\XINTexprprint\expandafter.\romannumeral0\xintbareeval}%
\def\xinttheiexpr
   {\expanded\expandafter\xint_gobble_i\romannumeral`&&@\xintiexpr}%
\def\xintthefloatexpr
   {\expanded\expandafter\xint_gobble_i\romannumeral`&&@\xintfloatexpr}%
\def\xinttheiiexpr
   {\expanded\expandafter\XINTiiexprprint\expandafter.\romannumeral0\xintbareiieval}%
```

12.8.5 \xintbareeval, \xintbarefloateval, \xintbareiieval

At 1.4 added one expansion step via _start macros. Triggering is expected to be via either \romannumeral`^^@ or \romannumeral0 is also ok

```
\def\xintbareeval      {\XINT_expr_start  }%
\def\xintbarefloateval{\XINT_flexpr_start}%
\def\xintbareiieval    {\XINT_iiexpr_start}%
```

12.8.6 \xintthebareeval, \xintthebarefloateval, \xintthebareiieval

For matters of \XINT_NewFunc

```
\def\XINT_expr_unlock      {\expandafter\xint_firstofone\romannumeral`&&@}%
\def\xintthebareeval
    {\romannumeral0\expandafter\xint_stop_atfirstofone\romannumeral0\xintbareeval}%
\def\xintthebareiieval
    {\romannumeral0\expandafter\xint_stop_atfirstofone\romannumeral0\xintbareiieval}%
\def\xintthebarefloateval
    {\romannumeral0\expandafter\xint_stop_atfirstofone\romannumeral0\xintbarefloateval}%
\def\xintthebareroundedfloateval
{%
```

```
    \romannumeral0\expandafter\xintthebareroundedfloateval_a\romannumeral0\xintbarefloateval
}%
\def\xintthebareroundedfloateval_a
{%
    \expandafter\xint_stop_atfirstofone
    \expanded\XINT:NEhook:x:mapwithin\XINT:expr:mapwithin{\XINTinFloatSdigits_braced}%
}%
\def\XINTinFloatSdigits_braced#1{{\XINTinFloatS[\XINTdigits]{#1}}}%
```

12.8.7 \xinteval, \xintieval, \xintfloateval, \xintiieval

Refactored at 1.4.

The \expanded upfront ensures \xinteval still expands completely in two steps. No \romannumeral trigger here, in relation to the fact that \XINTexprprint is no f-expandable, only e-expandable.

(and attention that \xintexpr\relax is now legal, and an empty ople can be produced in output also from \xintexpr [17][1]\relax for example)

Modified at 1.4k (2022/05/18). The \xintieval and \xintfloateval optional bracketed argument can now be located outside the braces... took me years to finally make the step toward LaTeX users expectations for a decent interface.

```
\def\xinteval #1%
   {\expanded\expandafter\XINTexprprint\expandafter.\romannumeral0\xintbareeval#1\relax}%
\def\xintieval
   {\expanded\expandafter\xint_ieval_chkopt\string}%
\def\xint_ieval_chkopt #1%
{%
    \ifx [#1\expandafter\xint_ieval_opt
       \else\expandafter\xint_ieval_noopt
    \fi  #1%
}%
\def\xint_ieval_opt [#1]#2%
   {\expandafter\xint_gobble_i\romannumeral`&&@\xintiexpr[#1]#2\relax}%
\def\xint_ieval_noopt #1{\expandafter\xint_ieval\expandafter{\iffalse}\fi}%
\def\xint_ieval#1%
   {\expandafter\xint_gobble_i\romannumeral`&&@\xintiexpr#1\relax}%
\def\xintfloateval {\expanded\expandafter\xint_floateval_chkopt\string}%
\def\xint_floateval_chkopt #1%
{%
    \ifx [#1\expandafter\xint_floateval_opt
       \else\expandafter\xint_floateval_noopt
    \fi  #1%
}%
\def\xint_floateval_opt [#1]#2%
   {\expandafter\xint_gobble_i\romannumeral`&&@\xintfloatexpr[#1]#2\relax}%
\def\xint_floateval_noopt #1{\expandafter\xint_floateval\expandafter{\iffalse}\fi}%
\def\xint_floateval#1%
   {\expandafter\xint_gobble_i\romannumeral`&&@\xintfloatexpr#1\relax}%
\def\xintiieval #1%
   {\expanded\expandafter\XINTiiexprprint
            \expandafter.\romannumeral0\xintbareiieval#1\relax}%
```

12.8.8 \xintboolexpr, \XINT_boolexpr_print, \xinttheboolexpr

ATTENTION! 1.3d renamed \xinteval to \xintexpro etc...

Attention, the conversion to 1 or 0 is done only by the print macro. Perhaps I should force it also inside raw result.

```
\def\xintboolexpr
{%
    \romannumeral0\expandafter\XINT_boolexpr_done\romannumeral0\xintexpro
}%
\def\XINT_boolexpr_done #1.{\XINTfstop\XINTboolexprprint.}%
\def\xinttheboolexpr
{%
    \expanded\expandafter\XINTboolexprprint\expandafter.\romannumeral0\xintbareeval
}%
```

12.8.9 \xintifboolexpr, \xintifboolfloatexpr, \xintifbooliiexpr

They do not accept comma separated expressions input.

```
\def\xintifboolexpr      #1{\romannumeral0\xintiiifnotzero {\xinttheexpr #1\relax}}%
\def\xintifboolfloatexpr #1{\romannumeral0\xintiiifnotzero {\xintthefloatexpr #1\relax}}%
\def\xintifbooliiexpr    #1{\romannumeral0\xintiiifnotzero {\xinttheiiexpr #1\relax}}%
```

12.8.10 \xintifsgnexpr, \xintifsgnfloatexpr, \xintifsgniiexpr

Modified at 1.3d (2019/01/06). They do not accept comma separated expressions.

```
\def\xintifsgnexpr      #1{\romannumeral0\xintiiifsgn {\xinttheexpr #1\relax}}%
\def\xintifsgnfloatexpr #1{\romannumeral0\xintiiifsgn {\xintthefloatexpr #1\relax}}%
\def\xintifsgniiexpr    #1{\romannumeral0\xintiiifsgn {\xinttheiiexpr #1\relax}}%
```

12.8.11 \xint_FracToSci_x

Added at 1.4 (2020/01/31). Under the name of \xintFracToSci and defined in xintfrac.

Modified at 1.4e (2021/05/05). Refactored and much simplified

It only needs to be x-expandable, and indeed the implementation here is only x-expandable.

Finally for 1.4e release I modify. This is breaking change for all \xinteval output in case of scientific notation: it will not be with an integer mantissa, but with regular scientific notation, using the same rules as \xintPFloat.

Of course no float rounding! Also, as [0] will always or almost always be present from an \xinteval, we want then to use integer not scientific notation. But expression contained decimal fixed point input, or uses scientific functions, then probably the N will not be zero and this will trigger usage of scientific notation in output.

Implementing these changes sort of ruin our previous efforts to minimize grabbing the argument, but well. So the rules now are

Input: A, A/B, A[N], A/B[N]
Output: A, A/B, A if N=0, A/B if N=0
If N is not zero, scientific notation like \xintPFloat, i.e. behaviour like \xintfloateval apart from the rounding to significands of width Digits. At 1.4k, trimming of zeros from A is always done, i.e. the \xintPFloatMinTrimmed is ignored to keep behaviour. unchanged. Trailing zeros of B are kept as is.

The zero gives 0, except in A[N] and A/B[N] cases, it may give 0.0

Modified at 1.4k (2022/05/18). Moved from xintfrac to xintexpr.

Modified at 1.4l (2022/05/29). Renamed to \xint_FracToSci_x to make it private and provide in xintfrac another \xintFracToSci with same output but which behaves like other macros there: f-expandable and accepting the whole range of inputs accepted by the xintfrac public macros.

The private x-expandable macro here will have an empty output for an empty input but is never used for an empty input (see \xintexprEmptyItem).

```
\def\xint_FracToSci_x #1{\expandafter\XINT_FracToSci_x\romannumeral`&&@#1/\W[\R}%
\def\XINT_FracToSci_x #1/#2#3[#4%
{%
    \xint_gob_til_W #2\XINT_FracToSci_x_noslash\W
    \xint_gob_til_R #4\XINT_FracToSci_x_slash_noN\R
    \XINT_FracToSci_x_slash_N #1/#2#3[#4%
}%
\def\XINT_FracToSci_x_noslash#1\XINT_FracToSci_x_slash_N #2[#3%
{%
    \xint_gob_til_R #3\XINT_FracToSci_x_noslash_noN\R
    \XINT_FracToSci_x_noslash_N #2[#3%
}%
\def\XINT_FracToSci_x_noslash_noN\R\XINT_FracToSci_x_noslash_N #1/\W[\R{#1}%
\def\XINT_FracToSci_x_noslash_N #1[#2]/\W[\R%
{%
    \ifnum#2=\xint_c_ #1\else
      \romannumeral0\expandafter\XINT_pfloat_a_fork\romannumeral0\xintrez{#1[#2]}%
    \fi
}%
\def\XINT_FracToSci_x_slash_noN\R\XINT_FracToSci_x_slash_N #1#2/#3/\W[\R%
{%
    #1\xint_gob_til_zero#1\expandafter\iffalse\xint_gobble_ii0\iftrue
    #2\if\XINT_isOne{#3}1\else/#3\fi\fi
}%
\def\XINT_FracToSci_x_slash_N #1#2/#3[#4]/\W[\R%
{%
    \ifnum#4=\xint_c_ #1#2\else
      \romannumeral0\expandafter\XINT_pfloat_a_fork\romannumeral0\xintrez{#1#2[#4]}%
    \fi
    \if\XINT_isOne{#3}1\else\if#10\else/#3\fi\fi
}%
\let\xintexprPrintOne\xint_FracToSci_x
```

12.8.12 Small bits we have to put somewhere

Some renaming and modifications here with release 1.2 to switch from using chains of \romannumeral-`0 in order to gather numbers, possibly hexadecimals, to using a \csname governed expansion. In this way no more limit at 5000 digits, and besides this is a logical move because the \xintexpr parser is already based on \csname...\endcsname storage of numbers as one token.

The limitation at 5000 digits didn't worry me too much because it was not very realistic to launch computations with thousands of digits... such computations are still slow with 1.2 but less so now. Chains or \romannumeral are still used for the gathering of function names and other stuff which I have half-forgotten because the parser does many things.

In the earlier versions we used the lockscan macro after a chain of \romannumeral-`0 had ended gathering digits; this uses has been replaced by direct processing inside a \csname...\endcsname and the macro is kept only for matters of dummy variables.

Currently, the parsing of hexadecimal numbers needs two nested \csname...\endcsname, first to gather the letters (possibly with a hexadecimal fractional part), and in a second stage to apply \xintHexToDec to do the actual conversion. This should be faster than updating on the fly the number (which would be hard for the fraction part...).

```
\def\XINT_embrace#1{{#1}}%
\def\xint_gob_til_! #1!{}% ! with catcode 11
\def\xintError:noopening
{%
   \XINT_expandableerror{Extra ). This is serious and prospects are bleak.}%
}%
```

\xintthecoords 1.1 Wraps up an even number of comma separated items into pairs of TikZ coordinates; for use in the following way:

coordinates {\xintthecoords\xintfloatexpr ... \relax}

The crazyness with the \csname and unlock is due to TikZ somewhat STRANGE control of the TOTAL number of expansions which should not exceed the very low value of 100 !! As we implemented \XINT_thecoords_b in an "inline" style for efficiency, we need to hide its expansions.

Not to be used as \xintthecoords\xintthefloatexpr, only as \xintthecoords\xintfloatexpr (or \xintiexpr etc...). Perhaps \xintthecoords could make an extra check, but one should not accustom users to too loose requirements!

```
\def\xintthecoords#1%
  {\romannumeral`&&@\expandafter\XINT_thecoords_a\romannumeral0#1}%
\def\XINT_thecoords_a #1#2.#3% #2.=\XINTfloatprint<digits>. etc...
  {\expanded{\expandafter\XINT_thecoords_b\expanded#2.{#3},!,!,^}}%
\def\XINT_thecoords_b #1#2,#3#4,%
  {\xint_gob_til_! #3\XINT_thecoords_c ! (#1#2, #3#4)\XINT_thecoords_b }%
\def\XINT_thecoords_c #1^{}%
```

\xintthespaceseparated 1.4a This is a utility macro which was distributed previously separately for usage with PSTricks \listplot

```
\def\xintthespaceseparated#1%
  {\expanded\expandafter\xintthespaceseparated_a\romannumeral0#1}%
\def\xintthespaceseparated_a #1#2.#3%
  {{\expandafter\xintthespaceseparated_b\expanded#2.{#3},!,!,!,!,!,!,!,!,!,^}}%
\def\xintthespaceseparated_b #1,#2,#3,#4,#5,#6,#7,#8,#9,%
  {\xint_gob_til_! #9\xintthespaceseparated_c !%
   #1#2#3#4#5#6#7#8#9%
   \xintthespaceseparated_b}%
```

1.4c I add a space here to stop the \romannumeral`&&@ in case of empty input. But this space induces an extra un-needed space token after 9, 18, 27,... items before the last group of less than 9 items.

Fix (at 1.4h) is simple because I already use \expanded anyhow: I don't need at all the \romannumeral`&&@ which was first in \xintthespaceseparated, let's move the first \expanded which was in \xintthespaceseparated_a to \xintthespaceseparated, and remove the extra space here in _c.

(alternative would have been to put the space after #1 and accept a systematic trailing space, at least it is more aesthetic).

Again, I did have a test file, but it was not incorporated in my test suite, so I discovered the problem accidentally by compiling all files in an archive.

```
\def\xintthespaceseparated_c !#1!#2^{#1}%
```

12.9 Hooks into the numeric parser for usage by the \xintdeffunc symbolic parser

This is new with 1.3 and considerably refactored at 1.4. See «Mysterious stuff».

```
\let\XINT:NEhook:f:one:from:one\expandafter
\let\XINT:NEhook:f:one:from:one:direct\empty
\let\XINT:NEhook:f:one:from:two\expandafter
```

```
\let\XINT:NEhook:f:one:from:two:direct\empty
\let\XINT:NEhook:x:one:from:two\empty
\let\XINT:NEhook:f:one:and:opt:direct      \empty
\let\XINT:NEhook:f:tacitzeroifone:direct   \empty
\let\XINT:NEhook:f:iitacitzeroifone:direct \empty
\let\XINT:NEhook:x:select:obey\empty
\let\XINT:NEhook:x:listsel\empty
\let\XINT:NEhook:f:reverse\empty
```

At 1.4 it was \def\XINT:NEhook:f:from:delim:u #1#2^{#1#2^} which was trick to allow automatic unpacking of a nutple argument to multi-arguments functions such as gcd() or max(). But this sacrificied the usage with a single numeric argument.

Modified at 1.4i (2021/06/11). More sophisticated code to check if the argument ople was actually a single number. Notice that this forces numeric types to actually use catcode 12 tokens, and polexpr diverges a bit using P, but actually always testing with \if not \ifx.

This is used by gcd(), lcm(), max(), min(), `+`(), `*`(), all(), any(), xor().

The nil and None will give the same result due to the initial brace stripping done by \XINT:NEhook:f:from:delim:u (there was even a prior brace stripping to provide the #2 which is empty here for the nil and {} for the None).

```
\def\XINT:NEhook:f:from:delim:u #1#2^%
{%
    \expandafter\XINT_fooof_checkifnumber\expandafter#1\string#2^%
}%
\def\XINT_fooof_checkifnumber#1#2%
{%
    \expandafter#1%
    \romannumeral0\expanded{\if ^#2^\else
               \if\bgroup#2\noexpand\XINT_fooof_no\else
               \noexpand\XINT_fooof_yes#2\fi\fi}%
}%
\def\XINT_fooof_yes#1^{{#1}^}%
\def\XINT_fooof_no{\expandafter{\iffalse}\fi}%
```

Modified at 1.4i (2021/06/11). Same changes as for the other multiple arguments functions, making them again usable with a single numeric input.

Was at 1.4 \def\XINT:NEhook:f:noeval:from:braced:u#1#2^{#1{#2}} which is not compatible with a single numeric input.

Used by len(), first(), last() but it is a potential implementation bug that the three share this as the location where expansion takes places is one level deeper for the support macro of len().

The None is here handled as nil, i.e. it is unpacked, which is fine as the documentations says nutples are unpacked.

```
\def\XINT:NEhook:f:LFL #1{\expandafter#1\expandafter}%
\def\XINT:NEhook:r:check #1^%
{%
    \expandafter\XINT:NEhook:r:check_a\string#1^%
}%
\let\XINT:NEsaved:r:check \XINT:NEhook:r:check
\def\XINT:NEhook:r:check_a #1%
{%
    \if ^#1\xint_dothis\xint_c_\fi
    \if\bgroup#1\xint_dothis\XINT:NEhook:r:check_no\fi
    \xint_orthat{\XINT:NEhook:r:check_yes#1}%
}%
```

```
\def\XINT:NEhook:r:check_no
{%
    \expandafter\XINT:NEhook:r:check_no_b
    \expandafter\xint_c_\expandafter{\iffalse}\fi
}%
\def\XINT:NEhook:r:check_no_b#1^{#1}%
\def\XINT:NEhook:r:check_yes#1^{\xint_c_{#1}}%
\let\XINT:NEhook:branch\expandafter
\let\XINT:NEhook:seqx\empty
\let\XINT:NEhook:iter\expandafter
\let\XINT:NEhook:opx\empty
\let\XINT:NEhook:rseq\expandafter
\let\XINT:NEhook:iterr\expandafter
\let\XINT:NEhook:rrseq\expandafter
\let\XINT:NEhook:x:toblist\empty
\let\XINT:NEhook:x:mapwithin\empty
\let\XINT:NEhook:x:ndmapx\empty
```

12.10 \XINT_expr_getnext: fetch some value then an operator and present them to last waiter with the found operator precedence, then the operator, then the value

Big change in 1.1, no attempt to detect braced stuff anymore as the [N] notation is implemented otherwise. Now, braces should not be used at all; one level removed, then \romannumeral-`0 expansion.

Refactored at 1.4 to put expansion of \XINT_expr_getop after the fetched number, thus avoiding it to have to fetch it (which could happen then multiple times, it was not really important when it was only one token in pre-1.4 xintexpr).

Allow \xintexpr\relax at 1.4.

Refactored at 1.4 the articulation \XINT_expr_getnext/XINT_expr_func/XINT_expr_getop. For some legacy reason the first token picked by getnext was soon turned to catcode 12 The next ones after the first were not a priori stringified but the first token was, and this made allowing things such as \xintexpr\relax, \xintexpr,,\relax, [], 1+(), [:] etc... complicated and requiring each time specific measures.

The \expandafter chain in \XINT_expr_put_op_first is an overhead related to an 1.4 attempt, the "varvalue" mechanism. I.e.: expansion of \XINT_expr_var_foo is {\XINT_expr_varvalue_foo } and then for example \XINT_expr_varvalue_foo expands to {4/1[0]}. The mechanism was originally conceived to have only one token with idea its makes things faster. But the xintfrac macros break with syntax such as \xintMul\foo\bar and \foo expansion giving braces. So at 1.4c I added here these \expandafter, but this is REALLY not satisfactory because the \expandafter are needed it seems only for this variable "varvalue" mechanism.

See also the discussion of \XINT_expr_op__ which distinguishes variables from functions.

After a 1.4g refactoring it would be possible to drop here the \expandafter if the \XINT_expr_var_foo macro was defined to f-expand to {actual expanded value (as ople)} for example explicit {{3}}. I have to balance the relative weights of doing always the \expandafter but they are needed only for the case the value was encapsulated in a variable, and of never doing the \expandafter and ensure f-expansion of the _var_foo gives explicit value (now that the refactoring let it be f-expanded, and the case of fake variables omit and abort in particular was safely separated instead of being treated like other and imposing restrictions on general variable handling), and then there is the overhead of possibly moving around many digits in the #1 of \XINT_expr_put_op_first.

```
\def\XINT_expr_getnext #1%
```

```
{%
    \expandafter\XINT_expr_put_op_first\romannumeral`&&@%
    \expandafter\XINT_expr_getnext_a\romannumeral`&&@#1%
}%
\def\XINT_expr_put_op_first #1#2#3{\expandafter#2\expandafter#3\expandafter{#1}}%
\def\XINT_expr_getnext_a #1%
{%
    \ifx\relax #1\xint_dothis\XINT_expr_foundprematureend\fi
    \ifx\XINTfstop#1\xint_dothis\XINT_expr_subexpr\fi
    \ifcat\relax#1\xint_dothis\XINT_expr_countetc\fi
    \xint_orthat{}\XINT_expr_getnextfork #1%
}%
\def\XINT_expr_foundprematureend\XINT_expr_getnextfork #1{{}\xint_c_\relax}%
\def\XINT_expr_subexpr #1.#2%
{%
    \expanded{\unexpanded{{#2}}\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
```

1.2 adds \ht, \dp, \wd and the eTeX font things. 1.4 avoids big nested \if's, simply for code readability.

This "fetch as number" is dangerous as long as list is not complete... at 1.4g I belatedly add \catcode

```
\def\XINT_expr_countetc\XINT_expr_getnextfork#1%
{%
    \if0\ifx\count#11\fi
        \ifx\numexpr#11\fi
        \ifx\catcode#11\fi
        \ifx\dimen#11\fi
        \ifx\dimexpr#11\fi
        \ifx\skip#11\fi
        \ifx\glueexpr#11\fi
        \ifx\fontdimen#11\fi
        \ifx\ht#11\fi
        \ifx\dp#11\fi
        \ifx\wd#11\fi
        \ifx\fontcharht#11\fi
        \ifx\fontcharwd#11\fi
        \ifx\fontchardp#11\fi
        \ifx\fontcharic#11\fi
       0\expandafter\XINT_expr_fetch_as_number\fi
   \expandafter\XINT_expr_getnext_a\number #1%
}%
\def\XINT_expr_fetch_as_number
    \expandafter\XINT_expr_getnext_a\number #1%
{%
    \expanded{{{\number#1}}\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
```

This is the key initial dispatch component. It has been refactored at 1.4g to give priority to identifying letter and digit tokens first. It thus combines former \XINT_expr_getnextfork, \XINT_expr_scan_nbr_or_func and \XINT_expr_scanfunc. A branch of the latter having become \XINT_expr_startfunc. The handling of non-catcode 11 underscore _ has changed: it is now skipped completely like the +. Formerly it would cause an infinite loop because it triggered first insertion of a nil variable, (being confused with a possible operator at a location where one looks for a value), then tacit multiplication (being now interpreted as starting some name), and then it came back to getnextfork creating loop. The @ of catcode 12 could have caused the same issue if it was not handled especially because it is used in the syntax as special variable for recursion hence was recognized even if of catcode 12. Anyway I could have handled the _ like the @, to avoid this problem of infinite loop with a non-letter underscore used as first character but decided finally to have it be ignored (it is already ignored if among digits, but it can be a constituent of a function of variable name). It is not ignored of course if of catcode 11. It may then start a variable or function name, but only for use by the package (by polexpr for example), not by users.

Then the matter is handed over to specialized routines: gathering digits of a number (inclusive of a decimal mark, an exponential part) or letters of a function or variable. And we have to intercept some tokens to implement various functionalities.

In each dothis/orthat structure, the first encountered branches are usually handled slower than the next, because \if..\fi test cost less than grabbing tokens. The exception is in the first one where letters pass through slightly faster than digits, presumably because the \ifnum test is more costly. Prior to this 1.4g refactoring the case of a starting letter of a variable or function name was handled last, it is now handled first. Now, this is only first letter...

Here are the various possibilities in order that they are appear below (the indicative order of speed of treatment is given as a number).

-1 tokens of catcode letter start a variable or function name

-2 digits (I apply \string for the test, but I will have to review, it seems natural anyhow to require digits to be of catcode 12 and this is in fact basically done by the package, \numexpr does not work if not the case.),

-7 support for Python-like * "unpacking" unary operator (added at 1.4),

-6 support for [as opener for the [..] nutple constructor (1.4),

-5 support for the minus as unary operator of variable precedence,

-4 support for @ as first character of special variables even if not letter,

-3 support for opening parentheses (possibly triggering tacit multiplication),

-13 support for skipping over ignored + character,

-12 support for numbers starting with a decimal point,

-11 support for the \`+\`() and \`*\`() functions,

-10 support for the !() function,

-9 support for the ?() function,

-8 support for " for input of hexadecimal numbers. But xintbinhex must be loaded explicitly by user.

-17 support for \xintdeffunc via special handling of # token,

-16 support for ignoring _ if not of catcode 11 and at start of numbers or names (this 1.4g change fixes \xinteval{_4} creating infinite loop)

-15 support for inserting "nil" in front of operators, as needed in particular for the Python slicing syntax. This covers the comma, the :, the] and the) and also the ; although I don't think using ; to delimit nil is licit.

-14 support for inserting 0 as missing value if / or ^ are encountered directly. This 1.4g changes avoids \xinteval{/3} causing unrecoverable low level errors from \xintDiv receiving only one argument.

I did not see here other bad syntax to protect.

The handling of "nil" insertion penalizes Python slicing but anyway time differences in the 14-15-16-17 group are less than 5%. The alternative will be to do some positive test for the targets (:,], the comma and closing parenthesis) and do this in the prior group but this then penalizes others. Anyway. This is all negligible compared to actual computations...

Note: the above may not be in sync with code as it is extremely time-consuming to maintain correspondence in case of re-factoring.

```
\def\XINT_expr_getnextfork #1%
{%
```

```
    \ifcat a#1\xint_dothis\XINT_expr_startfunc\fi
    \ifnum \xint_c_ix<1\string#1 \xint_dothis\XINT_expr_startint\fi
    \xint_orthat\XINT_expr_getnextfork_a #1%
}%
\def\XINT_expr_getnextfork_a #1%
{%
    \if#1*\xint_dothis {{}\xint_c_ii^v 0}\fi
    \if#1[\xint_dothis {{}\xint_c_ii^v \XINT_expr_itself_obracket}\fi
    \if#1-\xint_dothis {{}{}-}\fi
    \if#1@\xint_dothis{\XINT_expr_startfunc @}\fi
    \if#1(\xint_dothis {{}\xint_c_ii^v (}\fi
    \xint_orthat{\XINT_expr_getnextfork_b#1}%
}%
\catcode96 11 % `
\def\XINT_expr_getnextfork_b #1%
{%
    \if#1+\xint_dothis \XINT_expr_getnext_a\fi
    \if#1.\xint_dothis \XINT_expr_startdec\fi
    \if#1`\xint_dothis {\XINT_expr_onliteral_`}\fi
    \if#1!\xint_dothis {\XINT_expr_startfunc !}\fi
    \if#1?\xint_dothis {\XINT_expr_startfunc ?}\fi
    \if#1"\xint_dothis \XINT_expr_starthex\fi
    \xint_orthat{\XINT_expr_getnextfork_c#1}%
}%
\def\XINT_tmpa #1{%
\def\XINT_expr_getnextfork_c ##1%
{%
    \if##1#1\xint_dothis \XINT_expr_getmacropar\fi
    \if##1_\xint_dothis \XINT_expr_getnext_a\fi
    \if0\if##1/1\fi\if##1^1\fi0\xint_dothis{\XINT_expr_insertnil##1}\fi
    \xint_orthat{\XINT_expr_missing_arg##1}%
}%
}\expandafter\XINT_tmpa\string#%
```

The ` syntax is here used for special constructs like `+`(..), `*`(..) where + or * will be treated as functions. Current implementation picks only one token (could have been braced stuff), here it will be + or *, and via \XINT_expr_op_` this then becomes a suitable \XINT_{expr|iiexpr|flexpr}_func_+ (or *). Documentation says to use `+`(...), but `+(...) is also valid. The opening parenthesis must be there, it is not allowed to require some expansion.

```
\def\XINT_expr_onliteral_` #1#2({{#1}\xint_c_ii^v `}%
\catcode96 12 % `
```

Prior to 1.4g, I was using a \lowercase technique to insert the catcode 12 #, but this is a bit risky when one does not ensure a priori control of all lccodes.

```
\def\XINT_tmpa #1{%
\def\XINT_expr_getmacropar ##1%
{%
    \expandafter{\expandafter{\expandafter#1\expandafter
    ##1\expandafter}\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
}\expandafter\XINT_tmpa\string#%
\def\XINT_expr_insertnil #1%
{%
    \expandafter{\expandafter}\romannumeral`&&@\XINT_expr_getop_a#1%
```

```
}%
\def\XINT_expr_missing_arg#1%
{%
    \expanded{\XINT_expandableerror
              {Expected a value, got nothing before `#1'. Inserting 0.}{{0}}\expandafter}%
    \romannumeral`&&@\XINT_expr_getop_a#1%
}%
```

12.11 \XINT_expr_startint

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1.2 release has replaced chains of \romannumeral-`0 by \csname governed expansion. Thus there is no more the limit at about 5000 digits for parsed numbers.

In order to avoid having to lock and unlock in succession to handle the scientific part and adjust the exponent according to the number of digits of the decimal part, the parsing of this decimal part counts on the fly the number of digits it encounters.

There is some slight annoyance with \xintiiexpr which should never be given a [n] inside its \csname.=<digits>\endcsname storage of numbers (because its arithmetic uses the ii macros which know nothing about the [N] notation). Hence if the parser has only seen digits when hitting something else than the dot or e (or E), it will not insert a [0]. Thus we very slightly compromise the efficiency of \xintexpr and \xintfloatexpr in order to be able to share the same code with \xintiiexpr.

Indeed, the parser at this location is completely common to all, it does not know if it is working inside \xintexpr or \xintiiexpr. On the other hand if a dot or a e (or E) is met, then the (common) parser has no scruples ending this number with a [n], this will provoke an error later if that was within an \xintiiexpr, as soon as an arithmetic macro is used.

As the gathered numbers have no spaces, no pluses, no minuses, the only remaining issue is with leading zeroes, which are discarded on the fly. The hexadecimal numbers leading zeroes are stripped in a second stage by the \xintHexToDec macro.

With 1.2, \xinttheexpr . \relax does not work anymore (it did in earlier releases). There must be digits either before or after the decimal mark. Thus both \xinttheexpr 1.\relax and \xinttheexpr .1\relax are legal.

Attention at this location #1 was of catcode 12 in all versions prior to 1.4.

We assume anyhow that catcodes of digits are 12...

```
\def\XINT_expr_startint #1%
{%
    \if #10\expandafter\XINT_expr_gobz_a\else\expandafter\XINT_expr_scanint_a\fi #1%
}%
\def\XINT_expr_scanint_a #1#2%
    {\expanded\bgroup{{\iffalse}}\fi #1% spare a \string
     \expandafter\XINT_expr_scanint_main\romannumeral`&&@#2}%
\def\XINT_expr_gobz_a #1#2%
    {\expanded\bgroup{{\iffalse}}\fi
     \expandafter\XINT_expr_gobz_scanint_main\romannumeral`&&@#2}%
\def\XINT_expr_startdec #1%
    {\expanded\bgroup{{\iffalse}}\fi
     \expandafter\XINT_expr_scandec_a\romannumeral`&&@#1}%
```

12.11.1 Integral part (skipping zeroes)

1.2 has modified the code to give highest priority to digits, the accelerating impact is non-negligeable. I don't think the doubled \string is a serious penalty.

(reference to \string is obsolete: it is only used in the test but the tokens are not submitted to \string anymore)

```
\def\XINT_expr_scanint_main #1%
{%
    \ifcat \relax #1\expandafter\XINT_expr_scanint_hit_cs \fi
    \ifnum\xint_c_ix<1\string#1 \else\expandafter\XINT_expr_scanint_next\fi
    #1\XINT_expr_scanint_again
}%
\def\XINT_expr_scanint_again #1%
{%
    \expandafter\XINT_expr_scanint_main\romannumeral`&&@#1%
}%
```

1.4f had _getop here, but let's jump directly to _getop_a.

```
\def\XINT_expr_scanint_hit_cs \ifnum#1\fi#2\XINT_expr_scanint_again
{%
    \iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#2%
}%
```

With 1.2d the tacit multiplication in front of a variable name or function name is now done with a higher precedence, intermediate between the common one of * and / and the one of ^. Thus x/2y is like x/(2y), but x^2y is like x^2*y and 2y! is not (2y)! but 2*y!.

Finally, 1.2d has moved away from the _scan macros all the business of the tacit multiplication in one unique place via \XINT_expr_getop. For this, the ending token is not first given to \string as was done earlier before handing over back control to \XINT_expr_getop. Earlier we had to identify the catcode 11 ! signaling a sub-expression here. With no \string applied we can do it in \XINT_expr_getop. As a corollary of this displacement, parsing of big numbers should be a tiny bit faster now.

Extended for 1.2l to ignore underscore character _ if encountered within digits; so it can serve as separator for better readability.

It is not obvious at 1.4 to support [] for three things: packing, slicing, ... and raw xintfrac syntax A/B[N]. The only good way would be to actually really separate completely \xintexpr, \xintfloatexpr and \xintiiexpr code which would allow to handle both / and [] from A/B[N] as we handle e and E. But triplicating the code is something I need to think about. It is not possible as in pre 1.4 to consider [only as an operator of same precedence as multiplication and division which was the way we did this, but we can use the technique of fake operators. Thus we intercept hitting a [here, which is not too much of a problem as anyhow we dropped temporarily 3*[1,2,3]+5 syntax so we don't have to worry that 3[1,2,3] should do tacit multiplication. I think only way in future will be to really separate the code of the three parsers (or drop entirely support for A/B[N]; as 1.4 has modified output of \xinteval to not use this notation this is not too dramatic).

Anyway we find a way to inject here the former handling of [N], which will use a delimited macro to directly fetch until the closing]. We do still need some fake operator because A/B[N] is (A/B) times 10^N and the /B is allowed to be missing. We hack this using the which is not used currently as operator elsewhere in the syntax and need to hook into \XINT_expr_getop_b. No finally I use the null char. It must be of catcode 12.

1.4f had _getop here, but let's jump directly to _getop_a.

```
\def\XINT_expr_scanint_next #1\XINT_expr_scanint_again
{%
    \if     [#1\xint_dothis\XINT_expr_rawxintfrac\fi
    \if     _#1\xint_dothis\XINT_expr_scanint_again\fi
```

```
    \if    e#1\xint_dothis{[\the\numexpr0\XINT_expr_scanexp_a +}\fi
    \if    E#1\xint_dothis{[\the\numexpr0\XINT_expr_scanexp_a +}\fi
    \if    .#1\xint_dothis{\XINT_expr_startdec_a .}\fi
    \xint_orthat
    {\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#1}%
}%
\def\XINT_expr_rawxintfrac
{%
    \iffalse{{{\fi}}\expandafter}\csname XINT_expr_precedence_&&@\endcsname&&@%
}%
\def\XINT_expr_gobz_scanint_main #1%
{%
    \ifcat \relax #1\expandafter\XINT_expr_gobz_scanint_hit_cs\fi
    \ifnum\xint_c_x<1\string#1 \else\expandafter\XINT_expr_gobz_scanint_next\fi
    #1\XINT_expr_scanint_again
}%
\def\XINT_expr_gobz_scanint_again #1%
{%
    \expandafter\XINT_expr_gobz_scanint_main\romannumeral`&&@#1%
}%
```

1.4f had _getop here, but let's jump directly to _getop_a.

```
\def\XINT_expr_gobz_scanint_hit_cs\ifnum#1\fi#2\XINT_expr_scanint_again
{%
    0\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#2%
}%
\def\XINT_expr_gobz_scanint_next #1\XINT_expr_scanint_again
{%
    \if    [#1\xint_dothis{\expandafter0\XINT_expr_rawxintfrac}\fi
    \if    _#1\xint_dothis\XINT_expr_gobz_scanint_again\fi
    \if    e#1\xint_dothis{0[\the\numexpr0\XINT_expr_scanexp_a +}\fi
    \if    E#1\xint_dothis{0[\the\numexpr0\XINT_expr_scanexp_a +}\fi
    \if    .#1\xint_dothis{\XINT_expr_gobz_startdec_a .}\fi
    \if    0#1\xint_dothis\XINT_expr_gobz_scanint_again\fi
    \xint_orthat
    {0\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#1}%
}%
```

12.11.2 Fractional part

Annoying duplication of code to allow 0. as input.

1.2a corrects a very bad bug in 1.2 \XINT_expr_gobz_scandec_b which should have stripped leading zeroes in the fractional part but didn't; as a result \xinttheexpr 0.01\relax returned 0 =:-(((Thanks to Kroum Tzanev who reported the issue. Does it improve things if I say the bug was introduced in 1.2, it wasn't present before ?

1.4f had _getop here, but let's jump directly to _getop_a.

```
\def\XINT_expr_startdec_a .#1%
{%
    \expandafter\XINT_expr_scandec_a\romannumeral`&&@#1%
}%
\def\XINT_expr_scandec_a #1%
{%
    \if .#1\xint_dothis{\iffalse{{{\fi}}\expandafter}%
```

```
                         \romannumeral`&&@\XINT_expr_getop_a..}\fi
    \xint_orthat {\XINT_expr_scandec_main 0.#1}%
}%
\def\XINT_expr_gobz_startdec_a .#1%
{%
    \expandafter\XINT_expr_gobz_scandec_a\romannumeral`&&@#1%
}%
\def\XINT_expr_gobz_scandec_a #1%
{%
    \if .#1\xint_dothis
    {0\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a..}\fi
    \xint_orthat {\XINT_expr_gobz_scandec_main 0.#1}%
}%
\def\XINT_expr_scandec_main #1.#2%
{%
    \ifcat \relax #2\expandafter\XINT_expr_scandec_hit_cs\fi
    \ifnum\xint_c_ix<1\string#2 \else\expandafter\XINT_expr_scandec_next\fi
    #2\expandafter\XINT_expr_scandec_again\the\numexpr #1-\xint_c_i.%
}%
\def\XINT_expr_scandec_again #1.#2%
{%
    \expandafter\XINT_expr_scandec_main
    \the\numexpr #1\expandafter.\romannumeral`&&@#2%
}%
```

1.4f had _getop here, but let's jump directly to _getop_a.

```
\def\XINT_expr_scandec_hit_cs\ifnum#1\fi
    #2\expandafter\XINT_expr_scandec_again\the\numexpr#3-\xint_c_i.%
{%
    [#3]\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#2%
}%
\def\XINT_expr_scandec_next #1#2\the\numexpr#3-\xint_c_i.%
{%
    \if    _#1\xint_dothis{\XINT_expr_scandec_again#3.}\fi
    \if    e#1\xint_dothis{[\the\numexpr#3\XINT_expr_scanexp_a +}\fi
    \if    E#1\xint_dothis{[\the\numexpr#3\XINT_expr_scanexp_a +}\fi
    \xint_orthat
    {[#3]\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#1}%
}%
\def\XINT_expr_gobz_scandec_main #1.#2%
{%
    \ifcat \relax #2\expandafter\XINT_expr_gobz_scandec_hit_cs\fi
    \ifnum\xint_c_ix<1\string#2 \else\expandafter\XINT_expr_gobz_scandec_next\fi
    \if0#2\expandafter\xint_firstoftwo\else\expandafter\xint_secondoftwo\fi
    {\expandafter\XINT_expr_gobz_scandec_main}%
    {#2\expandafter\XINT_expr_scandec_again}\the\numexpr#1-\xint_c_i.%
}%
```

1.4f had _getop here, but let's jump directly to _getop_a.

```
\def\XINT_expr_gobz_scandec_hit_cs \ifnum#1\fi\if0#2#3\xint_c_i.%
{%
    0[0]\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#2%
}%
\def\XINT_expr_gobz_scandec_next\if0#1#2\fi #3\numexpr#4-\xint_c_i.%
```

```
{%
    \if    _#1\xint_dothis{\XINT_expr_gobz_scandec_main #4.}\fi
    \if    e#1\xint_dothis{0[\the\numexpr0\XINT_expr_scanexp_a +}\fi
    \if    E#1\xint_dothis{0[\the\numexpr0\XINT_expr_scanexp_a +}\fi
    \xint_orthat
    {0[0]\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#1}%
}%
```

12.11.3 Scientific notation

Some pluses and minuses are allowed at the start of the scientific part, however not later, and no parenthesis.

ATTENTION! 1e\numexpr2+3\relax or 1e\xintiexpr i\relax, i=1..5 are not allowed and 1e1\numexpr2\relax does 1e1 * \numexpr2\relax. Use \the\numexpr, \xinttheiexpr, etc...

```
\def\XINT_expr_scanexp_a #1#2%
{%
    #1\expandafter\XINT_expr_scanexp_main\romannumeral`&&@#2%
}%
\def\XINT_expr_scanexp_main #1%
{%
    \ifcat \relax #1\expandafter\XINT_expr_scanexp_hit_cs\fi
    \ifnum\xint_c_ix<1\string#1 \else\expandafter\XINT_expr_scanexp_next\fi
    #1\XINT_expr_scanexp_again
}%
\def\XINT_expr_scanexp_again #1%
{%
    \expandafter\XINT_expr_scanexp_main_b\romannumeral`&&@#1%
}%
```

1.4f had _getop here, but let's jump directly to _getop_a.

```
\def\XINT_expr_scanexp_hit_cs\ifnum#1\fi#2\XINT_expr_scanexp_again
{%
    ]\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#2%
}%
\def\XINT_expr_scanexp_next #1\XINT_expr_scanexp_again
{%
    \if    _#1\xint_dothis  \XINT_expr_scanexp_again   \fi
    \if    +#1\xint_dothis {\XINT_expr_scanexp_a +}\fi
    \if    -#1\xint_dothis {\XINT_expr_scanexp_a -}\fi
    \xint_orthat
    {]\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#1}%
}%
\def\XINT_expr_scanexp_main_b #1%
{%
    \ifcat \relax #1\expandafter\XINT_expr_scanexp_hit_cs_b\fi
    \ifnum\xint_c_ix<1\string#1 \else\expandafter\XINT_expr_scanexp_next_b\fi
    #1\XINT_expr_scanexp_again_b
}%
```

1.4f had _getop here, but let's jump directly to _getop_a.

```
\def\XINT_expr_scanexp_hit_cs_b\ifnum#1\fi#2\XINT_expr_scanexp_again_b
{%
    ]\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#2%
}%
```

```
\def\XINT_expr_scanexp_again_b #1%
{%
    \expandafter\XINT_expr_scanexp_main_b\romannumeral`&&@#1%
}%
\def\XINT_expr_scanexp_next_b #1\XINT_expr_scanexp_again_b
{%
    \if _#1\xint_dothis\XINT_expr_scanexp_again\fi
    \xint_orthat
    {]\iffalse{{{\fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop_a#1}%
}%
```

12.11.4 Hexadecimal numbers

1.2d has moved most of the handling of tacit multiplication to \XINT_expr_getop, but we have to do some of it here, because we apply \string before calling \XINT_expr_scanhexI_aa. I do not insert the * in \XINT_expr_scanhexI_a, because it is its higher precedence variant which will is expected, to do the same as when a non-hexadecimal number prefixes a sub-expression. Tacit multiplication in front of variable or function names will not work (because of this \string).

Extended for 1.2l to ignore underscore character _ if encountered within digits.

(some above remarks have been obsoleted for some long time, no more applied \string since 1.4)

Notice that internal representation adds a [N] part only in case input used "DDD.dddd form, for compatibility with \xintiiexpr which is not compatible with such internal representation.

At 1.4g a very long-standing bug was fixed: input such as "\foo broke the parser because (incredibly) the \foo token was picked up unexpanded and ended up as is in an \ifcat !

Another long-standing bug was fixed at 1.4g: contrarily to the decimal case, here in the hexadecimal input leading zeros were not trimmed. This was ok, because formerly \xintHexToDec trimmed leading zeros, but at 1.2m 2017/07/31 xintbinhex.sty was modified and this ceased being the case. But I forgot to upgrade the parser here at that time. Leading zeros would in many circumstances (presence of a fractional part, or \xintiiexpr context) lead to wrong results. Leading zeros are now trimmed during input.

```
\def\XINT_expr_hex_in #1.#2#3;%
{%
    \expanded{{{\if#2>%
      \xintHexToDec{#1}%
    \else
      \xintiiMul{\xintiiPow{625}{\xintLength{#3}}}{\xintHexToDec{#1#3}}%
      [\the\numexpr-4*\xintLength{#3}]%
    \fi}}\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
```

Let's not forget to grab-expand next token first as is normal rule of operation. Formerly called \XINT_expr_scanhex_I and had " upfront.

```
\def\XINT_expr_starthex #1%
{%
    \expandafter\XINT_expr_hex_in\expanded\bgroup
    \expandafter\XINT_expr_scanhexIgobz_a\romannumeral`&&@#1%
}%
\def\XINT_expr_scanhexIgobz_a #1%
{%
    \ifcat #1\relax
      0.>;\iffalse{\fi\expandafter}\expandafter\xint_gobble_i\fi
    \XINT_expr_scanhexIgobz_aa #1%
}%
```

```
\def\XINT_expr_scanhexIgobz_aa #1%
{%
    \if\ifnum`#1>`0
       \ifnum`#1>`9
       \ifnum`#1>`@
       \ifnum`#1>`F
       0\else1\fi\else0\fi\else1\fi\else0\fi 1%
       \xint_dothis\XINT_expr_scanhexI_b
    \fi
    \if 0#1\xint_dothis\XINT_expr_scanhexIgobz_bgob\fi
    \if _#1\xint_dothis\XINT_expr_scanhexIgobz_bgob\fi
    \if .#1\xint_dothis\XINT_expr_scanhexIgobz_toII\fi
    \xint_orthat
     {\XINT_expandableerror
        {Expected an hexadecimal digit but got `#1'. Using `0'.}%
      0.>;\iffalse{\fi}}%
    #1%
}%
\def\XINT_expr_scanhexIgobz_bgob #1#2%
{%
    \expandafter\XINT_expr_scanhexIgobz_a\romannumeral`&&@#2%
}%
\def\XINT_expr_scanhexIgobz_toII .#1%
{%
    0..\expandafter\XINT_expr_scanhexII_a\romannumeral`&&@#1%
}%
\def\XINT_expr_scanhexI_a #1%
{%
    \ifcat #1\relax
      .>;\iffalse{\fi\expandafter}\expandafter\xint_gobble_i\fi
    \XINT_expr_scanhexI_aa #1%
}%
\def\XINT_expr_scanhexI_aa #1%
{%
    \if\ifnum`#1>`/
       \ifnum`#1>`9
       \ifnum`#1>`@
       \ifnum`#1>`F
       0\else1\fi\else0\fi\else1\fi\else0\fi 1%
       \expandafter\XINT_expr_scanhexI_b
    \else
       \if _#1\xint_dothis{\expandafter\XINT_expr_scanhexI_bgob}\fi
       \if .#1\xint_dothis{\expandafter\XINT_expr_scanhexI_toII}\fi
       \xint_orthat {.>;\iffalse{\fi\expandafter}}%
    \fi
    #1%
}%
\def\XINT_expr_scanhexI_b #1#2%
{%
    #1\expandafter\XINT_expr_scanhexI_a\romannumeral`&&@#2%
}%
\def\XINT_expr_scanhexI_bgob #1#2%
```

```
{%
    \expandafter\XINT_expr_scanhexI_a\romannumeral`&&@#2%
}%
\def\XINT_expr_scanhexI_toII .#1%
{%
    ..\expandafter\XINT_expr_scanhexII_a\romannumeral`&&@#1%
}%
\def\XINT_expr_scanhexII_a #1%
{%
    \ifcat #1\relax\xint_dothis{;\iffalse{\fi}#1}\fi
    \xint_orthat {\XINT_expr_scanhexII_aa #1}%
}%
\def\XINT_expr_scanhexII_aa #1%
{%
    \if\ifnum`#1>`/
       \ifnum`#1>`9
       \ifnum`#1>`@
       \ifnum`#1>`F
       0\else1\fi\else0\fi\else1\fi\else0\fi 1%
       \expandafter\XINT_expr_scanhexII_b
    \else
       \if _#1\xint_dothis{\expandafter\XINT_expr_scanhexII_bgob}\fi
       \xint_orthat{;\iffalse{\fi\expandafter}}%
    \fi
    #1%
}%
\def\XINT_expr_scanhexII_b #1#2%
{%
    #1\expandafter\XINT_expr_scanhexII_a\romannumeral`&&@#2%
}%
\def\XINT_expr_scanhexII_bgob #1#2%
{%
    \expandafter\XINT_expr_scanhexII_a\romannumeral`&&@#2%
}%
```

12.11.5 \XINT_expr_startfunc: collecting names of functions and variables

At 1.4 the first token left over has not been submitted to \string. We also know it is not a control sequence. So we can test catcode to identify if operator is found. And it is allowed to hit some operator such as a closing parenthesis we will then insert the «nil» value (edited: which however will cause certain breakage of the infix binary operators: I notice I did not insert None {{}} but nil {}, perhaps by oversight).

There was prior to 1.4 solely the dispatch in \XINT_expr_scanfunc_b but now we do it immediately and issue \XINT_expr_func only in certain cases.

Comments here have been removed because 1.4g did a refactoring and renamed \XINT_expr_scanfunc to \XINT_expr_startfunc, moving half of it earlier inside the getnextfork macros.

```
\def\XINT_expr_startfunc #1%
   {\expandafter\XINT_expr_func\expanded\bgroup#1\XINT_expr_scanfunc_a}%
\def\XINT_expr_scanfunc_a #1%
{%
    \expandafter\XINT_expr_scanfunc_b\romannumeral`&&@#1%
}%
```

This handles: 1) (indirectly) tacit multiplication by a variable in front a of sub-expression, 2) (indirectly) tacit multiplication in front of a \count etc..., 3) functions which are recognized via an encountered opening parenthesis (but later this must be disambiguated from variables with tacit multiplication) 4) 5) 6) 7) acceptable components of a variable or function names: @, underscore, digits, letters (or chars of category code letter.)

The short lived 1.2d which followed the even shorter lived 1.2c managed to introduce a bug here as it removed the check for catcode 11 !, which must be recognized if ! is not to be taken as part of a variable name. Don't know what I was thinking, it was the time when I was moving the handling of tacit mutliplication entirely to the \XINT_expr_getop side. Fixed in 1.2e.

I almost decided to remove the \ifcat\relax test whose rôle is to avoid the \string#1 to do something bad is the escape char is a digit! Perhaps I will remove it at some point ! I truly almost did it, but also the case of no escape char is a problem (\string\0, if \0 is a count ...)

The (indirectly) above means that via \XINT_expr_func then \XINT_expr_op__ one goes back to \XINT_expr_getop then \XINT_expr_getop_b which is the location where tacit multiplication is now centralized. This makes the treatment of tacit multiplication for situations such as <variable>\count or <variable>\xintexpr..\relax, perhaps a bit sub-optimal, but first the variable name must be gathered, second the variable must expand to its value.

```
\def\XINT_expr_scanfunc_b #1%
{%
  \ifcat \relax#1\xint_dothis{\iffalse{\fi}(_#1}\fi
  \if (#1\xint_dothis{\iffalse{\fi}(`}\fi
  \if 1\ifcat a#10\fi
       \ifnum\xint_c_ix<1\string#1 0\fi
       \if @#10\fi
       \if _#10\fi
      1%
      \xint_dothis{\iffalse{\fi}(_#1}\fi
  \xint_orthat {#1\XINT_expr_scanfunc_a}%
}%
```

12.11.6 \XINT_expr_func: dispatch to variable replacement or to function execution

Comments written 2015/11/12: earlier there was an \ifcsname test for checking if we had a variable in front of a (, for tacit multiplication for example in x(y+z(x+w)) to work. But after I had implemented functions (that was yesterday...), I had the problem if was impossible to re-declare a variable name such as "f" as a function name. The problem is that here we can not test if the function is available because we don't know if we are in expr, iiexpr or floatexpr. The \xint_c_ii^v causes all fetching operations to stop and control is handed over to the routines which will be expr, iiexpr ou floatexpr specific, i.e. the \XINT_{expr|iiexpr|flexpr}_op_{`|_} which are invoked by the until_<op>_b macros earlier in the stream. Functions may exist for one but not the two other parsers. Variables are declared via one parser and usable in the others, but naturally \xintiiexpr has its restrictions.

Thinking about this again I decided to treat a priori cases such as x(...) as functions, after having assigned to each variable a low-weight macro which will convert this into _getop\.=<value of x>*(...). To activate that macro at the right time I could for this exploit the "onliteral" intercept, which is parser independent (1.2c).

This led to me necessarily to rewrite partially the seq, add, mul, subs, iter ... routines as now the variables fetch only one token. I think the thing is more efficient.

1.2c had \def\XINT_expr_func #1(#2{\xint_c_ii^v #2{#1}}

In \XINT_expr_func the #2 is _ if #1 must be a variable name, or #2=` if #1 must be either a function name or possibly a variable name which will then have to be followed by tacit multiplication before the opening parenthesis.

The \xint_c_ii^v is there because _op_` must know in which parser it works. Dispendious for _. Hence I modify for 1.2d.

```
\def\XINT_expr_func #1(#2{\if _#2\xint_dothis{\XINT_expr_op__{#1}}\fi
                            \xint_orthat{{#1}\xint_c_ii^v #2}}%
```

12.12 \XINT_expr_op_`: launch function or pseudo-function, or evaluate variable and insert operator of multiplication in front of parenthesized contents

The "onliteral" intercepts is for bool, togl, protect, ... but also for add, mul, seq, etc... Genuine functions have expr, iiexpr and flexpr versions (or only one or two of the three) and trigger here the use of the suitable parser-dependant form. The former (pseudo functions and functions handling dummy variables) first trigger a parser independent mechanism.

With 1.2c "onliteral" is also used to disambiguate a variable followed by an opening parenthesis from a function and then apply tacit multiplication. However as I use only a \ifcsname test, in order to be able to re-define a variable as function, I move the check for being a function first. Each variable name now has its onliteral_<name> associated macro. This used to be decided much earlier at the time of \XINT_expr_func.

The advantage of 1.2c code is that the same name can be used for a variable or a function.

Modified at 1.4i (2021/06/11). The 1.2c abuse of «onliteral» for both tacit multiplication in front of an opening parenthesis and «generic» functions or pseudo-functions meant that the latter were vulnerable against user redefinition of a function name as a variable name. This applied to subs, subsm, subsn, seq, add, mul, ndseq, ndmap, ndfillraw, bool, togl, protect, qint, qfrac, qfloat, qraw, random, qrand, rbit and the most susceptible in real life was probably "seq".

Now variables have an associated «var*» named macro, not «onliteral».

In passing I refactor here in a \romannumeral inspired way how \csname and TeX booleans are intertwined, minimizing \expandafter usage.

```
\def\XINT_tmpa #1#2#3{%
  \def #1##1%
  {%
    \csname
      XINT_\ifcsname XINT_#3_func_##1\endcsname
        #3_func_##1\expandafter\endcsname\romannumeral`&&@\expandafter#2%
      \romannumeral\else
      \ifcsname XINT_expr_onliteral_##1\endcsname
        expr_onliteral_##1\expandafter\endcsname\romannumeral
      \else
      \ifcsname XINT_expr_var*_##1\endcsname
        expr_var*_##1\expandafter\endcsname\romannumeral
      \else
        #3_func_\XINT_expr_unknown_function {##1}%
                \expandafter\endcsname\romannumeral`&&@\expandafter#2%
      \romannumeral
      \fi\fi\fi\xint_c_
  }%
}%
\xintFor #1 in {expr,flexpr,iiexpr} \do {%
     \expandafter\XINT_tmpa
                 \csname XINT_#1_op_`\expandafter\endcsname
                 \csname XINT_#1_oparen\endcsname
                 {#1}%
}%
\def\XINT_expr_unknown_function #1%
```

```
  {\XINT_expandableerror{`#1' is unknown, say `Isome_func' or I use 0.}}%
\def\XINT_expr_func_ #1#2#3{#1#2{{0}}}%
\let\XINT_flexpr_func_\XINT_expr_func_
\let\XINT_iiexpr_func_\XINT_expr_func_
```

12.13 \XINT_expr_op__: replace a variable by its value and then fetch next operator

The 1.1 mechanism for \XINT_expr_var_<varname> has been modified in 1.2c. The <varname> associated macro is now only expanded once, not twice. We arrive here via \XINT_expr_func.

At 1.4 \XINT_expr_getop is launched with accumulated result on its left. But the omit and abort keywords are implemented via fake variables which rely on possibility to modify incoming upfront tokens. If we did here something such as

```
_var_#1\expandafter\endcsname\romannumeral`^^@\XINT_expr_getop
```

the premature expansion of getop would break the var_omit and var_abort mechanism. Thus we revert to former code which locates an \XINT_expr_getop (call it _legacy) before the tokens from the variable expansion (in xintexpr < 1.4 the normal variables expanded to a single token so the overhead was not serious) so we can expand fake variables first.

Abusing variables to manipulate the incoming token stream is a bit bad, usually I prefer functions for this (such as the break() function) but then I have to define 3 macros for the 3 parsers.

This trick of fake variables puts thus a general overhead at various locations, and the situation here is REALLY not satisfactory. But 1.4 has (had) to be released now.

Even if I could put the \csname XINT_expr_var_foo\endcsname upfront, which would then be f-expanded, this would still need \XINT_expr_put_op_first to use its \expandafter's as long as \XINT_expr_var_foo expands to {\XINT_expr_varvalue_foo} with a not-yet expanded \XINT_expr_var_value.

I could let \XINT_expr_var_foo expand to \expandafter{\XINT_expr_varvalue_foo} allowing then (if it gets f-expanded) probably to drop the \expandafter in \XINT_expr_put_op_first. But I can not consider this option in the form

```
_var_foo\expandafter\endcsname\romannumeral`^^@\XINT_expr_getop
```

until the issue with fake variables such as omit and abort which must act before \XINT_expr_getop has some workaround. This could be implemented here with some extra branch, i.e. there would not be some \XINT_expr_var_omit but something else filtered out in the \else branch here.

The above comments mention only omit and abort, but the case of real dummy variables also needs consideration.

At 1.4g, I test first for existence of \XINT_expr_onliteral_foo.

Updated for 1.4i: now rather existence of \XINT_expr_var*_foo is tested.

This is a trick which allows to distinguish actual or dummy variables from really fake variables omit and abort (must check if there are others). For the real or dummy variables we can trigger the expansion of the \XINT_expr_getop before the one of the variable. I could test vor varvalue_foo but this applies only to real variables not dummy variables. Actual and dummy variables are thus handled slightly faster at 1.4g as there is less induced moving around (the \expandafter chain in \XINT_expr_put_op_first still applies at this stage, as I have not yet re-examined the var/varlue mechanism). And the test for var_foo is moved directly inside the \csname construct in the \else branch which now handles together fake variables and non-existing variables.

I only have to make sure dummy variables are really safe being handled this way with the getop action having being done before they expand, but it looks ok. Attention it is crucial that if \XINT_expr_getop finds a \relax it inserts \xint_c_\relax so the \relax token is still there!

With this refactoring the \XINT_expr_getop_legacy is applied only in case of non-existent variables or fake variables omit/abort or things such as nil, None, false, true, False, True.

If user in interactive mode fixes the variable name, the \XINT_expr_var_foo expanded once with deliver {\XINT_expr_varvalue_foo} (if not dummy), and the braces are maintained by \XINT_expr_ge top_legacy.

```
\def\XINT_expr_op__  #1% op__ with two _'s
{%
    \ifcsname XINT_expr_var*_#1\endcsname
       \csname XINT_expr_var_#1\expandafter\endcsname
       \romannumeral`&&@\expandafter\XINT_expr_getop
    \else
      \expandafter\expandafter\expandafter\XINT_expr_getop_legacy
      \csname XINT_expr_var_%
              \ifcsname XINT_expr_var_#1\endcsname#1\else\XINT_expr_unknown_variable{#1}\fi
      \expandafter\endcsname
    \fi
}%
\def\XINT_expr_unknown_variable #1%
   {\XINT_expandableerror {`#1' unknown, say `Isome_var' or I use 0.}}%
\def\XINT_expr_var_{{{0}}}%
\let\XINT_flexpr_op__ \XINT_expr_op__
\let\XINT_iiexpr_op__ \XINT_expr_op__
\def\XINT_expr_getop_legacy #1%
{%
    \expanded{\unexpanded{{#1}}\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
```

12.14 \XINT_expr_getop: fetch the next operator or closing parenthesis or end of expression

Release 1.1 implements multi-character operators.

1.2d adds tacit mutiplication also in front of variable or functions names starting with a letter, not only a @ or a _ as was already the case. This is for (x+y)z situations. It also applies higher precedence in cases like x/2y or x/2@, or x/2max(3,5), or x/2\xintexpr 3\relax.

In fact, finally I decide that all sorts of tacit multiplication will always use the higher precedence.

Indeed I hesitated somewhat: with the current code one does not know if \XINT_expr_getop as invoked after a closing parenthesis or because a number parsing ended, and I felt distinguishing the two was unneeded extra stuff. This means cases like (a+b)/(c+d)(e+f) will first multiply the last two parenthesized terms.

1.2q adds tacit multiplication in cases such as (1+1)3 or 5!7!

1.4 has simplified coding here as \XINT_expr_getop expansion happens at a time when a fetched value has already being stored.

Prior to 1.4g there was an \if _#1\xint_dothis\xint_secondofthree\fi because the _ can be used to start names, for private use by package (for example by polexpr). But this test was silly because these usages are only with a _ of catcode 11. And allowing non-catcode 11 _ also to trigger tacit multiplication caused an infinite loop in collaboration with \XINT_expr_scanfunc, see explanations there (now removed after refactoring, see \XINT_expr_startfunc).

The situation with the @ is different because we must allow it even as catcode 12 as a name, as it used in the syntax and must work the same if of catcode 11 or 12. No infinite loop because it is filtered out by one of the \XINT_expr_getnextfork macros.

The check for : to send it to thirdofthree "getop" branch is needed, last time I checked, because during some part of at least \xintdeffunc, some scantokens are done which need to work with the : of catcode 11, and it would be misconstrued to start a name if not filtered out.

```
\def\XINT_expr_getop #1%
{%
```

```
    \expandafter\XINT_expr_getop_a\romannumeral`&&@#1%
}%
\catcode`* 11
\def\XINT_expr_getop_a #1%
{%
    \ifx   \relax #1\xint_dothis\xint_firstofthree\fi
    \ifcat \relax #1\xint_dothis\xint_secondofthree\fi
    \ifnum\xint_c_ix<1\string#1 \xint_dothis\xint_secondofthree\fi
    \if    :#1\xint_dothis      \xint_thirdofthree\fi
    \if    @#1\xint_dothis      \xint_secondofthree\fi
    \if    (#1\xint_dothis      \xint_secondofthree\fi %)
    \ifcat a#1\xint_dothis      \xint_secondofthree\fi
    \xint_orthat \xint_thirdofthree
```

Formerly \XINT_expr_foundend as firstofthree but at 1.4g let's simply insert \xint_c_ as the #1 is \relax (and anyhow a place-holder according to remark in definition of \XINT_expr_foundend

```
    \xint_c_
```

Tacit multiplication with higher precedence. Formerly \XINT_expr_precedence_*** was used, renamed to \XINT_expr_prec_tacit at 1.4g in case a backport is done of the \bnumdefinfix from bnumexpr.

```
    {\XINT_expr_prec_tacit *}%
```

This is only location which jumps to \XINT_expr_getop_b. At 1.4f and perhaps for old legacy reasons this was \expandafter\XINT_expr_getop_b \string#1 but I see no reason now for applying \string to #1. Removed at 1.4g. And the #1 now moved out of the secondofthree and thirdofthree branches.

```
    \XINT_expr_getop_b
    #1%
}%
\catcode`* 12
```

\relax is a place holder here. At 1.4g, we don't use \XINT_expr_foundend anymore in \XINT_expr_getop_a which was slightly refactored, but it is used elsewhere.

Attention that keeping a \relax around if \XINT_expr_getop hits it is crucial to good functioning of dummy variables after 1.4g refactoring of \XINT_expr_op__, the \relax being used as delimiter by dummy variables, and \XINT_expr_getop is now expanded before the variable itself does its thing.

```
\def\XINT_expr_foundend {\xint_c_ \relax}%
```

? is a very special operator with top precedence which will check if the next token is another ?, while avoiding removing a brace pair from token stream due to its syntax. Pre 1.1 releases used : rather than ??, but we need : for Python like slices of lists.

null char is used as hack to implement A/B[N] raw input at 1.4. See also \XINT_expr_scanint_c.

Memo: 1.4g, the token fetched by \XINT_expr_getop_b has not anymore been previously submitted in \XINT_expr_getop_a to \string.

```
\def\XINT_expr_getop_b#1{\def\XINT_expr_getop_b ##1%
{%
     \if &&@##1\xint_dothis{#1&&@}\fi
     \if   '##1\xint_dothis{\XINT_expr_binopwrd }\fi
     \if   ?##1\xint_dothis{\XINT_expr_precedence_? ?}\fi
     \xint_orthat          {\XINT_expr_scanop_a ##1}%
}}\expandafter\XINT_expr_getop_b\csname XINT_expr_precedence_&&@\endcsname
\def\XINT_expr_binopwrd #1'%
{%
    \expandafter\XINT_expr_foundop_a
```

```
    \csname XINT_expr_itself_\xint_zapspaces #1 \xint_gobble_i\endcsname
}%
\def\XINT_expr_scanop_a #1#2%
{%
    \expandafter\XINT_expr_scanop_b\expandafter#1\romannumeral`&&@#2%
}%
```

Multi-character operators have an associated itself macro at each stage of decomposition starting at two characters. Here, nothing imposes to the operator characters not to be of catcode letter, this constraint applies only on the first character and is done via \XINT_expr_getop_a, to handle in particular tacit multiplication in front of variable or function names.

But it would be dangerous to allow letters in operator characters, again due to existence of variables and functions, and anyhow there is no user interface to add such custom operators. However in bnumexpr, such a constraint does not exist.

I don't worry too much about efficiency here... and at 1.4g I have re-written for code readability only. Once we see that #1#2 is not a candidate to be or start an operator, we need to check if single-character operator #1 is really an operator and this is done via the existence of the precedence token.

Unfortunately the 1.4g refactoring of the scanop macros had a bad bug: \XINT_expr_scanop_c inserted \romannumeral`^^@ in stream but did not grab a token first so a space would stop the \romannumeral and then the #2 in \XINT_expr_scanop_d was not pre-expanded and ended up alone in \ifcat. It is too distant in the past the time when I wrote the core of xintexpr in 2013... older and dumber now.

```
\def\XINT_expr_scanop_b #1#2%
{%
    \unless\ifcat#2\relax
           \ifcsname XINT_expr_itself_#1#2\endcsname
           \XINT_expr_scanop_c
    \fi\fi
    \XINT_expr_foundop_a #1#2%
}%
\def\XINT_expr_scanop_c #1#2#3#4#5#6% #1#2=\fi\fi
{%
    #1#2%
    \expandafter\XINT_expr_scanop_d\csname XINT_expr_itself_#4#5\expandafter\endcsname
    \romannumeral`&&@#6%
}%
\def\XINT_expr_scanop_d #1#2%
{%
    \unless\ifcat#2\relax
           \ifcsname XINT_expr_itself_#1#2\endcsname
           \XINT_expr_scanop_c
    \fi\fi
    \XINT_expr_foundop #1#2%
}%
\def\XINT_expr_foundop_a #1%
{%
    \ifcsname XINT_expr_precedence_#1\endcsname
        \csname XINT_expr_precedence_#1\expandafter\endcsname
        \expandafter #1%
    \else
        \expandafter\XINT_expr_getop\romannumeral`&&@%
        \xint_afterfi{\XINT_expandableerror
```

```
        {Expected an operator but got `#1'. Ignoring.}}%
    \fi
}%
\def\XINT_expr_foundop #1{\csname XINT_expr_precedence_#1\endcsname #1}%
```

12.15 Expansion spanning; opening and closing parentheses

These comments apply to all definitions coming next relative to execution of operations from parsing of syntax.

Refactored (and unified) at 1.4. In particular the 1.4 scheme uses op, exec, check-, and checkp. Formerly it was until_a (check-) and until_b (now split into checkp and exec).

This way neither check- nor checkp have to grab the accumulated number so far (top of stack if you like) and besides one never has to go back to check- from checkp (and neither from check-).

Prior to 1.4, accumulated intermediate results were stored as one token, but now we have to use \expanded to propagate expansion beyond possibly arbitrary long braced nested data. With the 1.4 refactoring we do this only once and only grab a second time the data if we actually have to act upon it.

Version 1.1 had a hack inside the until macros for handling the omit and abort in iterations over dummy variables. This has been removed by 1.2c, see the subsection where omit and abort are discussed.

Exceptionally, the check- is here abbreviated to check.

```
\catcode`) 11
\def\XINT_tmpa #1#2#3#4#5#6%
{%
    \def#1% start
    {%
        \expandafter#2\romannumeral`&&@\XINT_expr_getnext
    }%
    \def#2##1% check
    {%
        \xint_UDsignfork
          ##1{\expandafter#3\romannumeral`&&@#4}%
            -{#3##1}%
        \krof
    }%
    \def#3##1##2% checkp
    {%
        \ifcase ##1%
           \expandafter\XINT_expr_done
        \or\expandafter#5%
        \else
           \expandafter#3\romannumeral`&&@\csname XINT_#6_op_##2\expandafter\endcsname
        \fi
    }%
    \def#5%
    {%
        \XINT_expandableerror
        {Extra ) removed. Hit <return>, fingers crossed.}%
        \expandafter#2\romannumeral`&&@\expandafter\XINT_expr_put_op_first
        \romannumeral`&&@\XINT_expr_getop_legacy
    }%
}%
```

```
\let\XINT_expr_done\space
\xintFor #1 in {expr,flexpr,iiexpr} \do {%
    \expandafter\XINT_tmpa
    \csname XINT_#1_start\expandafter\endcsname
    \csname XINT_#1_check\expandafter\endcsname
    \csname XINT_#1_checkp\expandafter\endcsname
    \csname XINT_#1_op_-xii\expandafter\endcsname
    \csname XINT_#1_extra_)\endcsname
    {#1}%
}%
```

Here also we take some shortcuts relative to general philosophy and have no explicit exec macro.

```
\def\XINT_tmpa #1#2#3#4#5#6#7%
{%
    \def #1##1% op_(
    {%
        \expandafter #4\romannumeral`&&@\XINT_expr_getnext
    }%
    \def #2##1% op_)
    {%
        \expanded{\unexpanded{\XINT_expr_put_op_first{##1}}\expandafter}%
        \romannumeral`&&@\XINT_expr_getop
    }%
    \def #3% oparen
    {%
        \expandafter #4\romannumeral`&&@\XINT_expr_getnext
    }%
    \def #4##1% check-
    {%
        \xint_UDsignfork
            ##1{\expandafter#5\romannumeral`&&@#6}%
              -{#5##1}%
        \krof
    }%
    \def #5##1##2% checkp
    {%
        \ifcase ##1\expandafter\XINT_expr_missing_)
        \or \csname XINT_#7_op_##2\expandafter\endcsname
        \else
          \expandafter #5\romannumeral`&&@\csname XINT_#7_op_##2\expandafter\endcsname
        \fi
    }%
}%
\def\XINT_expr_missing_)
   {\XINT_expandableerror{End of expression found, but some ) was missing there.}%
    \xint_c_ \XINT_expr_done }%
\xintFor #1 in {expr,flexpr,iiexpr} \do {%
    \expandafter\XINT_tmpa
    \csname XINT_#1_op_(\expandafter\endcsname
    \csname XINT_#1_op_)\expandafter\endcsname
    \csname XINT_#1_oparen\expandafter\endcsname
    \csname XINT_#1_check-_)\expandafter\endcsname
    \csname XINT_#1_checkp_)\expandafter\endcsname
```

```
    \csname XINT_#1_op_-xii\endcsname
    {#1}%
}%
\let\XINT_expr_precedence_)\xint_c_i
\catcode`) 12
```

12.16 The comma as binary operator

New with 1.09a. Refactored at 1.4.

```
\def\XINT_tmpa #1#2#3#4#5#6%
{%
    \def #1##1% \XINT_expr_op_,
    {%
      \expanded{\unexpanded{#2{##1}}\expandafter}%
      \romannumeral`&&@\expandafter#3\romannumeral`&&@\XINT_expr_getnext
    }%
    \def #2##1##2##3##4{##2##3{##1##4}}% \XINT_expr_exec_,
    \def #3##1% \XINT_expr_check-_,
    {%
      \xint_UDsignfork
        ##1{\expandafter#4\romannumeral`&&@#5}%
          -{#4##1}%
      \krof
    }%
    \def #4##1##2% \XINT_expr_checkp_,
    {%
      \ifnum ##1>\xint_c_iii
        \expandafter#4%
           \romannumeral`&&@\csname XINT_#6_op_##2\expandafter\endcsname
      \else
        \expandafter##1\expandafter##2%
      \fi
    }%
}%
\xintFor #1 in {expr,flexpr,iiexpr} \do {%
\expandafter\XINT_tmpa
    \csname XINT_#1_op_,\expandafter\endcsname
    \csname XINT_#1_exec_,\expandafter\endcsname
    \csname XINT_#1_check-_,\expandafter\endcsname
    \csname XINT_#1_checkp_,\expandafter\endcsname
    \csname XINT_#1_op_-xii\endcsname {#1}%
}%
\expandafter\let\csname XINT_expr_precedence_,\endcsname\xint_c_iii
```

12.17 The minus as prefix operator of variable precedence level

Inherits the precedence level of the previous infix operator, if the latter has at least the precedence level of binary + and -, i.e. currently 12.

Refactored at 1.4.

At 1.4g I belatedly observe that I have been defining architecture for op_-xvi but such operator can never be created, because there are no infix operators of precedence level 16. Perhaps in the past this was really needed? But now such 16 is precedence level of tacit multiplication which is implemented simply by the \XINT_expr_prec_tacit token, there is no macro check-_*** which would need an op_-xvi.

For the record: at least one scenario exists which creates tacit multiplication in front of a unary -, it is 2\count0 which first generates tacit multiplication then applies \number to \count0, but the operator is still *, so this triggers only \XINT_expr_op_-xiv, not -xvi.

At 1.4g we need 17 and not 18 anymore as the precedence of unary minus following power operators ^ and **. The needed \xint_c_xvii creation was added to xintkernel.sty.

```
\def\XINT_tmpb #1#2#3#4#5#6#7%
{%
    \def #1% \XINT_expr_op_-<level>
    {%
      \expandafter #2\romannumeral`&&@\expandafter#3%
      \romannumeral`&&@\XINT_expr_getnext
    }%
    \def #2##1##2##3% \XINT_expr_exec_-<level>
    {%
      \expandafter ##1\expandafter ##2\expandafter
       {%
        \romannumeral`&&@\XINT:NEhook:f:one:from:one
        {\romannumeral`&&@#7##3}%
       }%
    }%
    \def #3##1% \XINT_expr_check-_-<level>
    {%
      \xint_UDsignfork
        ##1{\expandafter #4\romannumeral`&&@#1}%
          -{#4##1}%
      \krof
    }%
    \def #4##1##2% \XINT_expr_checkp_-<level>
    {%
      \ifnum ##1>#5%
        \expandafter #4%
        \romannumeral`&&@\csname XINT_#6_op_##2\expandafter\endcsname
      \else
        \expandafter ##1\expandafter ##2%
      \fi
    }%
}%
\def\XINT_tmpa #1#2#3%
{%
    \expandafter\XINT_tmpb
    \csname XINT_#1_op_-#3\expandafter\endcsname
    \csname XINT_#1_exec_-#3\expandafter\endcsname
    \csname XINT_#1_check-_-#3\expandafter\endcsname
    \csname XINT_#1_checkp_-#3\expandafter\endcsname
    \csname xint_c_#3\endcsname {#1}#2%
}%
\xintApplyInline{\XINT_tmpa {expr}\xintOpp}{{xii}{xiv}{xvii}}%
\xintApplyInline{\XINT_tmpa {flexpr}\xintOpp}{{xii}{xiv}{xvii}}%
\xintApplyInline{\XINT_tmpa {iiexpr}\xintiiOpp}{{xii}{xiv}{xvii}}%
```

12.18 The * as Python-like «unpacking» prefix operator

New with 1.4. Prior to 1.4 the internal data structure was the one of \csname encapsulated comma separated numbers. No hierarchical structure was (easily) possible. At 1.4, we can use TeX braces because there is no detokenization to catcode 12.

```
\def\XINT_tmpa#1#2#3%
{%
    \def#1##1{\expandafter#2\romannumeral`&&@\XINT_expr_getnext}%
    \def#2##1##2%
    {%
      \ifnum ##1>\xint_c_xx
        \expandafter #2%
        \romannumeral`&&@\csname XINT_#3_op_##2\expandafter\endcsname
      \else
        \expandafter##1\expandafter##2\romannumeral0\expandafter\XINT:NEhook:unpack
      \fi
    }%
}%
\def\XINT:NEhook:unpack{\xint_stop_atfirstofone}%
\xintFor* #1 in {{expr}{flexpr}{iiexpr}}:
    {\expandafter\XINT_tmpa\csname XINT_#1_op_0\expandafter\endcsname
                            \csname XINT_#1_until_unpack\endcsname {#1}}%
```

12.19 Infix operators

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1.2d adds the *** for tying via tacit multiplication, for example x/2y. Actually I don't need the _itself mechanism for ***, only a precedence.

At 1.4b we must make sure that the ! in expansion of \XINT_expr_itself_!= is of catcode 12 and not of catcode 11. This is because implementation of chaining of comparison operators proceeds via inserting the itself macro directly into upcoming token stream, whereas formerly such itself macros would be expanded only in a \csname...\endcsname context.

```
\catcode`& 12 \catcode`! 12
\xintFor* #1 in {{==}{!=}{<=}{>=}{&&}{||}{//}{/:}{..}{..[}{].}{]..}}%
    \do {\expandafter\def\csname XINT_expr_itself_#1\endcsname {#1}}%
\catcode`& 7  \catcode`! 11
```

12.19.1 &&, ||, //, /:, +, −, *, /, ^, **, 'and', 'or', 'xor', and 'mod'

At 1.4g I finally decide to enact the switch to right associativity for the power operators ^ and **.

This goes via inserting into the checkp macros not anymore the precedence chardef token (which now only serves as left precedence, inserted in the token stream) but in its place an \xint_c

_<roman> token holding the right precedence. Which is also transmitted to spanned unary minus operators.

Here only levels 12, 14, and 17 are created as right precedences.

#6 and #7 got permuted and the new #7 is directly a control sequence. Also #3 and #4 are now integers which need \romannumeral. The change in \XINT_expr_defbin_c does not propagate as it is re-defined shortly thereafter.

```
\def\XINT_expr_defbin_c #1#2#3#4#5#6#7#8%
{%
  \def #1##1% \XINT_expr_op_<op>
  {%
    \expanded{\unexpanded{#2{##1}}\expandafter}%
    \romannumeral`&&@\expandafter#3\romannumeral`&&@\XINT_expr_getnext
  }%
  \def #2##1##2##3###4% \XINT_expr_exec_<op>
  {%
    \expandafter##2\expandafter##3\expandafter
      {\romannumeral`&&@\XINT:NEhook:f:one:from:two{\romannumeral`&&@#7##1###4}}%
  }%
  \def #3##1% \XINT_expr_check-_<op>
  {%
    \xint_UDsignfork
      ##1{\expandafter#4\romannumeral`&&@#5}%
        -{#4##1}%
    \krof
  }%
  \def #4##1##2% \XINT_expr_checkp_<op>
  {%
    \ifnum ##1>#6%
      \expandafter#4%
      \romannumeral`&&@\csname XINT_#8_op_##2\expandafter\endcsname
    \else
      \expandafter ##1\expandafter ##2%
    \fi
  }%
}%
\def\XINT_expr_defbin_b #1#2#3#4#5%
{%
  \expandafter\XINT_expr_defbin_c
  \csname XINT_#1_op_#2\expandafter\endcsname
  \csname XINT_#1_exec_#2\expandafter\endcsname
  \csname XINT_#1_check-_#2\expandafter\endcsname
  \csname XINT_#1_checkp_#2\expandafter\endcsname
  \csname XINT_#1_op_-\romannumeral\ifnum#4>12 #4\else12\fi\expandafter\endcsname
  \csname xint_c_\romannumeral#4\endcsname
  #5%
  {#1}%
  \expandafter % done 3 times but well
  \let\csname XINT_expr_precedence_#2\expandafter\endcsname
      \csname xint_c_\romannumeral#3\endcsname
}%
\XINT_expr_defbin_b {expr}  {||} {6} {6} \xintOR
\XINT_expr_defbin_b {flexpr}{||} {6} {6} \xintOR
```

```
\XINT_expr_defbin_b {iiexpr}{||} {6} {6} \xintOR
\catcode`& 12
\XINT_expr_defbin_b {expr}  {&&} {8} {8} \xintAND
\XINT_expr_defbin_b {flexpr}{&&} {8} {8} \xintAND
\XINT_expr_defbin_b {iiexpr}{&&} {8} {8} \xintAND
\catcode`& 7
\XINT_expr_defbin_b {expr}  {xor}{6} {6} \xintXOR
\XINT_expr_defbin_b {flexpr}{xor}{6} {6} \xintXOR
\XINT_expr_defbin_b {iiexpr}{xor}{6} {6} \xintXOR
\XINT_expr_defbin_b {expr}  {//} {14}{14}\xintDivFloor
\XINT_expr_defbin_b {flexpr}{//} {14}{14}\XINTinFloatDivFloor
\XINT_expr_defbin_b {iiexpr}{//} {14}{14}\xintiiDivFloor
\XINT_expr_defbin_b {expr}  {/:} {14}{14}\xintMod
\XINT_expr_defbin_b {flexpr}{/:} {14}{14}\XINTinFloatMod
\XINT_expr_defbin_b {iiexpr}{/:} {14}{14}\xintiiMod
\XINT_expr_defbin_b {expr}   +   {12}{12}\xintAdd
\XINT_expr_defbin_b {flexpr} +   {12}{12}\XINTinFloatAdd
\XINT_expr_defbin_b {iiexpr} +   {12}{12}\xintiiAdd
\XINT_expr_defbin_b {expr}   -   {12}{12}\xintSub
\XINT_expr_defbin_b {flexpr} -   {12}{12}\XINTinFloatSub
\XINT_expr_defbin_b {iiexpr} -   {12}{12}\xintiiSub
\XINT_expr_defbin_b {expr}   *   {14}{14}\xintMul
\XINT_expr_defbin_b {flexpr} *   {14}{14}\XINTinFloatMul
\XINT_expr_defbin_b {iiexpr} *   {14}{14}\xintiiMul
\let\XINT_expr_prec_tacit \xint_c_xvi
\XINT_expr_defbin_b {expr}   /   {14}{14}\xintDiv
\XINT_expr_defbin_b {flexpr} /   {14}{14}\XINTinFloatDiv
\XINT_expr_defbin_b {iiexpr} /   {14}{14}\xintiiDivRound
```

At 1.4g, right associativity is implemented via a lowered right precedence here.

```
\XINT_expr_defbin_b {expr}   ^   {18}{17}\xintPow
\XINT_expr_defbin_b {flexpr} ^   {18}{17}\XINTinFloatSciPow
\XINT_expr_defbin_b {iiexpr} ^   {18}{17}\xintiiPow
```

1.4g This is a trick (which was in old version of bnumexpr, I wonder why I did not have it here) but it will make error messages in case of **<token> confusing. The ^ here is of catcode 11 but it does not matter.

```
\expandafter\def\csname XINT_expr_itself_**\endcsname{^}%
\catcode`& 12
```

For this which contributes to implementing 'and', 'or', etc... see \XINT_expr_binopwrd.

```
\xintFor #1 in {and,or,xor,mod} \do
{%
   \expandafter\def\csname XINT_expr_itself_#1\endcsname {#1}%
}%
\expandafter\let\csname XINT_expr_precedence_and\expandafter\endcsname
                \csname XINT_expr_precedence_&&\endcsname
\expandafter\let\csname XINT_expr_precedence_or\expandafter\endcsname
                \csname XINT_expr_precedence_||\endcsname
\expandafter\let\csname XINT_expr_precedence_mod\expandafter\endcsname
                \csname XINT_expr_precedence_/:\endcsname
\xintFor #1 in {expr, flexpr, iiexpr} \do
{%
   \expandafter\let\csname XINT_#1_op_and\expandafter\endcsname
```

```
                    \csname XINT_#1_op_&&\endcsname
    \expandafter\let\csname XINT_#1_op_or\expandafter\endcsname
                    \csname XINT_#1_op_||\endcsname
    \expandafter\let\csname XINT_#1_op_mod\expandafter\endcsname
                    \csname XINT_#1_op_/:\endcsname
}%
\catcode`& 7
```

12.19.2 .., ..[, and].. for a..b and a..[b]..c syntax

The 1.4 exec_..[macros (which do no further expansion!) had silly \expandafter doing nothing for the sole reason of sharing a common \XINT_expr_defbin_c as used previously for the +, - etc... operators. At 1.4b we take the time to set things straight and do other similar simplifications.

```
\def\XINT_expr_defbin_c #1#2#3#4#5#6#7%
{%
  \def #1##1% \XINT_expr_op_..[
  {%
    \expanded{\unexpanded{#2{##1}}\expandafter}%
    \romannumeral`&&@\expandafter#3\romannumeral`&&@\XINT_expr_getnext
  }%
  \def #2##1##2##3##4% \XINT_expr_exec_..[
  {%
    ##2##3{{##1##4}}%
  }%
  \def #3##1% \XINT_expr_check-_..[
  {%
    \xint_UDsignfork
      ##1{\expandafter#4\romannumeral`&&@#5}%
        -{#4##1}%
    \krof
  }%
  \def #4##1##2% \XINT_expr_checkp_..[
  {%
    \ifnum ##1>#6%
      \expandafter#4%
      \romannumeral`&&@\csname XINT_#7_op_##2\expandafter\endcsname
    \else
      \expandafter ##1\expandafter ##2%
    \fi
  }%
}%
\def\XINT_expr_defbin_b #1%
{%
  \expandafter\XINT_expr_defbin_c
  \csname XINT_#1_op_..[\expandafter\endcsname
  \csname XINT_#1_exec_..[\expandafter\endcsname
  \csname XINT_#1_check-_..[\expandafter\endcsname
  \csname XINT_#1_checkp_..[\expandafter\endcsname
  \csname XINT_#1_op_-xii\expandafter\endcsname
  \csname XINT_expr_precedence_..[\endcsname
  {#1}%
}%
\XINT_expr_defbin_b {expr}%
```

```
\XINT_expr_defbin_b {flexpr}%
\XINT_expr_defbin_b {iiexpr}%
\expandafter\let\csname XINT_expr_precedence_..[\endcsname\xint_c_vi
\def\XINT_expr_defbin_c #1#2#3#4#5#6#7#8%
{%
  \def #1##1% \XINT_expr_op_<op>
  {%
    \expanded{\unexpanded{#2{##1}}\expandafter}%
    \romannumeral`&&@\expandafter#3\romannumeral`&&@\XINT_expr_getnext
  }%
  \def #2##1##2##3##4% \XINT_expr_exec_<op>
  {%
    \expandafter##2\expandafter##3\expanded
    {{\XINT:NEhook:x:one:from:two#8##1##4}}%
  }%
  \def #3##1% \XINT_expr_check-_<op>
  {%
    \xint_UDsignfork
      ##1{\expandafter#4\romannumeral`&&@#5}%
        -{#4##1}%
    \krof
  }%
  \def #4##1##2% \XINT_expr_checkp_<op>
  {%
    \ifnum ##1>#6%
      \expandafter#4%
      \romannumeral`&&@\csname XINT_#7_op_##2\expandafter\endcsname
    \else
      \expandafter ##1\expandafter ##2%
    \fi
  }%
}%
\def\XINT_expr_defbin_b #1#2#3%
{%
  \expandafter\XINT_expr_defbin_c
  \csname XINT_#1_op_#2\expandafter\endcsname
  \csname XINT_#1_exec_#2\expandafter\endcsname
  \csname XINT_#1_check-_#2\expandafter\endcsname
  \csname XINT_#1_checkp_#2\expandafter\endcsname
  \csname XINT_#1_op_-xii\expandafter\endcsname
  \csname XINT_expr_precedence_#2\endcsname
  {#1}#3%
  \expandafter\let
  \csname XINT_expr_precedence_#2\expandafter\endcsname\xint_c_vi
}%
\XINT_expr_defbin_b {expr}   {..}\xintSeq:tl:x
\XINT_expr_defbin_b {flexpr} {..}\xintSeq:tl:x
\XINT_expr_defbin_b {iiexpr} {..}\xintiiSeq:tl:x
\XINT_expr_defbin_b {expr}  {]..}\xintSeqB:tl:x
\XINT_expr_defbin_b {flexpr}{]..}\xintSeqB:tl:x
\XINT_expr_defbin_b {iiexpr}{]..}\xintiiSeqB:tl:x
```

12.19.3 <, >, ==, <=, >=, != with Python-like chaining

1.4b This is preliminary implementation of chaining of comparison operators like Python and (I think) l3fp do. I am not too happy with how many times the (second) operand (already evaluated) is fetched.

```
\def\XINT_expr_defbin_d #1#2%
{%
  \def #1##1##2##3##4% \XINT_expr_exec_<op>
  {%
    \expandafter##2\expandafter##3\expandafter
      {\romannumeral`&&@\XINT:NEhook:f:one:from:two{\romannumeral`&&@#2##1##4}}%
  }%
}%
\def\XINT_expr_defbin_c #1#2#3#4#5#6#7#8#9%
{%
  \def #1##1% \XINT_expr_op_<op>
  {%
    \expanded{\unexpanded{#2{##1}}\expandafter}%
    \romannumeral`&&@\expandafter#7%
    \romannumeral`&&@\expandafter#3\romannumeral`&&@\XINT_expr_getnext
  }%
  \def #3##1% \XINT_expr_check-_<op>
  {%
    \xint_UDsignfork
      ##1{\expandafter#4\romannumeral`&&@#5}%
        -{#4##1}%
    \krof
  }%
  \def #4##1##2% \XINT_expr_checkp_<op>
  {%
    \ifnum ##1>#6%
      \expandafter#4%
      \romannumeral`&&@\csname XINT_#9_op_##2\expandafter\endcsname
    \else
      \expandafter ##1\expandafter ##2%
    \fi
  }%
  \let #6\xint_c_x
  \def #7##1% \XINT_expr_checkc_<op>
  {%
    \ifnum ##1=\xint_c_x\expandafter#8\fi ##1%
  }%
  \edef #8##1##2##3% \XINT_expr_execc_<op>
  {%
    \csname XINT_#9_precedence_\string&\string&\endcsname
    \expandafter\noexpand\csname XINT_#9_itself_\string&\string&\endcsname
    {##3}%
    \XINTfstop.{##3}##2%
  }%
  \XINT_expr_defbin_d #2% \XINT_expr_exec_<op>
}%
\def\XINT_expr_defbin_b #1#2%#3%
{%
```

```
  \expandafter\XINT_expr_defbin_c
  \csname XINT_#1_op_#2\expandafter\endcsname
  \csname XINT_#1_exec_#2\expandafter\endcsname
  \csname XINT_#1_check-_#2\expandafter\endcsname
  \csname XINT_#1_checkp_#2\expandafter\endcsname
  \csname XINT_#1_op_-xii\expandafter\endcsname
  \csname XINT_expr_precedence_#2\expandafter\endcsname
  \csname XINT_#1_checkc_#2\expandafter\endcsname
  \csname XINT_#1_execc_#2\endcsname
  {#1}%#3%
}%
```

Attention that third token here is left in stream by defbin_b, then also by defbin_c and is picked up as #2 of defbin_d. Had to work around TeX accepting only 9 arguments. Why did it not start counting at #0 like all decent mathematicians do?

```
\XINT_expr_defbin_b {expr}  <\xintLt
\XINT_expr_defbin_b {flexpr}<\xintLt
\XINT_expr_defbin_b {iiexpr}<\xintiiLt
\XINT_expr_defbin_b {expr}  >\xintGt
\XINT_expr_defbin_b {flexpr}>\xintGt
\XINT_expr_defbin_b {iiexpr}>\xintiiGt
\XINT_expr_defbin_b {expr}  {==}\xintEq
\XINT_expr_defbin_b {flexpr}{==}\xintEq
\XINT_expr_defbin_b {iiexpr}{==}\xintiiEq
\XINT_expr_defbin_b {expr}  {<=}\xintLtorEq
\XINT_expr_defbin_b {flexpr}{<=}\xintLtorEq
\XINT_expr_defbin_b {iiexpr}{<=}\xintiiLtorEq
\XINT_expr_defbin_b {expr}  {>=}\xintGtorEq
\XINT_expr_defbin_b {flexpr}{>=}\xintGtorEq
\XINT_expr_defbin_b {iiexpr}{>=}\xintiiGtorEq
\XINT_expr_defbin_b {expr}  {!=}\xintNotEq
\XINT_expr_defbin_b {flexpr}{!=}\xintNotEq
\XINT_expr_defbin_b {iiexpr}{!=}\xintiiNotEq
```

12.19.4 Support macros for .., ..[and]..

\xintSeq:tl:x . . . 370
\xintiiSeq:tl:x . . . 371
\xintSeqA, \xintiiSeqA . . . 371
\xintSeqB:tl:x . . . 372
\xintiiSeqB:tl:x . . . 372

\xintSeq:tl:x Commence par remplacer a par ceil(a) et b par floor(b) et renvoie ensuite les entiers entre les deux, possiblement en décroissant, et extrémités comprises. Si a=b est non entier en obtient donc ceil(a) et floor(a). Ne renvoie jamais une liste vide.

Note: le a..b dans \xintfloatexpr utilise cette routine.

```
\def\xintSeq:tl:x #1#2%
{%
   \expandafter\XINT_Seq:tl:x
   \the\numexpr \xintiCeil{#1}\expandafter.\the\numexpr \xintiFloor{#2}.%
}%
\def\XINT_Seq:tl:x #1.#2.%
{%
```

```
   \ifnum #2=#1 \xint_dothis\XINT_Seq:tl:x_z\fi
   \ifnum #2<#1 \xint_dothis\XINT_Seq:tl:x_n\fi
   \xint_orthat\XINT_Seq:tl:x_p
   #1.#2.%
}%
\def\XINT_Seq:tl:x_z #1.#2.{{#1/1[0]}}%
\def\XINT_Seq:tl:x_p #1.#2.%
{%
    {#1/1[0]}\ifnum #1=#2 \XINT_Seq:tl:x_e\fi
    \expandafter\XINT_Seq:tl:x_p \the\numexpr #1+\xint_c_i.#2.%
}%
\def\XINT_Seq:tl:x_n #1.#2.%
{%
    {#1/1[0]}\ifnum #1=#2 \XINT_Seq:tl:x_e\fi
    \expandafter\XINT_Seq:tl:x_n \the\numexpr #1-\xint_c_i.#2.%
}%
\def\XINT_Seq:tl:x_e#1#2.#3.{#1}%
```

\xintiiSeq:tl:x

```
\def\xintiiSeq:tl:x #1#2%
{%
    \expandafter\XINT_iiSeq:tl:x
    \the\numexpr \xintiCeil{#1}\expandafter.\the\numexpr \xintiFloor{#2}.%
}%
\def\XINT_iiSeq:tl:x #1.#2.%
{%
   \ifnum #2=#1 \xint_dothis\XINT_iiSeq:tl:x_z\fi
   \ifnum #2<#1 \xint_dothis\XINT_iiSeq:tl:x_n\fi
   \xint_orthat\XINT_iiSeq:tl:x_p
   #1.#2.%
}%
\def\XINT_iiSeq:tl:x_z #1.#2.{{#1}}%
\def\XINT_iiSeq:tl:x_p #1.#2.%
{%
    {#1}\ifnum #1=#2 \XINT_Seq:tl:x_e\fi
    \expandafter\XINT_iiSeq:tl:x_p \the\numexpr #1+\xint_c_i.#2.%
}%
\def\XINT_iiSeq:tl:x_n #1.#2.%
{%
    {#1}\ifnum #1=#2 \XINT_Seq:tl:x_e\fi
    \expandafter\XINT_iiSeq:tl:x_n \the\numexpr #1-\xint_c_i.#2.%
}%
```

Contrarily to a..b which is limited to small integers, this works with a, b, and d (big) fractions. It will produce a «nil» list, if a>b and d<0 or a<b and d>0.

\xintSeqA, \xintiiSeqA

```
\def\xintSeqA        {\expandafter\XINT_SeqA\romannumeral0\xintraw}%
\def\xintiiSeqA     #1{\expandafter\XINT_iiSeqA\romannumeral`&&@#1;}%
\def\XINT_SeqA  #1]#2{\expandafter\XINT_SeqA_a\romannumeral0\xintraw {#2}#1]}%
\def\XINT_iiSeqA#1;#2{\expandafter\XINT_SeqA_a\romannumeral`&&@#2;#1;}%
\def\XINT_SeqA_a #1{\xint_UDzerominusfork
                                  #1-{z}%
```

```
                                    0#1{n}%
                                    0-{p}%
                       \krof #1}%
```

\xintSeqB:tl:x At 1.4, delayed expansion of start and step done here and not before, for matters of \xintdeffunc and «NEhooks».

The float variant at 1.4 is made identical to the exact variant. I.e. stepping is exact and comparison to the range limit too. But recall that a/b input will be converted to a float. To handle 1/3 step for example still better to use \xintexpr 1..1/3..10\relax for example inside the \xintfloateval.

```
\def\xintSeqB:tl:x  #1{\expandafter\XINT_SeqB:tl:x\romannumeral`&&@\xintSeqA#1}%
\def\XINT_SeqB:tl:x #1{\csname XINT_SeqB#1:tl:x\endcsname}%
\def\XINT_SeqBz:tl:x #1]#2]#3{{#2]}}%
\def\XINT_SeqBp:tl:x #1]#2]#3%
    {\expandafter\XINT_SeqBp:tl:x_a\romannumeral0\xintraw{#3}#2]#1]}%
\def\XINT_SeqBp:tl:x_a #1]#2]#3]%
{%
    \xintifCmp{#1]}{#2]}%
    {}{{#2]}}{{#2]}\expandafter\XINT_SeqBp:tl:x_b\romannumeral0\xintadd{#3]}{#2]}#1]#3]}%
}%
\def\XINT_SeqBp:tl:x_b #1]#2]#3]%
{%
    \xintifCmp{#1]}{#2]}%
    {{#1]}\expandafter\XINT_SeqBp:tl:x_b\romannumeral0\xintadd{#3]}{#1]}#2]#3]}{{#1]}}{}%
}%
\def\XINT_SeqBn:tl:x #1]#2]#3%
   {\expandafter\XINT_SeqBn:tl:x_a\romannumeral0\xintraw{#3}#2]#1]}%
\def\XINT_SeqBn:tl:x_a #1]#2]#3]%
{%
    \xintifCmp{#1]}{#2]}%
    {{#2]}\expandafter\XINT_SeqBn:tl:x_b\romannumeral0\xintadd{#3]}{#2]}#1]#3]}{{#2]}}{}%
}%
\def\XINT_SeqBn:tl:x_b #1]#2]#3]%
{%
    \xintifCmp{#1]}{#2]}%
    {}{{#1]}}{{#1]}\expandafter\XINT_SeqBn:tl:x_b\romannumeral0\xintadd{#3]}{#1]}#2]#3]}%
}%
```

\xintiiSeqB:tl:x

```
\def\xintiiSeqB:tl:x  #1{\expandafter\XINT_iiSeqB:tl:x\romannumeral`&&@\xintiiSeqA#1}%
\def\XINT_iiSeqB:tl:x #1{\csname XINT_iiSeqB#1:tl:x\endcsname}%
\def\XINT_iiSeqBz:tl:x #1;#2;#3{{#2}}%
\def\XINT_iiSeqBp:tl:x #1;#2;#3{\expandafter\XINT_iiSeqBp:tl:x_a\romannumeral`&&@#3;#2;#1;}%
\def\XINT_iiSeqBp:tl:x_a #1;#2;#3;%
{%
    \xintiiifCmp{#1}{#2}%
    {}{{#2}}{{#2}\expandafter\XINT_iiSeqBp:tl:x_b\romannumeral0\xintiiadd{#3}{#2};#1;#3;}%
}%
\def\XINT_iiSeqBp:tl:x_b #1;#2;#3;%
{%
    \xintiiifCmp{#1}{#2}%
    {{#1}\expandafter\XINT_iiSeqBp:tl:x_b\romannumeral0\xintiiadd{#3}{#1};#2;#3;}{{#1}}{}%
```

```
}%
\def\XINT_iiSeqBn:tl:x #1;#2;#3{\expandafter\XINT_iiSeqBn:tl:x_a\romannumeral`&&@#3;#2;#1;}%
\def\XINT_iiSeqBn:tl:x_a #1;#2;#3;%
{%
    \xintiiifCmp{#1}{#2}%
    {{#2}\expandafter\XINT_iiSeqBn:tl:x_b\romannumeral0\xintiiadd{#3}{#2};#1;#3;}{{#2}}{}%
}%
\def\XINT_iiSeqBn:tl:x_b #1;#2;#3;%
{%
    \xintiiifCmp{#1}{#2}%
    {}{{#1}}{{#1}\expandafter\XINT_iiSeqBn:tl:x_b\romannumeral0\xintiiadd{#3}{#1};#2;#3;}%
}%
```

12.20 Square brackets [ ] both as a container and a Python slicer

Refactored at 1.4

The architecture allows to implement separately a «left» and a «right» precedence and this is crucial.

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12.20.1 [...] as «oneple» constructor

In the definition of \XINT_expr_op_obracket the parameter is trash {}. The [is intercepted by the getnextfork and handled via the \xint_c_ii^v highest precedence trick to get op_obracket executed.

```
\def\XINT_expr_itself_obracket{obracket}%
\catcode`] 11 \catcode`[ 11
\def\XINT_expr_defbin_c #1#2#3#4#5#6%
{%
    \def #1##1%
    {%
      \expandafter#3\romannumeral`&&@\XINT_expr_getnext
    }%
    \def #2##1% op_]
    {%
      \expanded{\unexpanded{\XINT_expr_put_op_first{{##1}}}\expandafter}%
         \romannumeral`&&@\XINT_expr_getop
    }%
    \def #3##1%  until_cbracket_a
    {%
      \xint_UDsignfork
         ##1{\expandafter#4\romannumeral`&&@#5}%  #5 = op_-xii
           -{#4##1}%
      \krof
    }%
    \def #4##1##2%  until_cbracket_b
    {%
      \ifcase ##1\expandafter\XINT_expr_missing_]
      \or \expandafter\XINT_expr_missing_]
      \or \expandafter#2%
      \else
```

```
      \expandafter #4%
        \romannumeral`&&@\csname XINT_#6_op_##2\expandafter\endcsname
      \fi
    }%
}%
\def\XINT_expr_defbin_b #1%
{%
    \expandafter\XINT_expr_defbin_c
    \csname XINT_#1_op_obracket\expandafter\endcsname
    \csname XINT_#1_op_]\expandafter\endcsname
    \csname XINT_#1_until_cbracket_a\expandafter\endcsname
    \csname XINT_#1_until_cbracket_b\expandafter\endcsname
    \csname XINT_#1_op_-xii\endcsname
    {#1}%
}%
\XINT_expr_defbin_b {expr}%
\XINT_expr_defbin_b {flexpr}%
\XINT_expr_defbin_b {iiexpr}%
\def\XINT_expr_missing_]
   {\XINT_expandableerror{Ooops, looks like we are missing a ]. Aborting!}%
    \xint_c_ \XINT_expr_done}%
\let\XINT_expr_precedence_]\xint_c_ii
```

12.20.2 [...] brackets and : operator for NumPy-like slicing and item indexing syntax

The opening bracket [for the nutple constructor is filtered out by \XINT_expr_getnextfork and becomes «obracket» which behaves with precedence level 2. For the [..] Python slicer on the other hand, a real operator [is defined with precedence level 4 (it must be higher than precedence level of commas) on its right and maximal precedence on its left.

Important: although slicing and indexing shares many rules with Python/NumPy there are some significant differences: in particular there can not be any out-of-range error generated, slicing applies also to «oples» and not only to «nutple», and nested lists do not have to have their leaves at a constant depth. See the user manual.

Currently, NumPy-like nested (basic) slicing is implemented, i.e [a:b, c:d, N, e:f, M] type syntax with Python rules regarding negative integers. This is parsed as an expression and can arise from expansion or contain calculations.

Currently stepping, Ellipsis, and simultaneous multi-index extracting are not yet implemented.

There are some subtle things here with possibility of variables been passed by reference.

```
\def\XINT_expr_defbin_c #1#2#3#4#5#6%
{%
    \def #1##1% \XINT_expr_op_[
    {%
        \expanded{\unexpanded{#2{##1}}\expandafter}%
        \romannumeral`&&@\expandafter#3\romannumeral`&&@\XINT_expr_getnext
    }%
    \def #2##1##2##3###4% \XINT_expr_exec_]
    {%
         \expandafter\XINT_expr_put_op_first
         \expanded
          {%
           {\XINT:NEhook:x:listsel\XINT_ListSel_top ##1__##4&({##1}\expandafter}%
           \expandafter
          }%
```

```
          \romannumeral`&&@\XINT_expr_getop
     }%
     \def #3##1% \XINT_expr_check-_]
     {%
       \xint_UDsignfork
         ##1{\expandafter#4\romannumeral`&&@#5}%
           -{#4##1}%
       \krof
     }%
     \def #4##1##2% \XINT_expr_checkp_]
     {%
       \ifcase ##1\XINT_expr_missing_]
         \or \XINT_expr_missing_]
         \or \expandafter##1\expandafter##2%
         \else \expandafter#4%
               \romannumeral`&&@\csname XINT_#6_op_##2\expandafter\endcsname
       \fi
     }%
}%
\let\XINT_expr_precedence_[ \xint_c_xx
\def\XINT_expr_defbin_b #1%
{%
     \expandafter\XINT_expr_defbin_c
     \csname XINT_#1_op_[\expandafter\endcsname
     \csname XINT_#1_exec_]\expandafter\endcsname
     \csname XINT_#1_check-_]\expandafter\endcsname
     \csname XINT_#1_checkp_]\expandafter\endcsname
     \csname XINT_#1_op_-xii\endcsname
     {#1}%
}%
\XINT_expr_defbin_b {expr}%
\XINT_expr_defbin_b {flexpr}%
\XINT_expr_defbin_b {iiexpr}%
\catcode`] 12 \catcode`[ 12
```

At 1.4 the getnext, scanint, scanfunc, getop chain got revisited to trigger automatic insertion of the nil variable if needed, without having in situations like here to define operators to support «[:» or «:]». And as we want to implement nested slicing à la NumPy, we would have had to handle also «:,» for example. Thus here we simply have to define the sole operator «:» and it will be some sort of inert joiner preparing a slicing spec.

```
\def\XINT_expr_defbin_c #1#2#3#4#5#6%
{%
     \def #1##1% \XINT_expr_op_:
     {%
         \expanded{\unexpanded{#2{##1}}\expandafter}%
         \romannumeral`&&@\expandafter#3\romannumeral`&&@\XINT_expr_getnext
     }%
     \def #2##1##2##3##4% \XINT_expr_exec_:
     {%
        ##2##3{:##1{0};##4:_}%
     }%
     \def #3##1% \XINT_expr_check-_:
     {\xint_UDsignfork
```

```
          ##1{\expandafter#4\romannumeral`&&@#5}%
            -{#4##1}%
       \krof
      }%
      \def #4##1##2% \XINT_expr_checkp_:
      {%
        \ifnum ##1>\XINT_expr_precedence_:
          \expandafter #4\romannumeral`&&@%
                               \csname XINT_#6_op_##2\expandafter\endcsname
        \else
          \expandafter##1\expandafter##2%
        \fi
      }%
}%
\let\XINT_expr_precedence_: \xint_c_vi
\def\XINT_expr_defbin_b #1%
{%
    \expandafter\XINT_expr_defbin_c
    \csname XINT_#1_op_:\expandafter\endcsname
    \csname XINT_#1_exec_:\expandafter\endcsname
    \csname XINT_#1_check-_:\expandafter\endcsname
    \csname XINT_#1_checkp_:\expandafter\endcsname
    \csname XINT_#1_op_-xii\endcsname {#1}%
}%
\XINT_expr_defbin_b {expr}%
\XINT_expr_defbin_b {flexpr}%
\XINT_expr_defbin_b {iiexpr}%
```

12.20.3 Macro layer implementing indexing and slicing

xintexpr applies slicing not only to «objects» (which can be passed as arguments to functions) but also to «oples».

Our «nlists» are not necessarily regular N-dimensional arrays à la NumPy. Leaves can be at arbitrary depths. If we were handling regular «ndarrays», we could proceed a bit differently.

For the related explanations, refer to the user manual.

Notice that currently the code uses f-expandable (and not using \expanded) macros \xintApply, \xintApplyUnbraced, \xintKeep, \xintTrim, \xintNthOne from xinttools.

But the whole expansion happens inside an \expanded context, so possibly some gain could be achieved with x-expandable variants (xintexpr < 1.4 had an \xintKeep:x:csv).

I coded \xintApply:x and \xintApplyUnbraced:x in xinttools, Brief testing indicated they were perhaps a bit better for 5x5x5x5 and 15x15x15x15 arrays of 8 digits numbers and for 30x30x15 with 16 digits numbers: say 1% gain... this seems to raise to between 4% and 5% for 400x400 array of 1 digit...

Currently sticking with old macros.

```
\def\XINT_ListSel_deeper #1%
{%
    \if :#1\xint_dothis\XINT_ListSel_slice_next\fi
    \xint_orthat {\XINT_ListSel_extract_next {#1}}%
}%
\def\XINT_ListSel_slice_next #1(%
{%
    \xintApply{\XINT_ListSel_recurse{:#1}}%
}%
```

```
\def\XINT_ListSel_extract_next #1(%
{%
    \xintApplyUnbraced{\XINT_ListSel_recurse{#1}}%
}%
\def\XINT_ListSel_recurse #1#2%
{%
    \XINT_ListSel_check #2__#1({#2}\expandafter\empty\empty
}%
\def\XINT_ListSel_check{\expandafter\XINT_ListSel_check_a \string}%
\def\XINT_ListSel_check_a #1%
{%
    \if #1\bgroup\xint_dothis\XINT_ListSel_check_is_ok\fi
    \xint_orthat\XINT_ListSel_check_leaf
}%
\def\XINT_ListSel_check_leaf #1\expandafter{\expandafter}%
\def\XINT_ListSel_check_is_ok
{%
    \expandafter\XINT_ListSel_check_is_ok_a\expandafter{\string}%
}%
\def\XINT_ListSel_check_is_ok_a #1__#2%
{%
    \if :#2\xint_dothis{\XINT_ListSel_slice}\fi
    \xint_orthat {\XINT_ListSel_nthone {#2}}%
}%
\def\XINT_ListSel_top #1#2%
{%
    \if _\noexpand#2%
          \expandafter\XINT_ListSel_top_one_or_none\string#1.\else
          \expandafter\XINT_ListSel_top_at_least_two\fi
}%
\def\XINT_ListSel_top_at_least_two #1__{\XINT_ListSel_top_ople}%
\def\XINT_ListSel_top_one_or_none #1%
{%
    \if #1_\xint_dothis\XINT_ListSel_top_nil\fi
    \if #1.\xint_dothis\XINT_ListSel_top_nutple_a\fi
    \if #1\bgroup\xint_dothis\XINT_ListSel_top_nutple\fi
    \xint_orthat\XINT_ListSel_top_number
}%
\def\XINT_ListSel_top_nil #1\expandafter#2\expandafter{\fi\expandafter}%
\def\XINT_ListSel_top_nutple
{%
    \expandafter\XINT_ListSel_top_nutple_a\expandafter{\string}%
}%
\def\XINT_ListSel_top_nutple_a #1_#2#3(#4%
{%
    \fi\if :#2\xint_dothis{{\XINT_ListSel_slice #3(#4}}\fi
    \xint_orthat {\XINT_ListSel_nthone {#2}#3(#4}%
}%
\def\XINT_ListSel_top_number #1_{\fi\XINT_ListSel_top_ople}%
\def\XINT_ListSel_top_ople #1%
{%
    \if :#1\xint_dothis\XINT_ListSel_slice\fi
```

```
    \xint_orthat {\XINT_ListSel_nthone {#1}}%
}%
\def\XINT_ListSel_slice #1%
{%
    \expandafter\XINT_ListSel_slice_a \expandafter{\romannumeral0\xintnum{#1}}%
}%
\def\XINT_ListSel_slice_a #1#2;#3#4%
{%
   \if _#4\expandafter\XINT_ListSel_s_b
          \else\expandafter\XINT_ListSel_slice_b\fi
   #1;#3%
}%
\def\XINT_ListSel_s_b #1#2;#3#4%
{%
    \if &#4\expandafter\XINT_ListSel_s_last\fi
    \XINT_ListSel_s_c #1{#1#2}{#4}%
}%
\def\XINT_ListSel_s_last\XINT_ListSel_s_c #1#2#3(#4%
{%
   \if-#1\expandafter\xintKeep\else\expandafter\xintTrim\fi {#2}{#4}%
}%
\def\XINT_ListSel_s_c #1#2#3(#4%
{%
   \expandafter\XINT_ListSel_deeper
   \expanded{\unexpanded{#3}(\expandafter}\expandafter{%
   \romannumeral0%
   \if-#1\expandafter\xintkeep\else\expandafter\xinttrim\fi {#2}{#4}}%
}%
```

\xintNthElt from xinttools (knowingly) strips one level of braces when fetching kth «item» from {v1}...{vN}. If we expand {\xintNthElt{k}{{v1}...{vN}}} (notice external braces):

if k is out of range we end up with {}

if k is in range and the kth braced item was {} we end up with {}

if k is in range and the kth braced item was {17} we end up with {17}

Problem is that individual numbers such as 17 are stored {{17}}. So we must have one more brace pair and in the first two cases we end up with {{}}. But in the first case we should end up with the empty ople {}, not the empty bracketed ople {{}}.

I have thus added \xintNthOne to xinttools which does not strip brace pair from an extracted item.

Attention: \XINT_nthonepy_a does no expansion on second argument. But here arguments are either numerical or already expanded. Normally.

```
\def\XINT_ListSel_nthone #1#2%
{%
    \if &#2\expandafter\XINT_ListSel_nthone_last\fi
    \XINT_ListSel_nthone_a {#1}{#2}%
}%
\def\XINT_ListSel_nthone_a #1#2(#3%
{%
    \expandafter\XINT_ListSel_deeper
    \expanded{\unexpanded{#2}(\expandafter}\expandafter{%
    \romannumeral0\expandafter\XINT_nthonepy_a\the\numexpr\xintNum{#1}.{#3}}%
}%
\def\XINT_ListSel_nthone_last\XINT_ListSel_nthone_a #1#2(%#3%
```

```
{%
    \romannumeral0\expandafter\XINT_nthonepy_a\the\numexpr\xintNum{#1}.%{#3}
}%
```

The macros here are basically f-expandable and use the f-expandable \xintKeep and \xintTrim. Prior to xint 1.4, there was here an x-expandable \xintKeep:x:csv dealing with comma separated items, for time being we make do with our f-expandable toolkit.

```
\def\XINT_ListSel_slice_b #1;#2_#3%
{%
    \if &#3\expandafter\XINT_ListSel_slice_last\fi
    \expandafter\XINT_ListSel_slice_c \expandafter{\romannumeral0\xintnum{#2}};#1;{#3}%
}%
\def\XINT_ListSel_slice_last\expandafter\XINT_ListSel_slice_c #1;#2;#3(%#4
{%
   \expandafter\XINT_ListSel_slice_last_c #1;#2;%{#4}
}%
\def\XINT_ListSel_slice_last_c #1;#2;#3%
{%
    \romannumeral0\XINT_ListSel_slice_d #2;#1;{#3}%
}%
\def\XINT_ListSel_slice_c #1;#2;#3(#4%
{%
   \expandafter\XINT_ListSel_deeper
   \expanded{\unexpanded{#3}(\expandafter}\expandafter{%
   \romannumeral0\XINT_ListSel_slice_d #2;#1;{#4}}%
}%
\def\XINT_ListSel_slice_d #1#2;#3#4;%
{%
    \xint_UDsignsfork
       #1#3\XINT_ListSel_N:N
        #1-\XINT_ListSel_N:P
        -#3\XINT_ListSel_P:N
         --\XINT_ListSel_P:P
    \krof #1#2;#3#4;%
}%
\def\XINT_ListSel_P:P #1;#2;#3%
{%
    \unless\ifnum #1<#2 \expandafter\xint_gob_andstop_iii\fi
    \xintkeep{#2-#1}{\xintTrim{#1}{#3}}%
}%
\def\XINT_ListSel_N:N #1;#2;#3%
{%
    \expandafter\XINT_ListSel_N:N_a
    \the\numexpr #2-#1\expandafter;\the\numexpr#1+\xintLength{#3};{#3}%
}%
\def\XINT_ListSel_N:N_a #1;#2;#3%
{%
    \unless\ifnum #1>\xint_c_ \expandafter\xint_gob_andstop_iii\fi
    \xintkeep{#1}{\xintTrim{\ifnum#2<\xint_c_\xint_c_\else#2\fi}{#3}}%
}%
\def\XINT_ListSel_N:P #1;#2;#3%
{%
    \expandafter\XINT_ListSel_N:P_a
```

```
    \the\numexpr #1+\xintLength{#3};#2;{#3}%
}%
\def\XINT_ListSel_N:P_a #1#2;%
   {\if -#1\expandafter\XINT_ListSel_O:P\fi\XINT_ListSel_P:P #1#2;}%
\def\XINT_ListSel_O:P\XINT_ListSel_P:P #1;{\XINT_ListSel_P:P 0;}%
\def\XINT_ListSel_P:N #1;#2;#3%
{%
    \expandafter\XINT_ListSel_P:N_a
    \the\numexpr #2+\xintLength{#3};#1;{#3}%
}%
\def\XINT_ListSel_P:N_a #1#2;#3;%
   {\if -#1\expandafter\XINT_ListSel_P:O\fi\XINT_ListSel_P:P #3;#1#2;}%
\def\XINT_ListSel_P:O\XINT_ListSel_P:P #1;#2;{\XINT_ListSel_P:P #1;0;}%
```

12.21 Support for raw A/B[N]

Releases earlier than 1.1 required the use of braces around A/B[N] input. The [N] is now implemented directly. *BUT* this uses a delimited macro! thus N is not allowed to be itself an expression (I could add it...). \xintE, \xintiiE, and \XINTinFloatE all put #2 in a \numexpr. But attention to the fact that \numexpr stops at spaces separating digits: \the\numexpr 3 + 7 9\relax gives 109\relax !! Hence we have to be careful.

\numexpr will not handle catcode 11 digits, but adding a \detokenize will suddenly make illicit for N to rely on macro expansion.

At 1.4, [is already overloaded and it is not easy to support this. We do this by a kludge maintaining more or less former (very not efficient) way but using $ sign which is free for time being. No, finally I use the null character, should be safe enough! (I hesitated about using R with catcode 12).

As for ? operator we needed to hack into \XINT_expr_getop_b for intercepting that pseudo operator. See also \XINT_expr_scanint_c (\XINT_expr_rawxintfrac).

```
\catcode0 11
\let\XINT_expr_precedence_&&@ \xint_c_xiv
\def\XINT_expr_op_&&@ #1#2]%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded{{{\xintE#1{\xint_zapspaces #2 \xint_gobble_i}}}%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT_iiexpr_op_&&@ #1#2]%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded{{{\xintiiE#1{\xint_zapspaces #2 \xint_gobble_i}}}%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT_flexpr_op_&&@ #1#2]%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded{{{\XINTinFloatE#1{\xint_zapspaces #2 \xint_gobble_i}}}%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\catcode0 12
```

12.22 ? as two-way and ?? as three-way «short-circuit» conditionals

Comments undergoing reconstruction.

```
\let\XINT_expr_precedence_? \xint_c_xx
\catcode`- 11
\def\XINT_expr_op_?  {\XINT_expr_op__? \XINT_expr_op_-xii}%
\def\XINT_flexpr_op_?{\XINT_expr_op__? \XINT_flexpr_op_-xii}%
\def\XINT_iiexpr_op_?{\XINT_expr_op__? \XINT_iiexpr_op_-xii}%
\catcode`- 12
\def\XINT_expr_op__? #1#2#3%
    {\XINT_expr_op__?_a #3!\xint_bye\XINT_expr_exec_? {#1}{#2}{#3}}%
\def\XINT_expr_op__?_a #1{\expandafter\XINT_expr_op__?_b\detokenize{#1}}%
\def\XINT_expr_op__?_b #1%
    {\if ?#1\expandafter\XINT_expr_op__?_c\else\expandafter\xint_bye\fi }%
\def\XINT_expr_op__?_c #1{\xint_gob_til_! #1\XINT_expr_op_?? !\xint_bye}%
\def\XINT_expr_op_?? !\xint_bye\xint_bye\XINT_expr_exec_?{\XINT_expr_exec_??}%
\catcode`- 11
\def\XINT_expr_exec_? #1#2%
{%
    \expandafter\XINT_expr_check-_after?\expandafter#1%
    \romannumeral`&&@\expandafter\XINT_expr_getnext\romannumeral0\xintiiifnotzero#2%
}%
\def\XINT_expr_exec_?? #1#2#3%
{%
    \expandafter\XINT_expr_check-_after?\expandafter#1%
    \romannumeral`&&@\expandafter\XINT_expr_getnext\romannumeral0\xintiiifsgn#2%
}%
\def\XINT_expr_check-_after? #1{%
\def\XINT_expr_check-_after? ##1##2%
{%
    \xint_UDsignfork
        ##2{##1}%
        #1{##2}%
    \krof
}}\expandafter\XINT_expr_check-_after?\string -%
\catcode`- 12
```

12.23 ! as postfix factorial operator

```
\let\XINT_expr_precedence_! \xint_c_xx
\def\XINT_expr_op_! #1%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded{{\romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintFac#1}}\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT_flexpr_op_! #1%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded{{\romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatFacdigits#1}}\expandafter}%
    \romannumeral`&&@\XINT_expr_getop
}%
```

```
\def\XINT_iiexpr_op_! #1%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded{{\romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiFac#1}}\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
```

At 1.4g, fix for input "x! == y" via a fake operator !==. The ! is of catcode 11 but this does not matter here. The definition of \XINT_expr_itself_!== is required by the functioning of the scanop macros.

We don't have to worry about "x! = y" as the single-character Boolean comparison = operator has been removed from syntax. Fixing it would have required obeying space tokens when parsing operators. For "x! == y" case, obeying space tokens would not solve "x!==y" input case anyhow.

```
\expandafter
\def\csname XINT_expr_precedence_!==\expandafter\endcsname
    \csname XINT_expr_itself_!==\endcsname {\XINT_expr_precedence_! !==}%
\expandafter\def\csname XINT_expr_itself_!==\endcsname{!==}%
```

12.24 User defined variables

12.24.1 \xintdefvar, \xintdefiivar, \xintdeffloatvar 382
12.24.2 \xintunassignvar 386

12.24.1 \xintdefvar, \xintdefiivar, \xintdeffloatvar

Modified at 1.1 (2014/10/28).

Modified at 1.2p (2017/12/05). Extends \xintdefvar et al.to accept simultaneous assignments to multiple variables.

Modified at 1.3c (2018/06/17). Use \xintexprSafeCatcodes (to palliate issue with active semi-colon from Babel+French if in body of a LaTeX document).

And allow usage with both syntaxes name:=expr; or name=expr;. Also the colon may have catcode 11, 12, or 13 with no issue. Variable names may contain letters, digits, underscores, and must not start with a digit. Names starting with @ or an underscore are reserved.

- currently @, @1, @2, @3, and @4 are reserved because they have special meanings for use in iterations,
- @@, @@@, @@@@ are also reserved but are technically functions, not variables: a user may possibly define @@ as a variable name, but if it is followed by parentheses, the function interpretation will be applied (rather than the variable interpretation followed by a tacit multiplication),
- since 1.21, the underscore _ may be used as separator of digits in long numbers. Hence a variable whose name starts with _ will not play well with the mechanism of tacit multiplication of variables by numbers: the underscore will be removed from input stream by the number scanner, thus creating an undefined or wrong variable name, or none at all if the variable name was an initial _ followed by digits.

Note that the optional argument [P] as usable with \xintfloatexpr is **not** supported by \xintdeffloatvar. One must do \xintdeffloatvar foo = \xintfloatexpr[16] blabla \relax; to achieve the effect.

Modified at 1.4 (2020/01/31). The expression will be fetched up to final semi-colon in a manner allowing inner semi-colons as used in the iter(), rseq(), subsm(), subsn() etc... syntax. They don't need to be hidden within a braced pair anymore.

Modified at 1.4 (2020/01/31). Automatic unpacking in case of simultaneous assignments if the expression evaluates to a nutple.

Notes (added much later on 2021/06/10 during preparation of 1.4i):

1. the code did not try to intercept illicit syntax such as \xintdefvar a,b,c:=<number>;. It blindly «unpacked» the number handling it as if it was a nutple. The extended functionality added at 1.4i requires to check for such a situation, as the syntax is not illicit anymore.

2. the code was broken in case the expression to evaluate was an ople of length 10 or more, due to a silly mistake at some point during 1.4 development which replaced some \ifnum by an \if, perhaps due to mental confusion with the fact that functions can have at most 9 arguments, but here the code is about defining variables. Anyway this got fixed as corollary to the 1.4i extension.

Modified at 1.4c (2021/02/20). One year later I realized I had broken tacit multiplication for situations such as variable(1+2). As hinted at in comments above before 1.4 release I had been doing some deep refactoring here, which I cancelled almost completely in the end... but not quite, and as a result there was a problem that some macro holding braced contents was expanded to late, once it was in old core routines of xintfrac not expecting other things than digits. I do an emergency bugfix here with some \expandafter's but I don't have the code in my brain at this time, and don't have the luxury now to invest into it. Let's hope this does not induce breakage elsewhere, and that the February 2020 1.4 did not break something else.

Modified at 1.4e (2021/05/05). Modifies \xintdeffloatvar to round to the prevailing precision (formerly, any operation would induce rounding, but in case of things such as \xintdeffloatvar foo:=\xintexpr 1/100!\relax; there was no automatic rounding. One could use 0+ syntax to trigger it, and for oples, some trick like \xintfloatexpr[\XINTdigits]...\relax extra wrapper.

Modified at 1.4g (2021/05/25). The \expandafter\expandafter\expandafter et al. chain which was kept by \XINT_expr_defvar_one_b for expanding only at time of use the \XINT_expr_var_foo in \XINT_expr_onliteral_foo were senseless overhead added at 1.4c. This is used only for real variables, not dummy variables or fake variables and it is simpler to have the \XINT_expr_var_foo pre-expanded. So let's use some \edef here.

The \XINT_expr_onliteral_foo is expanded as result of action of \XINT_expr_op_` (or \XINT_flexpr_op_`, \XINT_iiexpr_op_`) which itself was triggered consuming already an \XINT_expr_put_op_first, so its expansion has to produce tokens as expected after \XINT_expr_put_op_first: <precedence token><op token>{expanded value}.

Modified at 1.4i (2021/06/11). Implement extended notion of simultaneous assignments: if there are more variables than values, define the extra variables to be nil. If there are less variables than values let the last variable be defined as the ople concatenating all non reclaimed values.

If there are at least two variables, the right hand side, if it turns out to be a nutple, is (as since 1.4) automatically unpacked, then the above rules apply.

Modified at 1.4i (2021/06/11). Fix the long-standing «seq renaming bug» via a change here of the name of auxiliary macro. Previously «onliteral_<varname>» now «var*_<varname>». I hesitated with using «var_varname*» rather.

Hesitated adding \XINT_expr_letvar_one (motivation: case of simultaneous assignments leading to defining «nil» variables). Finally, no.

```
\catcode`* 11
\def\XINT_expr_defvar_one #1#2%
{%
    \XINT_global
    \expandafter\edef\csname XINT_expr_varvalue_#1\endcsname {#2}%
    \XINT_expr_defvar_one_b {#1}%
}%
\def\XINT_expr_defvar_one_b #1%
{%
    \XINT_global
    \expandafter\edef\csname XINT_expr_var_#1\endcsname
```

```
        {{\expandafter\noexpand\csname XINT_expr_varvalue_#1\endcsname}}%
    \XINT_global
    \expandafter\edef\csname XINT_expr_var*_#1\endcsname
        {\XINT_expr_prec_tacit *\csname XINT_expr_var_#1\endcsname(}%
    \ifxintverbose\xintMessage{xintexpr}{Info}
       {Variable #1 \ifxintglobaldefs globally \fi
        defined with value \csname XINT_expr_varvalue_#1\endcsname.}%
    \fi
}%
\catcode`* 12
\catcode`~ 13
\catcode`: 12
\def\XINT_expr_defvar_getname #1:#2~%
{%
    \endgroup
    \def\XINT_defvar_tmpa{#1}\edef\XINT_defvar_tmpc{\xintCSVLength{#1}}%
}%
\def\XINT_expr_defvar #1#2%
{%
    \def\XINT_defvar_tmpa{#2}%
    \expandafter\XINT_expr_defvar_a\expanded{\unexpanded{{#1}}\expandafter}%
    \romannumeral\XINT_expr_fetch_to_semicolon
}%
\def\XINT_expr_defvar_a #1#2%
{%
    \xintexprRestoreCatcodes
```

Maybe SafeCatcodes was without effect because the colon and the rest are from some earlier macro definition. Give a safe definition to active colon (even if in math mode with a math active colon..).

The \XINT_expr_defvar_getname closes the group opened here.

```
    \begingroup\lccode`~`: \lowercase{\let~}\empty
    \edef\XINT_defvar_tmpa{\XINT_defvar_tmpa}%
    \edef\XINT_defvar_tmpa{\xint_zapspaces_o\XINT_defvar_tmpa}%
    \expandafter\XINT_expr_defvar_getname
            \detokenize\expandafter{\XINT_defvar_tmpa}:~%
    \ifcase\XINT_defvar_tmpc\space
      \xintMessage {xintexpr}{Error}
      {Aborting: not allowed to declare variable with empty name.}%
    \or
     \XINT_global
     \expandafter
     \edef\csname XINT_expr_varvalue_\XINT_defvar_tmpa\endcsname{#1#2\relax}%
     \XINT_expr_defvar_one_b\XINT_defvar_tmpa
    \else
     \edef\XINT_defvar_tmpb{#1#2\relax}%
     \edef\XINT_defvar_tmpd{\expandafter\xintLength\expandafter{\XINT_defvar_tmpb}}%
     \ifnum\XINT_defvar_tmpd=\xint_c_i
         \oodef\XINT_defvar_tmpb{\expandafter\xint_firstofone\XINT_defvar_tmpb}%
         \if0\expandafter\expandafter\expandafter\XINT_defvar_checkifnutple
                     \expandafter\string\XINT_defvar_tmpb _\xint_bye
           \odef\XINT_defvar_tmpb{\expandafter{\XINT_defvar_tmpb}}%
         \else
```

```
           \edef\XINT_defvar_tmpd{\expandafter\xintLength\expandafter{\XINT_defvar_tmpb}}%
         \fi
     \fi
     \xintAssignArray\xintCSVtoList\XINT_defvar_tmpa\to\XINT_defvar_tmpvar
     \def\XINT_defvar_tmpe{1}%
     \expandafter\XINT_expr_defvar_multiple\XINT_defvar_tmpb\relax
   \fi
}%
\def\XINT_defvar_checkifnutple#1%
{%
    \if#1_1\fi
    \if#1\bgroup1\fi
    0\xint_bye
}%
\def\XINT_expr_defvar_multiple
{%
    \ifnum\XINT_defvar_tmpe<\XINT_defvar_tmpc\space
        \expandafter\XINT_expr_defvar_multiple_one
    \else
        \expandafter\XINT_expr_defvar_multiple_last\expandafter\empty
    \fi
}%
\def\XINT_expr_defvar_multiple_one
{%
    \ifnum\XINT_defvar_tmpe>\XINT_defvar_tmpd\space
       \expandafter\XINT_expr_defvar_one
       \csname XINT_defvar_tmpvar\XINT_defvar_tmpe\endcsname{}%
       \edef\XINT_defvar_tmpe{\the\numexpr\XINT_defvar_tmpe+1}%
       \expandafter\XINT_expr_defvar_multiple
    \else
       \expandafter\XINT_expr_defvar_multiple_one_a
    \fi
}%
\def\XINT_expr_defvar_multiple_one_a #1%
{%
    \expandafter\XINT_expr_defvar_one
       \csname XINT_defvar_tmpvar\XINT_defvar_tmpe\endcsname{{#1}}%
    \edef\XINT_defvar_tmpe{\the\numexpr\XINT_defvar_tmpe+1}%
    \XINT_expr_defvar_multiple
}%
\def\XINT_expr_defvar_multiple_last #1\relax
{%
    \expandafter\XINT_expr_defvar_one
       \csname XINT_defvar_tmpvar\XINT_defvar_tmpe\endcsname{#1}%
    \xintRelaxArray\XINT_defvar_tmpvar
    \let\XINT_defvar_tmpa\empty
    \let\XINT_defvar_tmpb\empty
    \let\XINT_defvar_tmpc\empty
    \let\XINT_defvar_tmpd\empty
    \let\XINT_defvar_tmpe\empty
}%
\catcode`~ 3
```

```
\catcode`: 11
```

This SafeCatcodes is mainly in the hope that semi-colon ending the expression can still be sanitized.

Pre 1.4e definition:

```
\def\xintdeffloatvar      {\xintexprSafeCatcodes\xintdeffloatvar_a}
\def\xintdeffloatvar_a #1={\XINT_expr_defvar\xintthebarefloateval{#1}}
```

This would keep the value (or values) with extra digits, now. If this is actually wanted one can use \xintdefvar foo:=\xintfloatexpr...\relax; syntax, but recalling that only operations trigger the rounding inside \xintfloatexpr. Some tricks are needed for no operations case if multiple or nested values. But for a single one, one can use simply the float() function.

```
\def\xintdefvar      {\xintexprSafeCatcodes\xintdefvar_a}%
\def\xintdefvar_a#1={\XINT_expr_defvar\xintthebareeval{#1}}%
\def\xintdefiivar      {\xintexprSafeCatcodes\xintdefiivar_a}%
\def\xintdefiivar_a#1={\XINT_expr_defvar\xintthebareiieval{#1}}%
\def\xintdeffloatvar  {\xintexprSafeCatcodes\xintdeffloatvar_a}%
\def\xintdeffloatvar_a #1={\XINT_expr_defvar\xintthebareroundedfloateval{#1}}%
```

12.24.2 \xintunassignvar

Modified at 1.2e (2015/11/22).

Modified at 1.3d (2019/01/06). Embarrassingly I had for a long time a misunderstanding of \ifcsname (let's blame its documentation) and I was not aware that it chooses FALSE branch if tested control sequence has been \let to \undefined... So earlier version didn't do the right thing (and had another bug: failure to protect \.=0 from expansion).

The \ifcsname tests are done in \XINT_expr_op__ and \XINT_expr_op_`.

Modified at 1.4i (2021/06/11). Track s/onliteral/var*/ change in macro names.

```
\def\xintunassignvar #1{%
   \edef\XINT_unvar_tmpa{#1}%
   \edef\XINT_unvar_tmpa {\xint_zapspaces_o\XINT_unvar_tmpa}%
   \ifcsname XINT_expr_var_\XINT_unvar_tmpa\endcsname
       \ifnum\expandafter\xintLength\expandafter{\XINT_unvar_tmpa}=\@ne
         \expandafter\xintnewdummy\XINT_unvar_tmpa
       \else
         \XINT_global\expandafter
           \let\csname XINT_expr_varvalue_\XINT_unvar_tmpa\endcsname\xint_undefined
         \XINT_global\expandafter
           \let\csname XINT_expr_var_\XINT_unvar_tmpa\endcsname\xint_undefined
         \XINT_global\expandafter
           \let\csname XINT_expr_var*_\XINT_unvar_tmpa\endcsname\xint_undefined
         \ifxintverbose\xintMessage {xintexpr}{Info}
           {Variable \XINT_unvar_tmpa\space has been
            \ifxintglobaldefs globally \fi ``unassigned''.}%
         \fi
       \fi
   \else
       \xintMessage {xintexpr}{Warning}
           {Error: there was no such variable \XINT_unvar_tmpa\space to unassign.}%
   \fi
}%
```

12.25 Support for dummy variables

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12.25.1 \xintnewdummy

Comments under reconstruction.
1.4 adds multi-letter names as usable dummy variables!

Modified at 1.4i (2021/06/11). s/onliteral/var*/ to fix the «seq renaming bug».

```
\catcode`* 11
\def\XINT_expr_makedummy #1%
{%
   \edef\XINT_tmpa{\xint_zapspaces #1 \xint_gobble_i}%
   \ifcsname XINT_expr_var_\XINT_tmpa\endcsname
     \XINT_global
     \expandafter\let\csname XINT_expr_var_\XINT_tmpa/old\expandafter\endcsname
                     \csname XINT_expr_var_\XINT_tmpa\expandafter\endcsname
   \fi
   \ifcsname XINT_expr_var*_\XINT_tmpa\endcsname
     \XINT_global
     \expandafter\let\csname XINT_expr_var*_\XINT_tmpa/old\expandafter\endcsname
                     \csname XINT_expr_var*_\XINT_tmpa\expandafter\endcsname
   \fi
   \expandafter\XINT_global
   \expanded
   {\edef\expandafter\noexpand
        \csname XINT_expr_var_\XINT_tmpa\endcsname ##1\relax !\XINT_tmpa##2}%
      {{##2}##1\relax !\XINT_tmpa{##2}}%
   \expandafter\XINT_global
   \expanded
   {\edef\expandafter\noexpand
        \csname XINT_expr_var*_\XINT_tmpa\endcsname ##1\relax !\XINT_tmpa##2}%
      {\XINT_expr_prec_tacit *{##2}(##1\relax !\XINT_tmpa{##2}}%)
}%
\xintApplyUnbraced \XINT_expr_makedummy {abcdefghijklmnopqrstuvwxyz}%
\xintApplyUnbraced \XINT_expr_makedummy {ABCDEFGHIJKLMNOPQRSTUVWXYZ}%
\def\xintnewdummy #1{%
    \XINT_expr_makedummy{#1}%
    \ifxintverbose\xintMessage {xintexpr}{Info}%
```

```
        {\XINT_tmpa\space now
         \ifxintglobaldefs globally \fi usable as dummy variable.}%
    \fi
}%
\catcode`* 12
```

The nil variable was need in xint < 1.4 (with some other meaning) in places the syntax could not allow emptiness, such as ,,, and other things, but at 1.4 meaning as changed.

The other variables are new with 1.4. Don't use the None, it is tentative, and may be input as [].

Refactored at 1.4i to define them as really genuine variables, i.e. also with associated var* macros involved in tacit multiplication (even though it will be broken with nil, and with None in \xintiiexpr). No real reason, because \XINT_expr_op__ managed them fine even in absence of var* macros.

```
\XINT_expr_defvar_one{nil}{}%
\XINT_expr_defvar_one{None}{{}}% ? tentative
\XINT_expr_defvar_one{false}{{0}}% Maple, TeX
\XINT_expr_defvar_one{true}{{1}}%
\XINT_expr_defvar_one{False}{{0}}% Python
\XINT_expr_defvar_one{True}{{1}}%
```

12.25.2 \xintensuredummy, \xintrestorevariable

1.3e \xintensuredummy differs from \xintnewdummy only in the informational message... Attention that this is not meant to be nested.

1.4 fixes that the message mentioned non-existent \xintrestoredummy (real name was \xintrestorelettervar and renames the latter to \xintrestorevariable as it applies also to multi-letter names.

```
\def\xintensuredummy #1{%
    \XINT_expr_makedummy{#1}%
    \ifxintverbose\xintMessage {xintexpr}{Info}%
        {\XINT_tmpa\space now
         \ifxintglobaldefs globally \fi usable as dummy variable.&&J
         Issue \string\xintrestorevariable{\XINT_tmpa} to restore former meaning.}%
    \fi
}%
\def\xintrestorevariablesilently #1{%
   \edef\XINT_tmpa{\xint_zapspaces #1 \xint_gobble_i}%
   \ifcsname XINT_expr_var_\XINT_tmpa/old\endcsname
     \XINT_global
     \expandafter\let\csname XINT_expr_var_\XINT_tmpa\expandafter\endcsname
                     \csname XINT_expr_var_\XINT_tmpa/old\expandafter\endcsname
   \fi
   \ifcsname XINT_expr_var*_\XINT_tmpa/old\endcsname
     \XINT_global
     \expandafter\let\csname XINT_expr_var*_\XINT_tmpa\expandafter\endcsname
                     \csname XINT_expr_var*_\XINT_tmpa/old\expandafter\endcsname
   \fi
}%
\def\xintrestorevariable #1{%
    \xintrestorevariablesilently {#1}%
    \ifxintverbose\xintMessage {xintexpr}{Info}%
        {\XINT_tmpa\space
```

```
        \ifxintglobaldefs globally \fi restored to its earlier status, if any.}%
    \fi
}%
```

12.25.3 Checking (without expansion) that a symbolic expression contains correctly nested parentheses

Expands to \xint_c_mone in case a closing) had no opening (matching it, to \@ne if opening (had no closing) matching it, to \z@ if expression was balanced. Call it as:

\XINT_isbalanced_a \relax #1(\xint_bye)\xint_bye

This is legacy f-expandable code not using \expanded even at 1.4.

```
\def\XINT_isbalanced_a #1({\XINT_isbalanced_b #1)\xint_bye }%
\def\XINT_isbalanced_b #1)#2%
   {\xint_bye #2\XINT_isbalanced_c\xint_bye\XINT_isbalanced_error }%
```

if #2 is not \xint_bye, a) was found, but there was no (. Hence error -> -1

```
\def\XINT_isbalanced_error #1)\xint_bye {\xint_c_mone}%
```

#2 was \xint_bye, was there a) in original #1?

```
\def\XINT_isbalanced_c\xint_bye\XINT_isbalanced_error #1%
    {\xint_bye #1\XINT_isbalanced_yes\xint_bye\XINT_isbalanced_d #1}%
```

#1 is \xint_bye, there was never (nor) in original #1, hence OK.

```
\def\XINT_isbalanced_yes\xint_bye\XINT_isbalanced_d\xint_bye )\xint_bye {\xint_c_ }%
```

#1 is not \xint_bye, there was indeed a (in original #1. We check if we see a). If we do, we then loop until no (nor) is to be found.

```
\def\XINT_isbalanced_d #1)#2%
   {\xint_bye #2\XINT_isbalanced_no\xint_bye\XINT_isbalanced_a #1#2}%
```

#2 was \xint_bye, we did not find a closing) in original #1. Error.

```
\def\XINT_isbalanced_no\xint_bye #1\xint_bye\xint_bye {\xint_c_i }%
```

12.25.4 Fetching balanced expressions E1, E2 and a variable name Name from E1, Name=E2)

Multi-letter dummy variables added at 1.4.

```
\def\XINT_expr_fetch_E_comma_V_equal_E_a #1#2,%
{%
    \ifcase\XINT_isbalanced_a \relax #1#2(\xint_bye)\xint_bye
           \expandafter\XINT_expr_fetch_E_comma_V_equal_E_c
        \or\expandafter\XINT_expr_fetch_E_comma_V_equal_E_b
      \else\expandafter\xintError:noopening
    \fi {#1#2},%
}%
\def\XINT_expr_fetch_E_comma_V_equal_E_b #1,%
   {\XINT_expr_fetch_E_comma_V_equal_E_a {#1,}}%
\def\XINT_expr_fetch_E_comma_V_equal_E_c #1,#2#3=%
{%
    \expandafter\XINT_expr_fetch_E_comma_V_equal_E_d\expandafter
    {\expanded{{\xint_zapspaces #2#3 \xint_gobble_i}}{#1}}{}%
}%
\def\XINT_expr_fetch_E_comma_V_equal_E_d #1#2#3)%
{%
    \ifcase\XINT_isbalanced_a \relax #2#3(\xint_bye)\xint_bye
        \or\expandafter\XINT_expr_fetch_E_comma_V_equal_E_e
```

```
        \else\expandafter\xintError:noopening
    \fi
    {#1}{#2#3}%
}%
\def\XINT_expr_fetch_E_comma_V_equal_E_e #1#2%
   {\XINT_expr_fetch_E_comma_V_equal_E_d {#1}{#2}}}%
```

12.25.5 Fetching a balanced expression delimited by a semi-colon

1.4. For subsn() leaner syntax of nested substitutions.

Will also serve to \xintdeffunc, to not have to hide inner semi-colons in for example an iter() from \xintdeffunc.

Adding brace removal protection for no serious reason, anyhow the xintexpr parsers always removes braces when moving forward, but well.

Trigger by \romannumeral\XINT_expr_fetch_to_semicolon upfront.

```
\def\XINT_expr_fetch_to_semicolon {\XINT_expr_fetch_to_semicolon_a {}\empty}%
\def\XINT_expr_fetch_to_semicolon_a #1#2;%
{%
    \ifcase\XINT_isbalanced_a \relax #1#2(\xint_bye)\xint_bye
           \xint_dothis{\expandafter\XINT_expr_fetch_to_semicolon_c}%
        \or\xint_dothis{\expandafter\XINT_expr_fetch_to_semicolon_b}%
      \else\expandafter\xintError:noopening
    \fi\xint_orthat{}\expandafter{#2}{#1}%
}%
\def\XINT_expr_fetch_to_semicolon_b #1#2{\XINT_expr_fetch_to_semicolon_a {#2#1;}\empty}%
\def\XINT_expr_fetch_to_semicolon_c #1#2{\xint_c_{#2#1}}%
```

12.25.6 Low-level support for omit and abort keywords, the break() function, the n++ construct and the semi-colon as used in the syntax of seq(), add(), mul(), iter(), rseq(), iterr(), rrseq(), subsm(), subsn(), ndseq(), ndmap()

There is some clever play simply based on setting suitable precedence levels combined with special meanings given to op macros.

The special !? internal operator is a helper for omit and abort keywords in list generators.

Prior to 1.4 support for +[, *[, ...,]+,]*, had some elements here.

The n++ construct 1.1 2014/10/29 did \expandafter\.=+\xintiCeil which transformed it into \romannumeral0\xinticeil, which seems a bit weird. This exploited the fact that dummy variables macros could back then pick braced material (which in the case at hand here ended being {\romannumeral0\xinticeil...} and were submitted to two expansions. The result of this was to provide a not value which got expanded only in the first loop of the :_A and following macros of seq, iter, rseq, etc...

Anyhow with 1.2c I have changed the implementation of dummy variables which now need to fetch a single locked token, which they do not expand.

The \xintiCeil appears a bit dispendious, but I need the starting value in a \numexpr compatible form in the iteration loops.

```
\expandafter\def\csname XINT_expr_itself_++\endcsname {++}%
\expandafter\def\csname XINT_expr_itself_++)\endcsname {++)}%
\expandafter\let\csname XINT_expr_precedence_++)\endcsname \xint_c_i
\xintFor #1 in {expr,flexpr,iiexpr} \do {%
    \expandafter\def\csname XINT_#1_op_++)\endcsname ##1##2\relax
     {\expandafter\XINT_expr_foundend
```

```
                    \expanded{{+{\XINT:NEhook:f:one:from:one:direct\xintiCeil##1}}}%
     }%
}%
```

The break() function break is a true function, the parsing via expansion of the enclosed material proceeds via _oparen macros as with any other function.

```
\catcode`? 3
\def\XINT_expr_func_break #1#2#3{#1#2{?#3}}%
\catcode`? 11
\let\XINT_flexpr_func_break \XINT_expr_func_break
\let\XINT_iiexpr_func_break \XINT_expr_func_break
```

The omit and abort keywords Comments are currently undergoing reconstruction.

The mechanism is somewhat complex. The operator !? will fetch a dummy value ! or ^ which is then recognized int the loops implementing the various seq etc... construct using dummy variables and implement omit and abort.

In May 2021 I realized that the January 2020 1.4 had broken omit and abort if used inside a subs(). The definition

\edef\XINT_expr_var_omit #1\relax !{1\string !?!\relax !}

conflicted with the 1.4 refactoring of «subs» and similar things which had replaced formerly clean-up macros (of ! and what's next, as in now defunct \def\XINT_expr_subx:_end #1!#2#3{#1} which was involved in subs mechanism, and by the way would be incompatible with multi-letter dummy variables) by usage of an \iffalse as in "\relax\iffalse\relax !" to delimite a sub-expression, which was supposed to be clever (the "\relax !" being delimiter for dummy variables).

This \iffalse from subs mechanism ended up being gobbled by omit/abort thus inducing breakage.

Grabbing \relax #2! would be a fix but looks a bit dangerous, as there can be a subexpression after the omit or abort bringing its own \relax, although this is very very unlikely.

I considered to modify the dummy variables delimiter from \relax ! to \xint_Bye ! for example but got afraid from the ramifications, as all structures handling dummy variables would have needed refactoring.

So finally things here remain unchanged and the refactoring to fix this breakage was done in \XINT_allexpr_subsx (and also subsm). Done at 1.4h. See \XINT_allexpr_subsx for comments.

```
\edef\XINT_expr_var_omit  #1\relax !{1\string !?!\relax !}%
\edef\XINT_expr_var_abort #1\relax !{1\string !?^\relax !}%
\def\XINT_expr_itself_!? {!?}%
\def\XINT_expr_op_!? #1#2\relax{\XINT_expr_foundend{#2}}%
\let\XINT_iiexpr_op_!? \XINT_expr_op_!?
\let\XINT_flexpr_op_!? \XINT_expr_op_!?
\let\XINT_expr_precedence_!? \xint_c_iv
```

The semi-colon Obsolete comments undergoing re-construction

```
\xintFor #1 in {expr,flexpr,iiexpr} \do {%
     \expandafter\def\csname XINT_#1_op_;\endcsname {\xint_c_i ;}%
}%
\expandafter\let\csname XINT_expr_precedence_;\endcsname\xint_c_i
\expandafter\def\csname XINT_expr_itself_;)\endcsname {)}%
\expandafter\let\csname XINT_expr_precedence_;)\endcsname\xint_c_i
```

12.25.7 Reserved dummy variables @, @1, @2, @3, @4, @@, @@(1), ..., @@@, @@@(1), ... for recursions

Comments currently under reconstruction.

1.4 breaking change: @ and @1 behave differently and one can not use @ in place of @1 in iterr() and rrseq(). Formerly @ and @1 had the same definition.

Brace stripping in \XINT_expr_func_@@ is prevented by some ending 0 or other token see iterr() and rrseq() code.

For the record, the ~ and ? have catcode 3 in this code.

```
\catcode`* 11
\def\XINT_expr_var_@ #1~#2{{#2}#1~{#2}}%
\def\XINT_expr_var*_@ #1~#2{\XINT_expr_prec_tacit *{#2}(#1~{#2}}%
\expandafter
\def\csname XINT_expr_var_@1\endcsname #1~#2{{{#2}}#1~{#2}}%
\expandafter
\def\csname XINT_expr_var_@2\endcsname #1~#2#3{{{#3}}#1~{#2}{#3}}%
\expandafter
\def\csname XINT_expr_var_@3\endcsname #1~#2#3#4{{{#4}}#1~{#2}{#3}{#4}}%
\expandafter
\def\csname XINT_expr_var_@4\endcsname #1~#2#3#4#5{{{#5}}#1~{#2}{#3}{#4}{#5}}%
\expandafter\def\csname XINT_expr_var*_@1\endcsname #1~#2%
               {\XINT_expr_prec_tacit *{{#2}}(#1~{#2}}%
\expandafter\def\csname XINT_expr_var*_@2\endcsname #1~#2#3%
               {\XINT_expr_prec_tacit *{{#3}}(#1~{#2}{#3}}%
\expandafter\def\csname XINT_expr_var*_@3\endcsname #1~#2#3#4%
               {\XINT_expr_prec_tacit *{{#4}}(#1~{#2}{#3}{#4}}%
\expandafter\def\csname XINT_expr_var*_@4\endcsname #1~#2#3#4#5%
               {\XINT_expr_prec_tacit *{{#5}}(#1~{#2}{#3}{#4}{#5}}%
\catcode`* 12
\catcode`? 3
\def\XINT_expr_func_@@ #1#2#3#4~#5?%
{%
  \expandafter#1\expandafter#2\expandafter{\expandafter{%
      \romannumeral0\xintntheltnoexpand{\xintNum#3}{#5}}}#4~#5?%
}%
\def\XINT_expr_func_@@@ #1#2#3#4~#5~#6?%
{%
  \expandafter#1\expandafter#2\expandafter{\expandafter{%
      \romannumeral0\xintntheltnoexpand{\xintNum#3}{#6}}}#4~#5~#6?%
}%
\def\XINT_expr_func_@@@@ #1#2#3#4~#5~#6~#7?%
{%
  \expandafter#1\expandafter#2\expandafter{\expandafter{%
      \romannumeral0\xintntheltnoexpand{\xintNum#3}{#7}}}#4~#5~#6~#7?%
}%
\let\XINT_flexpr_func_@@\XINT_expr_func_@@
\let\XINT_flexpr_func_@@@\XINT_expr_func_@@@
\let\XINT_flexpr_func_@@@@\XINT_expr_func_@@@@
\def\XINT_iiexpr_func_@@ #1#2#3#4~#5?%
{%
  \expandafter#1\expandafter#2\expandafter{\expandafter{%
      \romannumeral0\xintntheltnoexpand{\xint_firstofone#3}{#5}}}#4~#5?%
}%
\def\XINT_iiexpr_func_@@@ #1#2#3#4~#5~#6?%
{%
  \expandafter#1\expandafter#2\expandafter{\expandafter{%
```

```
        \romannumeral0\xintntheltnoexpand{\xint_firstofone#3}{#6}}}#4~#5~#6?%
}%
\def\XINT_iiexpr_func_@@@@ #1#2#3#4~#5~#6~#7?%
{%
    \expandafter#1\expandafter#2\expandafter{\expandafter{%
        \romannumeral0\xintntheltnoexpand{\xint_firstofone#3}{#7}}}#4~#5~#6~#7?%
}%
\catcode`? 11
```

12.26 Pseudo-functions involving dummy variables and generating scalars or sequences

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12.26.1 Comments

Comments added 2020/01/16.

The mechanism for «seq» is the following. When the parser encounters «seq», which means it parsed these letters and encountered (from expansion) an opening parenthesis, the \XINT_expr_func mechanism triggers the «`» operator which realizes that «seq» is a pseudo-function (there is no _func_seq) and thus spans the \XINT_expr_onliteral_seq macro (currently this means however that the knowledge of which parser we are in is lost, see comments of \XINT_expr_op_` code). The latter will use delimited macros and parenthesis check to fetch (without any expansion), the symbolic expression ExprSeq to evaluate, the Name (now possibly multi-letter) of the variable and the expression ExprValues to evaluate which will give the values to assign to the dummy variable Name. It then positions upstream ExprValues suitably terminated (see next) and after it {{Name}{ExprSeq}}. Then it inserts a second call to the «`» operator with now «seqx» as argument hence the appropriate «{,fl,ii}expr_func_seqx» macros gets executed. The general way function macros work is that first all their arguments are evaluated via a call not to \xintbare{,float,ii}eval but to the suitable \XINT_{expr,flexpr,iiexpr}_oparen core macro which does almost same excepts it expects a final closing parenthesis (of course allowing nested parenthesis in-between) and stops there. Here, this closing parenthesis got positioned deliberately with a \relax after it, so the parser, which always after having gathered a value looks ahead to find the next operator, thinks it has hit the end of the expression and as result inserts a \xint_c_ (i.e. \z@) token for precedence level and a dummy \relax token (place-holder for a non-existing operator). Generally speaking «func_foo» macros expect to be executed with three parameters #1#2#3, #1 = precedence, #2 = operator, #3 = values (call it «args») i.e. the fully evaluated list of all its arguments. The special «func_seqx» and cousins know that the first two tokens are trash and they now proceed forward, having thus lying before them upstream the values to loop over, now fully evaluated, and {{Name}{ExprSeq}}. It then positions appropriately ExprSeq inside a sub-expression and after it, following suitable delimiter, Name and the evaluated values to assign to Name.

Dummy variables are essentially simply delimited macros where the delimiter is the variable name preceded by a \relax token and a catcode 11 exclamation point. Thus the various «subsx», «seqx», «iterx» position the tokens appropriately and launch suitable loops.

All of this nests well, inner «seq»'s (or more often in practice «subs»'s) being allowed to refer to the dummy variables used by outer «seq»'s because the outer «seq»'s have the values to assign to their variables evaluated first and their ExprSeq evaluated last. For inner dummy variables to be able to refer to outer dummy variables the author must be careful of course to not use in the implementation braces { and } which would break dummy variables to fetch values beyond the closing brace.

The above «seq» mechanism was done around June 15-25th 2014 at the time of the transition from 1.09n to 1.1 but already in October 2014 I made a note that I had a hard time to understand it again:

« [START OF YEAR 2014 COMMENTS]

All of seq, add, mul, rseq, etc... (actually all of the extensive changes from xintexpr 1.09n to 1.1) was done around June 15-25th 2014, but the problem is that I did not document the code enough, and I had a hard time understanding in October what I had done in June. Despite the lesson, again being short on time, I do not document enough my current understanding of the innards of the beast...

I added subs, and iter in October (also the [:n], [n:] list extractors), proving I did at least understand a bit (or rather could imitate) my earlier code (but don't ask me to explain \xintNewExpr !)

The \XINT_expr_fetch_E_comma_V_equal_E_a parses: "expression, variable=list)" (when it is called the opening (has been swallowed, and it looks for the ending one.) Both expression and list may themselves contain parentheses and commas, we allow nesting. For example "x^2,x=1..10)", at the end of seq_a we have {variable{expression}}{list}, in this example {x{x^2}}{1..10}, or more complicated "seq(add(y,y=1..x),x=1..10)" will work too. The variable is a single lowercase Latin letter.

The complications with \xint_c_ii^v in seq_f is for the recurrent thing that we don't know in what type of expressions we are, hence we must move back up, with some loss of efficiency (superfluous check for minus sign, etc...). But the code manages simultaneously expr, flexpr and iiexpr.

[END OF YEAR 2014 OLD COMMENTS]»

On Jeudi 16 janvier 2020 à 15:13:32 I finally did the documentation as above.

The case of «iter», «rseq», «iterr», «rrseq» differs slightly because the initial values need evaluation. This is done by genuine functions \XINT_<parser>_func_iter etc... (there was no \XINT_<parser>_func_seq). The trick is via the semi-colon ; which is a genuine operator having the precedence of a closing parenthesis and whose action is only to stop expansion. Thus this first step of gathering the initial values is done as part of the reguler expansion job of the parser not using delimited macros and the ; can be hidden in braces {;} because the three parsers when moving forward remove one level of braces always. Thus \XINT_<parser>_func_seq simply hand over to \XINT_allexpr_iter which will then trigger the fetching without expansion of ExprIter, Name=ExprValues as described previously for «seq».

With 1.4, multi-letter names for dummy variables are allowed.

Also there is the additional 1.4 ambition to make the whole thing parsable by \xintNewExpr/\xintdeffunc. This is done by checking if all is numerical, because the omit, abort and break() mechanisms have no translation into macros, and the only solution for symbolic material is to simply keep it as is, so that expansion will again activate the xintexpr parsers. At 1.4 this approach is fine although the initial goals of \xintNewExpr/\xintdeffunc was to completely replace the parsers (whose storage method hit the string pool formerly) by macros. Now that 1.4 does not impact the string pool we can make \xintdeffunc much more powerful but it will not be a construct using only xintfrac macros, it will still be partially the \xintexpr etc... parsers in such cases.

Got simpler with 1.2c as now the dummy variable fetches an already encapsulated value, which is anyhow the form in which we get it.

Refactored at 1.4 using \expanded rather than \csname.

And support for multi-letter variables, which means function declarations can now use multi-letter variables !

12.26.2 subs(): substitution of one variable

```
\def\XINT_expr_onliteral_subs
{%
    \expandafter\XINT_allexpr_subs_f
    \romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}%
}%
\def\XINT_allexpr_subs_f #1#2{\xint_c_ii^v `{subsx}#2)\relax #1}%
\def\XINT_expr_func_subsx   #1#2{\XINT_allexpr_subsx \xintbareeval }%
\def\XINT_flexpr_func_subsx #1#2{\XINT_allexpr_subsx \xintbarefloateval}%
\def\XINT_iiexpr_func_subsx #1#2{\XINT_allexpr_subsx \xintbareiieval }%
```

#2 is the value to assign to the dummy variable #3 is the dummy variable name (possibly multi-letter), #4 is the expression to evaluate

1.4 was doing something clever to get rid of the ! and tokens following it, via an \iffalse...\fi which erased them and propagated the expansion to trigger the getopt:

```
\expanded\bgroup\romannumeral0#1#4\relax \iffalse\relax !#3{#2}{\fi\expandafter}
```

But sadly, with a delay of more than one year later (right after having released 1.4g) I realized that this had broken omit and abort if inside a subs. As omit and abort would clean all up to \relax !, this meant here swallowing in particular the above \iffalse, leaving a dangling \fi. I had the files which show this bug already at time of 1.4 release but did not compile them, and they were not included in my test suite.

I hesitated with modifying the delimiter from "\relax !<varname>" (catcode 11 !) to "\relax \xint_Bye<varname>" for the dummy variables which would have allowed some trickery using \xint_Bye...\xint_bye clean-up but got afraid from the breakage potential of such refactoring with many induced changes.

A variant like this:

```
\def\XINT_allexpr_subsx #1#2#3#4
{
    \expandafter\XINT_expr_clean_and_put_op_first
    \expanded
    {\romannumeral0#1#4\relax !#3{#2}\xint:\expandafter}\romannumeral`&&\XINT_expr_getop
}
\def\XINT_expr_clean_and_put_op_first #1#2\xint:#3#4{#3#4{#1}}
```

breaks nesting: the braces make variables encountered in #4 unable to match their definition. This would work:

```
\def\XINT_allexpr_subsx #1#2#3#4
{
    \expandafter\XINT_allexpr_subsx_clean\romannumeral0#1#4\relax !#3{#2}\xint:
}
\def\XINT_allexpr_subsx_clean #1#2\xint:
{
    \expandafter\XINT_expr_put_op_first
    \expanded{\unexpanded{{#1}}\expandafter}\romannumeral`&&@\XINT_expr_getop
}
```

(not tested).

But in the end I decided to simply fix the first envisioned code above. This accepts expansion of supposedly inert #3{#2}. There is again the \iffalse but it is moved to the right. This change limits possibly hacky future developments. Done at 1.4h (2021/01/27).

No need for the \expandafter's from \XINT_expr_put_op_first in \XINT_expr_clean_and_put_op_first.

```
\def\XINT_allexpr_subsx #1#2#3#4%
{%
```

```
    \expandafter\XINT_expr_clean_and_put_op_first
    \expanded
    \bgroup\romannumeral0#1#4\relax !#3{#2}\xint:\iffalse{\fi\expandafter}%
    \romannumeral`&&@\XINT_expr_getop
}%
\def\XINT_expr_clean_and_put_op_first #1#2\xint:#3#4{#3#4{#1}}%
```

12.26.3 subsm(): simultaneous independent substitutions

New with 1.4. Globally the var1=expr1; var2=expr2; var2=expr3;... part can arise from expansion, except that once a semi-colon has been found (from expansion) the varK= thing following it must be there. And as for subs() the final parenthesis must be there from the start.

```
\def\XINT_expr_onliteral_subsm
{%
    \expandafter\XINT_allexpr_subsm_f
    \romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}%
}%
\def\XINT_allexpr_subsm_f #1#2{\xint_c_ii^v `{subsmx}#2)\relax #1}%
\def\XINT_expr_func_subsmx
{%
    \expandafter\XINT_allexpr_subsmx\expandafter\xintbareeval
    \expanded\bgroup{\iffalse}\fi\XINT_allexpr_subsm_A\XINT_expr_oparen
}%
\def\XINT_flexpr_func_subsmx
{%
    \expandafter\XINT_allexpr_subsmx\expandafter\xintbarefloateval
    \expanded\bgroup{\iffalse}\fi\XINT_allexpr_subsm_A\XINT_flexpr_oparen
}%
\def\XINT_iiexpr_func_subsmx
{%
    \expandafter\XINT_allexpr_subsmx\expandafter\xintbareiieval
    \expanded\bgroup{\iffalse}\fi\XINT_allexpr_subsm_A\XINT_iiexpr_oparen
}%
\def\XINT_allexpr_subsm_A #1#2#3%
{%
    \ifx#2\xint_c_
       \expandafter\XINT_allexpr_subsm_done
    \else
       \expandafter\XINT_allexpr_subsm_B
    \fi #1%
}%
\def\XINT_allexpr_subsm_B #1#2#3#4=%
{%
    {#2}\relax !\xint_zapspaces#3#4 \xint_gobble_i
    \expandafter\XINT_allexpr_subsm_A\expandafter#1\romannumeral`&&@#1%
}%
```

```
   #1 = \xintbareeval,  or \xintbarefloateval or \xintbareiieval
   #2 = evaluation of last variable assignment
```

```
\def\XINT_allexpr_subsm_done #1#2{{#2}\iffalse{{\fi}}}%
```

```
   #1 = \xintbareeval or \xintbarefloateval or \xintbareiieval
   #2 = {value1}\relax !var2{value2}....\relax !varN{valueN} (value's may be oples)
   #3 = {var1}
```

  #4 = the expression to evaluate
Refactored at 1.4h as for \XINT_allexpr_subsx, see comments there related to the omit/abort conundrum.

```
\def\XINT_allexpr_subsmx #1#2#3#4%
{%
    \expandafter\XINT_expr_clean_and_put_op_first
    \expanded
    \bgroup\romannumeral0#1#4\relax !#3#2\xint:\iffalse{\fi\expandafter}%
    \romannumeral`&&@\XINT_expr_getop
}%
```

12.26.4 subsn(): leaner syntax for nesting (possibly dependent) substitutions

New with 1.4. 2020/01/24

```
\def\XINT_expr_onliteral_subsn
{%
    \expandafter\XINT_allexpr_subsn_f
    \romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}%
}%
\def\XINT_allexpr_subsn_f #1{\XINT_allexpr_subsn_g #1}%
```

  #1 = Name1
  #2 = Expression in all variables which is to evaluate
  #3 = all the stuff after Name1 = and up to final parenthesis
This one needed no reactoring at 1.4h to fix the omit/abort problem, as there was no \iffalse..\fi clean-up: the clean-up is done directly via \XINT_allexpr_subsnx_J.

I only added usage of \XINT_expr_put_op_first_noexpand. There may be other locations where it could be used, but I can't afford now reviewing usage. For next release after 1.4h bugfix.

```
\def\XINT_allexpr_subsn_g #1#2#3%
{%
    \expandafter\XINT_allexpr_subsn_h
    \expanded\bgroup{\iffalse}\fi\expandafter\XINT_allexpr_subsn_B
    \romannumeral\XINT_expr_fetch_to_semicolon #1=#3;\hbox=;;^{#2}%
}%
\def\XINT_allexpr_subsn_B #1{\XINT_allexpr_subsn_C #1\vbox}%
\def\XINT_allexpr_subsn_C #1#2=#3\vbox
{%
    \ifx\hbox#1\iffalse{{\fi}\expandafter}\else
    {{\xint_zapspaces #1#2 \xint_gobble_i}};\unexpanded{{{#3}}}%
    \expandafter\XINT_allexpr_subsn_B
    \romannumeral\expandafter\XINT_expr_fetch_to_semicolon\fi
}%
\def\XINT_allexpr_subsn_h
{%
    \xint_c_ii^v `{subsnx}\romannumeral0\xintreverseorder
}%
\def\XINT_expr_func_subsnx #1#2#3#4#5;#6%
{%
    \xint_gob_til_^ #6\XINT_allexpr_subsnx_H ^%
    \expandafter\XINT_allexpr_subsnx\expandafter
    \xintbareeval\romannumeral0\xintbareeval #5\relax !#4{#3}\xintundefined
    {\relax !#4{#3}\relax !#6}%
}%
```

```
\def\XINT_iiexpr_func_subsnx #1#2#3#4#5;#6%
{%
    \xint_gob_til_^ #6\XINT_allexpr_subsnx_H ^%
    \expandafter\XINT_allexpr_subsnx\expandafter
    \xintbareiieval\romannumeral0\xintbareiieval #5\relax !#4{#3}\xintundefined
    {\relax !#4{#3}\relax !#6}%
}%
\def\XINT_flexpr_func_subsnx #1#2#3#4#5;#6%
{%
    \xint_gob_til_^ #6\XINT_allexpr_subsnx_H ^%
    \expandafter\XINT_allexpr_subsnx\expandafter
    \xintbarefloateval\romannumeral0\xintbarefloateval #5\relax !#4{#3}\xintundefined
    {\relax !#4{#3}\relax !#6}%
}%
\def\XINT_allexpr_subsnx #1#2!#3\xintundefined#4#5;#6%
{%
    \xint_gob_til_^ #6\XINT_allexpr_subsnx_I ^%
    \expandafter\XINT_allexpr_subsnx\expandafter
    #1\romannumeral0#1#5\relax !#4{#2}\xintundefined
    {\relax !#4{#2}\relax !#6}%
}%
\def\XINT_allexpr_subsnx_H ^#1\romannumeral0#2#3!#4\xintundefined #5#6%
{%
    \expandafter\XINT_allexpr_subsnx_J\romannumeral0#2#6#5%
}%
\def\XINT_allexpr_subsnx_I ^#1\romannumeral0#2#3\xintundefined #4#5%
{%
    \expandafter\XINT_allexpr_subsnx_J\romannumeral0#2#5#4%
}%
\def\XINT_allexpr_subsnx_J #1#2^%
{%
    \expandafter\XINT_expr_put_op_first_noexpand
    \expanded{\unexpanded{{#1}}\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT_expr_put_op_first_noexpand#1#2#3{#2#3{#1}}%
```

12.26.5 seq(): sequences from assigning values to a dummy variable

In seq_f, the #2 is the ExprValues expression which needs evaluation to provide the values to the dummy variable and #1 is {Name}{ExprSeq} where Name is the name of dummy variable and {ExprSeq} the expression which will have to be evaluated.

```
\def\XINT_allexpr_seq_f #1#2{\xint_c_ii^v `{seqx}#2)\relax #1}%
\def\XINT_expr_onliteral_seq
 {\expandafter\XINT_allexpr_seq_f\romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}}%
\def\XINT_expr_func_seqx   #1#2{\XINT:NEhook:seqx\XINT_allexpr_seqx\xintbareeval }%
\def\XINT_flexpr_func_seqx #1#2{\XINT:NEhook:seqx\XINT_allexpr_seqx\xintbarefloateval}%
\def\XINT_iiexpr_func_seqx #1#2{\XINT:NEhook:seqx\XINT_allexpr_seqx\xintbareiieval }%
\def\XINT_allexpr_seqx #1#2#3#4%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded \bgroup {\iffalse}\fi\XINT_expr_seq:_b {#1#4\relax !#3}#2^%
    \XINT_expr_cb_and_getop
}%
```

```
\def\XINT_expr_cb_and_getop{\iffalse{\fi\expandafter}\romannumeral`&&@\XINT_expr_getop}%
```

Comments undergoing reconstruction.

```
\catcode`? 3
\def\XINT_expr_seq:_b #1#2%
{%
    \ifx +#2\xint_dothis\XINT_expr_seq:_Ca\fi
    \ifx !#2!\xint_dothis\XINT_expr_seq:_noop\fi
    \ifx ^#2\xint_dothis\XINT_expr_seq:_end\fi
    \xint_orthat{\XINT_expr_seq:_c}{#2}{#1}%
}%
\def\XINT_expr_seq:_noop #1{\XINT_expr_seq:_b }%
\def\XINT_expr_seq:_end  #1#2{\iffalse{\fi}}%
\def\XINT_expr_seq:_c #1#2{\expandafter\XINT_expr_seq:_d\romannumeral0#2{{#1}}{#2}}%
\def\XINT_expr_seq:_d #1{\ifx ^#1\xint_dothis\XINT_expr_seq:_abort\fi
                         \ifx ?#1\xint_dothis\XINT_expr_seq:_break\fi
                         \ifx !#1\xint_dothis\XINT_expr_seq:_omit\fi
                         \xint_orthat{\XINT_expr_seq:_goon {#1}}}%
\def\XINT_expr_seq:_abort #1!#2^{\iffalse{\fi}}%
\def\XINT_expr_seq:_break #1!#2^{#1\iffalse{\fi}}%
\def\XINT_expr_seq:_omit  #1!#2#{\expandafter\XINT_expr_seq:_b\xint_gobble_i}%
\def\XINT_expr_seq:_goon  #1!#2#{#1\expandafter\XINT_expr_seq:_b\xint_gobble_i}%
\def\XINT_expr_seq:_Ca #1#2#3{\XINT_expr_seq:_Cc#3.{#2}}%
\def\XINT_expr_seq:_Cb #1{\expandafter\XINT_expr_seq:_Cc\the\numexpr#1+\xint_c_i.}%
\def\XINT_expr_seq:_Cc #1.#2{\expandafter\XINT_expr_seq:_D\romannumeral0#2{{#1}}{#1}{#2}}%
\def\XINT_expr_seq:_D #1{\ifx ^#1\xint_dothis\XINT_expr_seq:_abort\fi
                         \ifx ?#1\xint_dothis\XINT_expr_seq:_break\fi
                         \ifx !#1\xint_dothis\XINT_expr_seq:_Omit\fi
                         \xint_orthat{\XINT_expr_seq:_Goon {#1}}}%
\def\XINT_expr_seq:_Omit #1!#2#{\expandafter\XINT_expr_seq:_Cb\xint_gobble_i}%
\def\XINT_expr_seq:_Goon #1!#2#{#1\expandafter\XINT_expr_seq:_Cb\xint_gobble_i}%
```

12.26.6 iter()

Prior to 1.2g, the iter keyword was what is now called iterr, analogous with rrseq. Somehow I forgot an iter functioning like rseq with the sole difference of printing only the last iteration. Both rseq and iter work well with list selectors, as @ refers to the whole comma separated sequence of the initial values. I have thus deliberately done the backwards incompatible renaming of iter to iterr, and the new iter.

To understand the tokens which are presented to \XINT_allexpr_iter it is needed to check elsewhere in the source code how the ; hack is done.

The #2 in \XINT_allexpr_iter is \xint_c_i from the ; hack. Formerly (xint < 1.4) there was no such token. The change is motivated to using ; also in subsm() syntax.

```
\def\XINT_expr_func_iter    {\XINT_allexpr_iter \xintbareeval      }%
\def\XINT_flexpr_func_iter {\XINT_allexpr_iter \xintbarefloateval }%
\def\XINT_iiexpr_func_iter {\XINT_allexpr_iter \xintbareiieval     }%
\def\XINT_allexpr_iter #1#2#3#4%
{%
    \expandafter\XINT_expr_iterx
    \expandafter#1\expanded{\unexpanded{{#4}}\expandafter}%
    \romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}%
}%
\def\XINT_expr_iterx #1#2#3#4%
```

```
{%
    \XINT:NEhook:iter\XINT_expr_itery\romannumeral0#1(#4)\relax {#2}#3#1%
}%
\def\XINT_expr_itery #1#2#3#4#5%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded \bgroup {\iffalse}\fi
    \XINT_expr_iter:_b {#5#4\relax !#3}#1^~{#2}\XINT_expr_cb_and_getop
}%
\def\XINT_expr_iter:_b #1#2%
{%
    \ifx +#2\xint_dothis\XINT_expr_iter:_Ca\fi
    \ifx !#2!\xint_dothis\XINT_expr_iter:_noop\fi
    \ifx ^#2\xint_dothis\XINT_expr_iter:_end\fi
    \xint_orthat{\XINT_expr_iter:_c}{#2}{#1}%
}%
\def\XINT_expr_iter:_noop #1{\XINT_expr_iter:_b }%
\def\XINT_expr_iter:_end  #1#2~#3{#3\iffalse{\fi}}%
\def\XINT_expr_iter:_c #1#2{\expandafter\XINT_expr_iter:_d\romannumeral0#2{{#1}}{#2}}%
\def\XINT_expr_iter:_d #1{\ifx ^#1\xint_dothis\XINT_expr_iter:_abort\fi
                          \ifx ?#1\xint_dothis\XINT_expr_iter:_break\fi
                          \ifx !#1\xint_dothis\XINT_expr_iter:_omit\fi
                          \xint_orthat{\XINT_expr_iter:_goon {#1}}}%
\def\XINT_expr_iter:_abort #1!#2^~#3{#3\iffalse{\fi}}%
\def\XINT_expr_iter:_break #1!#2^~#3{#1\iffalse{\fi}}%
\def\XINT_expr_iter:_omit  #1!#2#{\expandafter\XINT_expr_iter:_b\xint_gobble_i}%
\def\XINT_expr_iter:_goon  #1!#2#{\XINT_expr_iter:_goon_a {#1}}%
\def\XINT_expr_iter:_goon_a #1#2#3~#4{\XINT_expr_iter:_b #3~{#1}}%
\def\XINT_expr_iter:_Ca #1#2#3{\XINT_expr_iter:_Cc#3.{#2}}%
\def\XINT_expr_iter:_Cb #1{\expandafter\XINT_expr_iter:_Cc\the\numexpr#1+\xint_c_i.}%
\def\XINT_expr_iter:_Cc #1.#2{\expandafter\XINT_expr_iter:_D\romannumeral0#2{{#1}}{#1}{#2}}%
\def\XINT_expr_iter:_D #1{\ifx ^#1\xint_dothis\XINT_expr_iter:_abort\fi
                          \ifx ?#1\xint_dothis\XINT_expr_iter:_break\fi
                          \ifx !#1\xint_dothis\XINT_expr_iter:_Omit\fi
                          \xint_orthat{\XINT_expr_iter:_Goon {#1}}}%
\def\XINT_expr_iter:_Omit  #1!#2#{\expandafter\XINT_expr_iter:_Cb\xint_gobble_i}%
\def\XINT_expr_iter:_Goon  #1!#2#{\XINT_expr_iter:_Goon_a {#1}}%
\def\XINT_expr_iter:_Goon_a #1#2#3~#4{\XINT_expr_iter:_Cb #3~{#1}}%
```

12.26.7 add(), mul()

Comments under reconstruction.

These were a bit anomalous as they did not implement omit and abort keyword and the break() function (and per force then neither the n++ syntax).

At 1.4 they are simply mapped to using adequately iter(). Thus, there is small loss in efficiency, but supporting omit, abort and break is important. Using dedicated macros here would have caused also slight efficiency drop. Simpler to remove the old approach.

```
\def\XINT_expr_onliteral_add
 {\expandafter\XINT_allexpr_add_f\romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}}%
\def\XINT_allexpr_add_f #1#2{\xint_c_ii^v `{opx}#2)\relax #1{+}{0}}%
\def\XINT_expr_onliteral_mul
 {\expandafter\XINT_allexpr_mul_f\romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}}%
\def\XINT_allexpr_mul_f #1#2{\xint_c_ii^v `{opx}#2)\relax #1{*}{1}}%
```

```
\def\XINT_expr_func_opx   {\XINT:NEhook:opx \XINT_allexpr_opx \xintbareeval     }%
\def\XINT_flexpr_func_opx {\XINT:NEhook:opx \XINT_allexpr_opx \xintbarefloateval}%
\def\XINT_iiexpr_func_opx {\XINT:NEhook:opx \XINT_allexpr_opx \xintbareiieval   }%
```

1.4a In case of usage of omit (did I not test it? obviously I didn't as neither omit nor abort could work; and break neither), 1.4 code using (#6) syntax caused a (somewhat misleading) «missing)» error message which originated in the #6. This is non-obvious problem (perhaps explained why prior to 1.4 I had not added support for omit and break() to add() and mul()...

Allowing () is not enough as it would have to be 0 or 1 depending on whether we are using add() or mul(). Hence the somewhat complicated detour (relying on precise way var_omit and var_abort work) via \XINT_allexpr_opx_ifnotomitted.

\break() has special meaning here as it is used as last operand, not as last value. The code is very unsatisfactory and inefficient but this is hotfix for 1.4a.

```
\def\XINT_allexpr_opx #1#2#3#4#5#6#7#8%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded \bgroup {\iffalse}\fi
    \XINT_expr_iter:_b {#1%
    \expandafter\XINT_allexpr_opx_ifnotomitted
    \romannumeral0#1#6\relax#7@\relax !#5}#4^~{{#8}}\XINT_expr_cb_and_getop
}%
\def\XINT_allexpr_opx_ifnotomitted #1%
{%
    \ifx !#1\xint_dothis{@\relax}\fi
    \ifx ^#1\xint_dothis{\XINTfstop. ^\relax}\fi
    \if ?\xintFirstItem{#1}\xint_dothis{\XINT_allexpr_opx_break{#1}}\fi
    \xint_orthat{\XINTfstop.{#1}}%
}%
\def\XINT_allexpr_opx_break #1#2\relax
{%
    break(\expandafter\XINTfstop\expandafter.\expandafter{\xint_gobble_i#1}#2)\relax
}%
```

12.26.8 rseq()

When func_rseq has its turn, initial segment has been scanned by oparen, the ; mimicking the rôle of a closing parenthesis, and stopping further expansion (and leaving a \xint_c_i left-over token since 1.4). The ; is discovered during standard parsing mode, it may be for example {;} or arise from expansion as rseq does not use a delimited macro to locate it.

```
\def\XINT_expr_func_rseq   {\XINT_allexpr_rseq \xintbareeval     }%
\def\XINT_flexpr_func_rseq {\XINT_allexpr_rseq \xintbarefloateval }%
\def\XINT_iiexpr_func_rseq {\XINT_allexpr_rseq \xintbareiieval    }%
\def\XINT_allexpr_rseq #1#2#3#4%
{%
    \expandafter\XINT_expr_rseqx
    \expandafter #1\expanded{\unexpanded{{#4}}\expandafter}%
    \romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}%
}%
\def\XINT_expr_rseqx #1#2#3#4%
{%
    \XINT:NEhook:rseq \XINT_expr_rseqy\romannumeral0#1(#4)\relax {#2}#3#1%
}%
\def\XINT_expr_rseqy #1#2#3#4#5%
```

```
{%
    \expandafter\XINT_expr_put_op_first
    \expanded \bgroup {\iffalse}\fi
    #2%
    \XINT_expr_rseq:_b {#5#4\relax !#3}#1^~{#2}\XINT_expr_cb_and_getop
}%
\def\XINT_expr_rseq:_b #1#2%
{%
    \ifx +#2\xint_dothis\XINT_expr_rseq:_Ca\fi
    \ifx !#2!\xint_dothis\XINT_expr_rseq:_noop\fi
    \ifx ^#2\xint_dothis\XINT_expr_rseq:_end\fi
    \xint_orthat{\XINT_expr_rseq:_c}{#2}{#1}%
}%
\def\XINT_expr_rseq:_noop #1{\XINT_expr_rseq:_b }%
\def\XINT_expr_rseq:_end  #1#2~#3{\iffalse{\fi}}%
\def\XINT_expr_rseq:_c #1#2{\expandafter\XINT_expr_rseq:_d\romannumeral0#2{{#1}}{#2}}%
\def\XINT_expr_rseq:_d #1{\ifx ^#1\xint_dothis\XINT_expr_rseq:_abort\fi
                          \ifx ?#1\xint_dothis\XINT_expr_rseq:_break\fi
                          \ifx !#1\xint_dothis\XINT_expr_rseq:_omit\fi
                          \xint_orthat{\XINT_expr_rseq:_goon {#1}}}%
\def\XINT_expr_rseq:_abort #1!#2^~#3{\iffalse{\fi}}%
\def\XINT_expr_rseq:_break #1!#2^~#3{#1\iffalse{\fi}}%
\def\XINT_expr_rseq:_omit  #1!#2#{\expandafter\XINT_expr_rseq:_b\xint_gobble_i}%
\def\XINT_expr_rseq:_goon  #1!#2#{\XINT_expr_rseq:_goon_a {#1}}%
\def\XINT_expr_rseq:_goon_a #1#2#3~#4{#1\XINT_expr_rseq:_b #3~{#1}}%
\def\XINT_expr_rseq:_Ca #1#2#3{\XINT_expr_rseq:_Cc#3.{#2}}%
\def\XINT_expr_rseq:_Cb #1{\expandafter\XINT_expr_rseq:_Cc\the\numexpr#1+\xint_c_i.}%
\def\XINT_expr_rseq:_Cc #1.#2{\expandafter\XINT_expr_rseq:_D\romannumeral0#2{{#1}}{#1}{#2}}%
\def\XINT_expr_rseq:_D #1{\ifx ^#1\xint_dothis\XINT_expr_rseq:_abort\fi
                          \ifx ?#1\xint_dothis\XINT_expr_rseq:_break\fi
                          \ifx !#1\xint_dothis\XINT_expr_rseq:_Omit\fi
                          \xint_orthat{\XINT_expr_rseq:_Goon {#1}}}%
\def\XINT_expr_rseq:_Omit  #1!#2#{\expandafter\XINT_expr_rseq:_Cb\xint_gobble_i}%
\def\XINT_expr_rseq:_Goon  #1!#2#{\XINT_expr_rseq:_Goon_a {#1}}%
\def\XINT_expr_rseq:_Goon_a #1#2#3~#4{#1\XINT_expr_rseq:_Cb #3~{#1}}%
```

12.26.9 iterr()

ATTENTION! at 1.4 the @ and @1 are not synonymous anymore. One *must* use @1 in iterr() context.

```
\def\XINT_expr_func_iterr   {\XINT_allexpr_iterr \xintbareeval      }%
\def\XINT_flexpr_func_iterr {\XINT_allexpr_iterr \xintbarefloateval }%
\def\XINT_iiexpr_func_iterr {\XINT_allexpr_iterr \xintbareiieval    }%
\def\XINT_allexpr_iterr #1#2#3#4%
{%
    \expandafter\XINT_expr_iterrx
    \expandafter #1\expanded{{\xintRevWithBraces{#4}}\expandafter}%
    \romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}%
}%
\def\XINT_expr_iterrx #1#2#3#4%
{%
    \XINT:NEhook:iterr\XINT_expr_iterry\romannumeral0#1(#4)\relax {#2}#3#1%
}%
\def\XINT_expr_iterry #1#2#3#4#5%
```

```
{%
    \expandafter\XINT_expr_put_op_first
    \expanded \bgroup {\iffalse}\fi
    \XINT_expr_iterr:_b {#5#4\relax !#3}#1^~#20?\XINT_expr_cb_and_getop
}%
\def\XINT_expr_iterr:_b #1#2%
{%
    \ifx +#2\xint_dothis\XINT_expr_iterr:_Ca\fi
    \ifx !#2!\xint_dothis\XINT_expr_iterr:_noop\fi
    \ifx ^#2\xint_dothis\XINT_expr_iterr:_end\fi
    \xint_orthat{\XINT_expr_iterr:_c}{#2}{#1}%
}%
\def\XINT_expr_iterr:_noop #1{\XINT_expr_iterr:_b }%
\def\XINT_expr_iterr:_end  #1#2~#3#4?{{#3}\iffalse{\fi}}%
\def\XINT_expr_iterr:_c #1#2{\expandafter\XINT_expr_iterr:_d\romannumeral0#2{{#1}}{#2}}%
\def\XINT_expr_iterr:_d #1{\ifx ^#1\xint_dothis\XINT_expr_iterr:_abort\fi
                           \ifx ?#1\xint_dothis\XINT_expr_iterr:_break\fi
                           \ifx !#1\xint_dothis\XINT_expr_iterr:_omit\fi
                           \xint_orthat{\XINT_expr_iterr:_goon {#1}}}%
\def\XINT_expr_iterr:_abort #1!#2^~#3?{\iffalse{\fi}}%
\def\XINT_expr_iterr:_break #1!#2^~#3?{#1\iffalse{\fi}}%
\def\XINT_expr_iterr:_omit  #1!#2#{\expandafter\XINT_expr_iterr:_b\xint_gobble_i}%
\def\XINT_expr_iterr:_goon  #1!#2#{\XINT_expr_iterr:_goon_a{#1}}%
\def\XINT_expr_iterr:_goon_a  #1#2#3~#4?%
{%
    \expandafter\XINT_expr_iterr:_b \expanded{\unexpanded{#3~}\xintTrim{-2}{#1#4}}0?%
}%
\def\XINT_expr_iterr:_Ca #1#2#3{\XINT_expr_iterr:_Cc#3.{#2}}%
\def\XINT_expr_iterr:_Cb #1{\expandafter\XINT_expr_iterr:_Cc\the\numexpr#1+\xint_c_i.}%
\def\XINT_expr_iterr:_Cc #1.#2%
   {\expandafter\XINT_expr_iterr:_D\romannumeral0#2{{#1}}{#1}{#2}}%
\def\XINT_expr_iterr:_D #1{\ifx ^#1\xint_dothis\XINT_expr_iterr:_abort\fi
                          \ifx ?#1\xint_dothis\XINT_expr_iterr:_break\fi
                          \ifx !#1\xint_dothis\XINT_expr_iterr:_Omit\fi
                          \xint_orthat{\XINT_expr_iterr:_Goon {#1}}}%
\def\XINT_expr_iterr:_Omit #1!#2#{\expandafter\XINT_expr_iterr:_Cb\xint_gooble_i}%
\def\XINT_expr_iterr:_Goon  #1!#2#{\XINT_expr_iterr:_Goon_a{#1}}%
\def\XINT_expr_iterr:_Goon_a  #1#2#3~#4?%
{%
    \expandafter\XINT_expr_iterr:_Cb \expanded{\unexpanded{#3~}\xintTrim{-2}{#1#4}}0?%
}%
```

12.26.10 rrseq()

When func_rrseq has its turn, initial segment has been scanned by oparen, the ; mimicking the rôle of a closing parenthesis, and stopping further expansion. #2 = \xint_c_i and #3 are left-over trash.

```
\def\XINT_expr_func_rrseq   {\XINT_allexpr_rrseq \xintbareeval      }%
\def\XINT_flexpr_func_rrseq {\XINT_allexpr_rrseq \xintbarefloateval }%
\def\XINT_iiexpr_func_rrseq {\XINT_allexpr_rrseq \xintbareiieval    }%
\def\XINT_allexpr_rrseq #1#2#3#4%
{%
    \expandafter\XINT_expr_rrseqx\expandafter#1\expanded
```

```
       {\unexpanded{{#4}}{\xintRevWithBraces{#4}}\expandafter}%
    \romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}%
}%
\def\XINT_expr_rrseqx #1#2#3#4#5%
{%
    \XINT:NEhook:rrseq\XINT_expr_rrseqy\romannumeral0#1(#5)\relax {#2}{#3}#4#1%
}%
\def\XINT_expr_rrseqy #1#2#3#4#5#6%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded \bgroup {\iffalse}\fi
    #2\XINT_expr_rrseq:_b {#6#5\relax !#4}#1^~#30?\XINT_expr_cb_and_getop
}%
\def\XINT_expr_rrseq:_b #1#2%
{%
    \ifx +#2\xint_dothis\XINT_expr_rrseq:_Ca\fi
    \ifx !#2!\xint_dothis\XINT_expr_rrseq:_noop\fi
    \ifx ^#2\xint_dothis\XINT_expr_rrseq:_end\fi
    \xint_orthat{\XINT_expr_rrseq:_c}{#2}{#1}%
}%
\def\XINT_expr_rrseq:_noop #1{\XINT_expr_rrseq:_b }%
\def\XINT_expr_rrseq:_end  #1#2~#3?{\iffalse{\fi}}%
\def\XINT_expr_rrseq:_c #1#2{\expandafter\XINT_expr_rrseq:_d\romannumeral0#2{{#1}}{#2}}%
\def\XINT_expr_rrseq:_d #1{\ifx ^#1\xint_dothis\XINT_expr_rrseq:_abort\fi
                           \ifx ?#1\xint_dothis\XINT_expr_rrseq:_break\fi
                           \ifx !#1\xint_dothis\XINT_expr_rrseq:_omit\fi
                           \xint_orthat{\XINT_expr_rrseq:_goon {#1}}}%
\def\XINT_expr_rrseq:_abort #1!#2^~#3?{\iffalse{\fi}}%
\def\XINT_expr_rrseq:_break #1!#2^~#3?{#1\iffalse{\fi}}%
\def\XINT_expr_rrseq:_omit  #1!#2#{\expandafter\XINT_expr_rrseq:_b\xint_gobble_i}%
\def\XINT_expr_rrseq:_goon  #1!#2#{\XINT_expr_rrseq:_goon_a {#1}}%
\def\XINT_expr_rrseq:_goon_a  #1#2#3~#4?%
{%
    #1\expandafter\XINT_expr_rrseq:_b\expanded{\unexpanded{#3~}\xintTrim{-2}{#1#4}}0?%
}%
\def\XINT_expr_rrseq:_Ca #1#2#3{\XINT_expr_rrseq:_Cc#3.{#2}}%
\def\XINT_expr_rrseq:_Cb #1{\expandafter\XINT_expr_rrseq:_Cc\the\numexpr#1+\xint_c_i.}%
\def\XINT_expr_rrseq:_Cc #1.#2%
   {\expandafter\XINT_expr_rrseq:_D\romannumeral0#2{{#1}}{#1}{#2}}%
\def\XINT_expr_rrseq:_D #1{\ifx ^#1\xint_dothis\XINT_expr_rrseq:_abort\fi
                          \ifx ?#1\xint_dothis\XINT_expr_rrseq:_break\fi
                          \ifx !#1\xint_dothis\XINT_expr_rrseq:_Omit\fi
                          \xint_orthat{\XINT_expr_rrseq:_Goon {#1}}}%
\def\XINT_expr_rrseq:_Omit  #1!#2#{\expandafter\XINT_expr_rrseq:_Cb\xint_gobble_i}%
\def\XINT_expr_rrseq:_Goon  #1!#2#{\XINT_expr_rrseq:_Goon_a {#1}}%
\def\XINT_expr_rrseq:_Goon_a  #1#2#3~#4?%
{%
    #1\expandafter\XINT_expr_rrseq:_Cb\expanded{\unexpanded{#3~}\xintTrim{-2}{#1#4}}0?%
}%
\catcode`? 11
```

12.27 Pseudo-functions related to N-dimensional hypercubic lists

12.27.1 ndseq()

New with 1.4. 2020/01/23. It is derived from subsm() but instead of evaluating one expression according to one value per variable, it constructs a nested bracketed seq... this means the expression is parsed each time ! Anyway, proof of concept. Nota Bene : omit, abort, break() work !

```
\def\XINT_expr_onliteral_ndseq
{%
    \expandafter\XINT_allexpr_ndseq_f
    \romannumeral`&&@\XINT_expr_fetch_E_comma_V_equal_E_a {}%
}%
\def\XINT_allexpr_ndseq_f #1#2{\xint_c_ii^v `{ndseqx}#2)\relax #1}%
\def\XINT_expr_func_ndseqx
{%
    \expandafter\XINT_allexpr_ndseqx\expandafter\xintbareeval
    \expandafter{\romannumeral0\expandafter\xint_gobble_i\string}%
    \expandafter\xintrevwithbraces
    \expanded\bgroup{\iffalse}\fi\XINT_allexpr_ndseq_A\XINT_expr_oparen
}%
\def\XINT_flexpr_func_ndseqx
{%
    \expandafter\XINT_allexpr_ndseqx\expandafter\xintbarefloateval
    \expandafter{\romannumeral0\expandafter\xint_gobble_i\string}%
    \expandafter\xintrevwithbraces
    \expanded\bgroup{\iffalse}\fi\XINT_allexpr_ndseq_A\XINT_flexpr_oparen
}%
\def\XINT_iiexpr_func_ndseqx
{%
    \expandafter\XINT_allexpr_ndseqx\expandafter\xintbareiieval
    \expandafter{\romannumeral0\expandafter\xint_gobble_i\string}%
    \expandafter\xintrevwithbraces
    \expanded\bgroup{\iffalse}\fi\XINT_allexpr_ndseq_A\XINT_iiexpr_oparen
}%
\def\XINT_allexpr_ndseq_A #1#2#3%
{%
    \ifx#2\xint_c_
       \expandafter\XINT_allexpr_ndseq_C
    \else
       \expandafter\XINT_allexpr_ndseq_B
    \fi #1%
}%
\def\XINT_allexpr_ndseq_B #1#2#3#4=%
{%
    {#2}{\xint_zapspaces#3#4 \xint_gobble_i}%
    \expandafter\XINT_allexpr_ndseq_A\expandafter#1\romannumeral`&&@#1%
}%
```

#1 = \xintbareeval, or \xintbarefloateval or \xintbareiieval #2 = values for last coordinate

```
\def\XINT_allexpr_ndseq_C #1#2{{#2}\iffalse{{{\fi}}}}%
```

#1 = \xintbareeval or \xintbarefloateval or \xintbareiieval #2 = {valuesN}...{values2}{var2}{values1}
#3 = {var1} #4 = the expression to evaluate

```
\def\XINT_allexpr_ndseqx #1#2#3#4%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded
    \bgroup
      \romannumeral0#1\empty
      \expanded{\xintReplicate{\xintLength{{#3}#2}/2}{[seq(}%
                \unexpanded{#4}%
                \XINT_allexpr_ndseqx_a #2{#3}^^%
                }%
      \relax
    \iffalse{\fi\expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT_allexpr_ndseqx_a #1#2%
{%
    \xint_gob_til_^ #1\XINT_allexpr_ndseqx_e ^%
    \unexpanded{,#2=\XINTfstop.{#1})]}\XINT_allexpr_ndseqx_a
}%
\def\XINT_allexpr_ndseqx_e ^#1\XINT_allexpr_ndseqx_a{}%
```

12.27.2 ndmap()

New with 1.4. 2020/01/24.

```
\def\XINT_expr_onliteral_ndmap #1,{\xint_c_ii^v `{ndmapx}\XINTfstop.{#1};}%
\def\XINT_expr_func_ndmapx #1#2#3%
{%
    \expandafter\XINT_allexpr_ndmapx
    \csname XINT_expr_func_\xint_zapspaces #3 \xint_gobble_i\endcsname
    \XINT_expr_oparen
}%
\def\XINT_flexpr_func_ndmapx #1#2#3%
{%
    \expandafter\XINT_allexpr_ndmapx
    \csname XINT_flexpr_func_\xint_zapspaces #3 \xint_gobble_i\endcsname
    \XINT_flexpr_oparen
}%
\def\XINT_iiexpr_func_ndmapx #1#2#3%
{%
    \expandafter\XINT_allexpr_ndmapx
    \csname XINT_iiexpr_func_\xint_zapspaces #3 \xint_gobble_i\endcsname
    \XINT_iiexpr_oparen
}%
\def\XINT_allexpr_ndmapx #1#2%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded\bgroup{\iffalse}\fi
    \expanded
      {\noexpand\XINT:NEhook:x:ndmapx
       \noexpand\XINT_allexpr_ndmapx_a
       \noexpand#1{}\expandafter}%
    \expanded\bgroup\expandafter\XINT_allexpr_ndmap_A
                    \expandafter#2\romannumeral`&&@#2%
}%
```

```
\def\XINT_allexpr_ndmap_A #1#2#3%
{%
    \ifx#3;%
       \expandafter\XINT_allexpr_ndmap_B
    \else
       \xint_afterfi{\XINT_allexpr_ndmap_C#2#3}%
    \fi #1%
}%
\def\XINT_allexpr_ndmap_B #1#2%
{%
    {#2}\expandafter\XINT_allexpr_ndmap_A\expandafter#1\romannumeral`&&@#1%
}%
\def\XINT_allexpr_ndmap_C #1#2#3#4%
{%
    {#4}^\relax\iffalse{{{\fi}}}#1#2%
}%
\def\XINT_allexpr_ndmapx_a #1#2#3%
{%
    \xint_gob_til_^ #3\XINT_allexpr_ndmapx_l ^%
    \XINT_allexpr_ndmapx_b #1{#2}{#3}%
}%
\def\XINT_allexpr_ndmapx_l ^#1\XINT_allexpr_ndmapx_b #2#3#4\relax
{%
    #2\empty\xint_firstofone{#3}%
}%
\def\XINT_allexpr_ndmapx_b #1#2#3#4\relax
{%
    {\iffalse}\fi\XINT_allexpr_ndmapx_c {#4\relax}#1{#2}#3^%
}%
\def\XINT_allexpr_ndmapx_c #1#2#3#4%
{%
    \xint_gob_til_^ #4\XINT_allexpr_ndmapx_e ^%
    \XINT_allexpr_ndmapx_a #2{#3{#4}}#1%
    \XINT_allexpr_ndmapx_c  {#1}#2{#3}%
}%
\def\XINT_allexpr_ndmapx_e ^#1\XINT_allexpr_ndmapx_c
   {\iffalse{\fi}\xint_gobble_iii}%
```

12.27.3 ndfillraw()

New with 1.4. 2020/01/24. J'hésite à autoriser un #1 quelconque, ou plutôt à le wrapper dans un \xintbareval. Mais il faut alors distinguer les trois. De toute façon les variables ne marcheraient pas donc j'hésite à mettre un wrapper automatique. Mais ce n'est pas bien d'autoriser l'injection de choses quelconques.

Pour des choses comme ndfillraw(\xintRandomBit,[10,10]).

Je n'aime pas le nom !. Le changer. ndconst? Surtout je n'aime pas que dans le premier argument il faut rajouter explicitement si nécessaire \xintiiexpr wrap.

```
\def\XINT_expr_onliteral_ndfillraw #1,{\xint_c_ii^v `{ndfillrawx}\XINTfstop.{{#1}},}%
\def\XINT_expr_func_ndfillrawx #1#2#3%
{%
    \expandafter#1\expandafter#2\expanded{{{\XINT_allexpr_ndfillrawx_a #3}}}%
}%
\let\XINT_iiexpr_func_ndfillrawx\XINT_expr_func_ndfillrawx
```

```
\let\XINT_flexpr_func_ndfillrawx\XINT_expr_func_ndfillrawx
\def\XINT_allexpr_ndfillrawx_a #1#2%
{%
    \expandafter\XINT_allexpr_ndfillrawx_b
    \romannumeral0\xintApply{\xintNum}{#2}^\relax {#1}%
}%
\def\XINT_allexpr_ndfillrawx_b #1#2\relax#3%
{%
    \xint_gob_til_^ #1\XINT_allexpr_ndfillrawx_c ^%
    \xintReplicate{#1}{{\XINT_allexpr_ndfillrawx_b #2\relax {#3}}}%
}%
\def\XINT_allexpr_ndfillrawx_c ^\xintReplicate #1#2%
{%
    \expandafter\XINT_allexpr_ndfillrawx_d\xint_firstofone #2%
}%
\def\XINT_allexpr_ndfillrawx_d\XINT_allexpr_ndfillrawx_b \relax #1{#1}%
```

12.28 Other pseudo-functions: bool(), togl(), protect(), qraw(), qint(), qfrac(), qfloat(), qrand(), random(), rbit()

bool, togl and protect use delimited macros. They are not true functions, they turn off the parser to gather their "variable".

Modified at 1.2 (2015/10/10). Adds qint(), qfrac(), qfloat().

Modified at 1.3c (2018/06/17). Adds qraw(). Useful to limit impact on TeX memory from abuse of \csname's storage when generating many comma separated values from a loop.

Modified at 1.3e (2019/04/05). qfloat() keeps a short mantissa if possible.

They allow the user to hand over quickly a big number to the parser, spaces not immediately removed but should be harmless in general. The qraw() does no post-processing at all apart complete expansion, useful for comma-separated values, but must be obedient to (non really documented) expected format. Each uses a delimited macro, the closing parenthesis can not emerge from expansion.

1.3b. random(), qrand() Function-like syntax but with no argument currently, so let's use fast parsing which requires though the closing parenthesis to be explicit.

Attention that qraw() which pre-supposes knowledge of internal storage model is fragile and may break at any release.

1.4 adds rbit(). Short for random bit.

```
\def\XINT_expr_onliteral_bool #1)%
    {\expandafter\XINT_expr_put_op_first\expanded{{{\xintBool{#1}}}\expandafter
     }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_togl #1)%
    {\expandafter\XINT_expr_put_op_first\expanded{{{\xintToggle{#1}}}\expandafter
     }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_protect #1)%
    {\expandafter\XINT_expr_put_op_first\expanded{{{\detokenize{#1}}}\expandafter
     }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_qint #1)%
    {\expandafter\XINT_expr_put_op_first\expanded{{{\xintiNum{#1}}}\expandafter
     }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_qfrac #1)%
    {\expandafter\XINT_expr_put_op_first\expanded{{{\xintRaw{#1}}}\expandafter
     }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_qfloat #1)%
    {\expandafter\XINT_expr_put_op_first\expanded{{{\XINTinFloatSdigits{#1}}}\expandafter
```

```
    }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_qraw #1)%
   {\expandafter\XINT_expr_put_op_first\expanded{{#1}\expandafter
    }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_random #1)%
   {\expandafter\XINT_expr_put_op_first\expanded{{{\XINTinRandomFloatSdigits}}\expandafter
    }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_qrand #1)%
  {\expandafter\XINT_expr_put_op_first\expanded{{{\XINTinRandomFloatSixteen}}\expandafter
    }\romannumeral`&&@\XINT_expr_getop}%
\def\XINT_expr_onliteral_rbit #1)%
  {\expandafter\XINT_expr_put_op_first\expanded{{{\xintRandBit}}\expandafter
    }\romannumeral`&&@\XINT_expr_getop}%
```

12.29 Regular built-in functions: **num()**, **reduce()**, **preduce()**, **abs()**, **sgn()**, **frac()**, **floor()**, **ceil()**, **sqr()**, **?()**, **!()**, **not()**, **odd()**, **even()**, **isint()**, **isone()**, **factorial()**, **sqrt()**, **sqrtr()**, **inv()**, **round()**, **trunc()**, **float()**, **sfloat()**, **ilog10()**, **divmod()**, **mod()**, **binomial()**, **pfactorial()**, **randrange()**, **iquo()**, **irem()**, **gcd()**, **lcm()**, **max()**, **min()**, **`+`()**, **`*`()**, **all()**, **any()**, **xor()**, **len()**, **first()**, **last()**, **reversed()**, **if()**, **ifint()**, **ifone()**, **ifsgn()**, **nuple()**, **unpack()**, **flat()** and **zip()**

```
\def\XINT:expr:f:one:and:opt #1#2#3!#4#5%
{%
    \if\relax#3\relax\expandafter\xint_firstoftwo\else
                     \expandafter\xint_secondoftwo\fi
    {#4}{#5[\xintNum{#2}]}{#1}%
}%
\def\XINT:expr:f:tacitzeroifone #1#2#3!#4#5%
{%
    \if\relax#3\relax\expandafter\xint_firstoftwo\else
                     \expandafter\xint_secondoftwo\fi
    {#4{0}}{#5{\xintNum{#2}}}{#1}%
}%
\def\XINT:expr:f:iitacitzeroifone #1#2#3!#4%
{%
    \if\relax#3\relax\expandafter\xint_firstoftwo\else
                     \expandafter\xint_secondoftwo\fi
    {#4{0}}{#4{#2}}{#1}%
}%
\def\XINT_expr_func_num #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintNum#3}}%
}%
\let\XINT_flexpr_func_num\XINT_expr_func_num
\let\XINT_iiexpr_func_num\XINT_expr_func_num
\def\XINT_expr_func_reduce #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
```

```
    {\romannumeral`&&@\xintIrr#3}}%
}%
\let\XINT_flexpr_func_reduce\XINT_expr_func_reduce
\def\XINT_expr_func_preduce #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintPIrr#3}}%
}%
\let\XINT_flexpr_func_preduce\XINT_expr_func_preduce
\def\XINT_expr_func_abs #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintAbs#3}}%
}%
\let\XINT_flexpr_func_abs\XINT_expr_func_abs
\def\XINT_iiexpr_func_abs #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiAbs#3}}%
}%
\def\XINT_expr_func_sgn #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintSgn#3}}%
}%
\let\XINT_flexpr_func_sgn\XINT_expr_func_sgn
\def\XINT_iiexpr_func_sgn #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiSgn#3}}%
}%
\def\XINT_expr_func_frac #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintTFrac#3}}%
}%
\def\XINT_flexpr_func_frac #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatFrac#3}}%
}%
```

no \XINT_iiexpr_func_frac

```
\def\XINT_expr_func_floor #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
```

```
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintFloor#3}}%
}%
\let\XINT_flexpr_func_floor\XINT_expr_func_floor
```

The floor and ceil functions in \xintiiexpr require protect(a/b) or, better, \qfrac(a/b); else the / will be executed first and do an integer rounded division.

```
\def\XINT_iiexpr_func_floor #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiFloor#3}}%
}%
\def\XINT_expr_func_ceil #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintCeil#3}}%
}%
\let\XINT_flexpr_func_ceil\XINT_expr_func_ceil
\def\XINT_iiexpr_func_ceil #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiCeil#3}}%
}%
\def\XINT_expr_func_sqr #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintSqr#3}}%
}%
\def\XINT_flexpr_func_sqr #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatSqr#3}}%
}%
\def\XINT_iiexpr_func_sqr #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiSqr#3}}%
}%
\def\XINT_expr_func_? #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiIsNotZero#3}}%
}%
\let\XINT_flexpr_func_? \XINT_expr_func_?
\let\XINT_iiexpr_func_? \XINT_expr_func_?
\def\XINT_expr_func_! #1#2#3%
```

```
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiIsZero#3}}%
}%
\let\XINT_flexpr_func_! \XINT_expr_func_!
\let\XINT_iiexpr_func_! \XINT_expr_func_!
\def\XINT_expr_func_not #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiIsZero#3}}%
}%
\let\XINT_flexpr_func_not \XINT_expr_func_not
\let\XINT_iiexpr_func_not \XINT_expr_func_not
\def\XINT_expr_func_odd #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintOdd#3}}%
}%
\let\XINT_flexpr_func_odd\XINT_expr_func_odd
\def\XINT_iiexpr_func_odd #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiOdd#3}}%
}%
\def\XINT_expr_func_even #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintEven#3}}%
}%
\let\XINT_flexpr_func_even\XINT_expr_func_even
\def\XINT_iiexpr_func_even #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiEven#3}}%
}%
\def\XINT_expr_func_isint #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintIsInt#3}}%
}%
\def\XINT_flexpr_func_isint #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintFloatIsInt#3}}%
```

```
}%
\let\XINT_iiexpr_func_isint\XINT_expr_func_isint % ? perhaps rather always 1
\def\XINT_expr_func_isone #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintIsOne#3}}%
}%
\let\XINT_flexpr_func_isone\XINT_expr_func_isone
\def\XINT_iiexpr_func_isone #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiIsOne#3}}%
}%
\def\XINT_expr_func_factorial #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:and:opt:direct
    \XINT:expr:f:one:and:opt #3,!\xintFac\XINTinFloatFac
    }}%
}%
\def\XINT_flexpr_func_factorial #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:and:opt:direct
    \XINT:expr:f:one:and:opt#3,!\XINTinFloatFacdigits\XINTinFloatFac
    }}%
}%
\def\XINT_iiexpr_func_factorial #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiFac#3}}%
}%
\def\XINT_expr_func_sqrt #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:and:opt:direct
    \XINT:expr:f:one:and:opt #3,!\XINTinFloatSqrtdigits\XINTinFloatSqrt
    }}%
}%
\let\XINT_flexpr_func_sqrt\XINT_expr_func_sqrt
\def\XINT_iiexpr_func_sqrt #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiSqrt#3}}%
}%
\def\XINT_iiexpr_func_sqrtr #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
```

```
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiSqrtR#3}}%
}%
\def\XINT_expr_func_inv #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintInv#3}}%
}%
\def\XINT_flexpr_func_inv #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatInv#3}}%
}%
\def\XINT_expr_func_round #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:tacitzeroifone:direct
    \XINT:expr:f:tacitzeroifone #3,!\xintiRound\xintRound
    }}%
}%
\let\XINT_flexpr_func_round\XINT_expr_func_round
\def\XINT_iiexpr_func_round #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:iitacitzeroifone:direct
    \XINT:expr:f:iitacitzeroifone #3,!\xintiRound
    }}%
}%
\def\XINT_expr_func_trunc #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:tacitzeroifone:direct
    \XINT:expr:f:tacitzeroifone #3,!\xintiTrunc\xintTrunc
    }}%
}%
\let\XINT_flexpr_func_trunc\XINT_expr_func_trunc
\def\XINT_iiexpr_func_trunc #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:iitacitzeroifone:direct
    \XINT:expr:f:iitacitzeroifone #3,!\xintiTrunc
    }}%
}%
```

Hesitation at 1.3e about using \XINTinFloatSdigits and \XINTinFloatS. Finally I add a sfloat() function. It helps for xinttrig.sty.

```
\def\XINT_expr_func_float #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:and:opt:direct
    \XINT:expr:f:one:and:opt #3,!\XINTinFloatdigits\XINTinFloat
```

```
    }}%
}%
\let\XINT_flexpr_func_float\XINT_expr_func_float
```

float_() was added at 1.4, as a shortcut alias to float() skipping the check for an optional second argument. This is useful to transfer function definitions between \xintexpr and \xintfloatexpr contexts.

No need for a similar shortcut for sfloat() as currently used in xinttrig.sty to go from float to expr: as it is used there as sfloat(x) with dummy x, it sees there is no optional argument, contrarily to for example float(\xintexpr...\relax) which has to allow for the inner expression to expand to an ople with two items, so does not know in which branch it is at time of definiion.

After some hesitation at 1.4e regarding guard digits mechanism the float_() got renamed to float_dgt(), but then renamed back to float_() to avoid a breaking change and having to document it.

Nevertheless the documentation of 1.4e mentioned float_dgt()... but it was still float_()... now changed into float_dgt() for real at 1.4f.

1.4f also adds private float_dgtormax and sfloat_dgtormax for matters of xinttrig.

```
\def\XINT_expr_func_float_dgt #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatdigits#3}}%
}%
\let\XINT_flexpr_func_float_dgt\XINT_expr_func_float_dgt
% no \XINT_iiexpr_func_float_dgt
\def\XINT_expr_func_float_dgtormax #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatdigitsormax#3}}%
}%
\let\XINT_flexpr_func_float_dgtormax\XINT_expr_func_float_dgtormax
\def\XINT_expr_func_sfloat #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:and:opt:direct
    \XINT:expr:f:one:and:opt #3,!\XINTinFloatSdigits\XINTinFloatS
    }}%
}%
\let\XINT_flexpr_func_sfloat\XINT_expr_func_sfloat
% no \XINT_iiexpr_func_sfloat
\def\XINT_expr_func_sfloat_dgtormax #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatSdigitsormax#3}}%
}%
\let\XINT_flexpr_func_sfloat_dgtormax\XINT_expr_func_sfloat_dgtormax
\expandafter\def\csname XINT_expr_func_ilog10\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:and:opt:direct
    \XINT:expr:f:one:and:opt #3,!\xintiLogTen\XINTFloatiLogTen
```

```
    }}%
}%
\expandafter\def\csname XINT_flexpr_func_ilog10\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:and:opt:direct
    \XINT:expr:f:one:and:opt #3,!\XINTFloatiLogTendigits\XINTFloatiLogTen
    }}%
}%
\expandafter\def\csname XINT_iiexpr_func_ilog10\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\xintiiLogTen#3}}%
}%
\def\XINT_expr_func_divmod #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintDivMod #3}}%
}%
\def\XINT_flexpr_func_divmod #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\XINTinFloatDivMod #3}}%
}%
\def\XINT_iiexpr_func_divmod #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintiiDivMod #3}}%
}%
\def\XINT_expr_func_mod #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintMod#3}}%
}%
\def\XINT_flexpr_func_mod #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\XINTinFloatMod#3}}%
}%
\def\XINT_iiexpr_func_mod #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintiiMod#3}}%
}%
\def\XINT_expr_func_binomial #1#2#3%
```

```
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintBinomial #3}}%
}%
\def\XINT_flexpr_func_binomial #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\XINTinFloatBinomial #3}}%
}%
\def\XINT_iiexpr_func_binomial #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintiiBinomial #3}}%
}%
\def\XINT_expr_func_pfactorial #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintPFactorial #3}}%
}%
\def\XINT_flexpr_func_pfactorial #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\XINTinFloatPFactorial #3}}%
}%
\def\XINT_iiexpr_func_pfactorial #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintiiPFactorial #3}}%
}%
\def\XINT_expr_func_randrange #1#2#3%
{%
    \expandafter #1\expandafter #2\expanded{{{%
    \XINT:expr:randrange #3,!%
    }}}%
}%
\let\XINT_flexpr_func_randrange\XINT_expr_func_randrange
\def\XINT_iiexpr_func_randrange #1#2#3%
{%
    \expandafter #1\expandafter #2\expanded{{{%
    \XINT:iiexpr:randrange #3,!%
    }}}%
}%
\def\XINT:expr:randrange #1#2#3!%
{%
    \if\relax#3\relax\expandafter\xint_firstoftwo\else
                     \expandafter\xint_secondoftwo\fi
```

```
    {\xintiiRandRange{\XINT:NEhook:f:one:from:one:direct\xintNum{#1}}}%
    {\xintiiRandRangeAtoB{\XINT:NEhook:f:one:from:one:direct\xintNum{#1}}%
                         {\XINT:NEhook:f:one:from:one:direct\xintNum{#2}}%
     }%
}%
\def\XINT:iiexpr:randrange #1#2#3!%
{%
    \if\relax#3\relax\expandafter\xint_firstoftwo\else
                     \expandafter\xint_secondoftwo\fi
    {\xintiiRandRange{#1}}%
    {\xintiiRandRangeAtoB{#1}{#2}}%
}%
\def\XINT_iiexpr_func_iquo #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintiiQuo #3}}%
}%
\def\XINT_iiexpr_func_irem #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\romannumeral`&&@%
    \XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintiiRem #3}}%
}%
\def\XINT_expr_func_gcd #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_GCDof#3^}}%
}%
\let\XINT_flexpr_func_gcd\XINT_expr_func_gcd
\def\XINT_iiexpr_func_gcd #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_iiGCDof#3^}}%
}%
\def\XINT_expr_func_lcm #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_LCMof#3^}}%
}%
\let\XINT_flexpr_func_lcm\XINT_expr_func_lcm
\def\XINT_iiexpr_func_lcm #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_iiLCMof#3^}}%
}%
\def\XINT_expr_func_max #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_Maxof#3^}}%
}%
\def\XINT_iiexpr_func_max #1#2#3%
```

```
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_iiMaxof#3^}}%
}%
\def\XINT_flexpr_func_max #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINTinFloatMaxof#3^}}%
}%
\def\XINT_expr_func_min #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_Minof#3^}}%
}%
\def\XINT_iiexpr_func_min #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_iiMinof#3^}}%
}%
\def\XINT_flexpr_func_min #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINTinFloatMinof#3^}}%
}%
\expandafter
\def\csname XINT_expr_func_+\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_Sum#3^}}%
}%
\expandafter
\def\csname XINT_flexpr_func_+\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINTinFloatSum#3^}}%
}%
\expandafter
\def\csname XINT_iiexpr_func_+\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_iiSum#3^}}%
}%
\expandafter
\def\csname XINT_expr_func_*\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_Prd#3^}}%
}%
\expandafter
\def\csname XINT_flexpr_func_*\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
```

```
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINTinFloatPrd#3^}}%
}%
\expandafter
\def\csname XINT_iiexpr_func_*\endcsname #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_iiPrd#3^}}%
}%
\def\XINT_expr_func_all #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_ANDof#3^}}%
}%
\let\XINT_flexpr_func_all\XINT_expr_func_all
\let\XINT_iiexpr_func_all\XINT_expr_func_all
\def\XINT_expr_func_any #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_ORof#3^}}%
}%
\let\XINT_flexpr_func_any\XINT_expr_func_any
\let\XINT_iiexpr_func_any\XINT_expr_func_any
\def\XINT_expr_func_xor #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{\expandafter
    {\romannumeral`&&@\XINT:NEhook:f:from:delim:u\XINT_XORof#3^}}%
}%
\let\XINT_flexpr_func_xor\XINT_expr_func_xor
\let\XINT_iiexpr_func_xor\XINT_expr_func_xor
\def\XINT_expr_func_len #1#2#3%
{%
    \expandafter#1\expandafter#2\expandafter{\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:LFL\xintLength
    {\romannumeral\XINT:NEhook:r:check#3^}%
    }}%
}%
\let\XINT_flexpr_func_len \XINT_expr_func_len
\let\XINT_iiexpr_func_len \XINT_expr_func_len
\def\XINT_expr_func_first #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:LFL\xintFirstOne
    {\romannumeral\XINT:NEhook:r:check#3^}%
    }%
}%
\let\XINT_flexpr_func_first\XINT_expr_func_first
\let\XINT_iiexpr_func_first\XINT_expr_func_first
\def\XINT_expr_func_last #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:LFL\xintLastOne
    {\romannumeral\XINT:NEhook:r:check#3^}%
```

```
    }%
}%
\let\XINT_flexpr_func_last\XINT_expr_func_last
\let\XINT_iiexpr_func_last\XINT_expr_func_last
\def\XINT_expr_func_reversed #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:reverse\XINT_expr_reverse
    #3^^#3\xint:\xint:\xint:\xint:
          \xint:\xint:\xint:\xint:\xint_bye
    }%
}%
\def\XINT_expr_reverse #1#2%
{%
    \if ^\noexpand#2%
       \expandafter\XINT_expr_reverse:_one_or_none\string#1.%
    \else
       \expandafter\XINT_expr_reverse:_at_least_two
    \fi
}%
\def\XINT_expr_reverse:_at_least_two #1^^{\XINT_revwbr_loop {}}%
\def\XINT_expr_reverse:_one_or_none #1%
{%
    \if #1\bgroup\xint_dothis\XINT_expr_reverse:_nutple\fi
    \if #1^\xint_dothis\XINT_expr_reverse:_nil\fi
    \xint_orthat\XINT_expr_reverse:_leaf
}%
\edef\XINT_expr_reverse:_nil #1\xint_bye{\noexpand\fi\space}%
\def\XINT_expr_reverse:_leaf#1\fi #2\xint:#3\xint_bye{\fi\xint_gob_andstop_i#2}%
\def\XINT_expr_reverse:_nutple%
{%
    \expandafter\XINT_expr_reverse:_nutple_a\expandafter{\string}%
}%
\def\XINT_expr_reverse:_nutple_a #1^#2\xint:#3\xint_bye
{%
    \fi\expandafter
    {\romannumeral0\XINT_revwbr_loop{}#2\xint:#3\xint_bye}%
}%
\let\XINT_flexpr_func_reversed\XINT_expr_func_reversed
\let\XINT_iiexpr_func_reversed\XINT_expr_func_reversed
\def\XINT_expr_func_if #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:branch{\romannumeral`&&@\xintiiifNotZero #3}}%
}%
\let\XINT_flexpr_func_if\XINT_expr_func_if
\let\XINT_iiexpr_func_if\XINT_expr_func_if
\def\XINT_expr_func_ifint #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:branch{\romannumeral`&&@\xintifInt #3}}%
}%
```

```
\let\XINT_iiexpr_func_ifint\XINT_expr_func_ifint
\def\XINT_flexpr_func_ifint #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:branch{\romannumeral`&&@\xintifFloatInt #3}}%
}%
\def\XINT_expr_func_ifone #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:branch{\romannumeral`&&@\xintifOne #3}}%
}%
\let\XINT_flexpr_func_ifone\XINT_expr_func_ifone
\def\XINT_iiexpr_func_ifone #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:branch{\romannumeral`&&@\xintiiifOne #3}}%
}%
\def\XINT_expr_func_ifsgn #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:branch{\romannumeral`&&@\xintiiifSgn #3}}%
}%
\let\XINT_flexpr_func_ifsgn\XINT_expr_func_ifsgn
\let\XINT_iiexpr_func_ifsgn\XINT_expr_func_ifsgn
\def\XINT_expr_func_nuple #1#2#3{#1#2{{#3}}}%
\let\XINT_flexpr_func_nuple\XINT_expr_func_nuple
\let\XINT_iiexpr_func_nuple\XINT_expr_func_nuple
\def\XINT_expr_func_unpack #1#2%#3%
   {\expandafter#1\expandafter#2\romannumeral0\XINT:NEhook:unpack}%
\let\XINT_flexpr_func_unpack\XINT_expr_func_unpack
\let\XINT_iiexpr_func_unpack\XINT_expr_func_unpack
\def\XINT_expr_func_flat #1#2%#3%
{%
    \expandafter#1\expandafter#2\expanded
    \XINT:NEhook:x:flatten\XINT:expr:flatten
}%
\let\XINT_flexpr_func_flat\XINT_expr_func_flat
\let\XINT_iiexpr_func_flat\XINT_expr_func_flat
\let\XINT:NEhook:x:flatten\empty
\def\XINT_expr_func_zip #1#2%#3%
{%
    \expandafter#1\expandafter#2\romannumeral`&&@%
    \XINT:NEhook:x:zip\XINT:expr:zip
}%
\let\XINT_flexpr_func_zip\XINT_expr_func_zip
\let\XINT_iiexpr_func_zip\XINT_expr_func_zip
\let\XINT:NEhook:x:zip\empty
\def\XINT:expr:zip#1{\expandafter{\expanded\XINT_zip_A#1\xint_bye\xint_bye}}%
```

12.30 User declared functions

It is possible that the author actually does understand at this time the \xintNewExpr/\xintdeffunc refactored code and mechanisms for the first time since 2014: past evolutions such as the 2018 1.3

refactoring were done a bit in the fog (although they did accomplish a crucial step).

The 1.4 version of function and macro definitions is much more powerful than 1.3 one. But the mechanisms such as «omit», «abort» and «break()» in iter() et al. can't be translated into much else than their actual code when they potentially have to apply to non-numeric only context. The 1.4 \xintdeffunc is thus apparently able to digest them but its pre-parsing benefits are limited compared to simply assigning such parts of an expression to a mock-function created by \xintNewFunction (which creates simply a TeX macro from its substitution expression in macro parameters and add syntactic sugar to let it appear to \xintexpr as a genuine «function» although nothing of the syntax has really been pre-parsed.)

At 1.4 fetching the expression up to final semi-colon is done using \XINT_expr_fetch_to_semicolon, hence semi-colons arising in the syntax do not need to be hidden inside braces.

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12.30.1 \xintdeffunc, \xintdefiifunc, \xintdeffloatfunc

Modified at 1.2c (2015/11/16). Note: it is possible to have same name assigned both to a variable and a function: things such as add(f(f), f=1..10) are possible.

Modified at 1.2c (2015/11/16). Function names first expanded then detokenized and cleaned of spaces.

Modified at 1.2e (2015/11/22). No \detokenize anymore on the function names. And #1(#2)#3=#4 parameter pattern to avoid to have to worry if a : is there and it is active.

Modified at 1.2f (2016/03/12). La macro associée à la fonction ne débute plus par un \romannumeral, car de toute façon elle est pour emploi dans \csname..\endcsname.

Modified at 1.2f (2016/03/12). Comma separated expressions allowed (formerly this required using parenthesis \xintdeffunc foo(x,..):=(.., .., ..);

Modified at 1.3c (2018/06/17). Usage of \xintexprSafeCatcodes to be compatible with an active semi-colon at time of use; the colon was not a problem (see ##3) already.

Modified at 1.3e (2019/04/05). \xintdefefunc variant added for functions which will expand completely if used with numeric arguments in other function definitions. They can't be used for recursive definitions.

Their functionality was merged into \xintdeffunc et al. at 1.4. The original macros were removed at 1.4m.

Modified at 1.4 (2020/01/31). Multi-letter variables can be used (with no prior declaration)

Modified at 1.4 (2020/01/31). The new internal data model has caused many worries initially (such as whether to allow functions with «ople» outputs in contrast to «numbers» or «nutples») but in the end all is simpler again and the refactoring of ? and ?? in function definitions allows to fuse inert functions (allowing recursive definitions) and expanding functions (expanding completely if with numeric arguments) into a single entity.

A special situation is with functions of no variables. In that case it will be handled as an inert entity, else they would not be different from variables.

Modified at 1.4 (2020/01/31). Addition de la syntaxe déclarative \xintdeffunc foo(a,b,...,*z) = ...;

Modified at 1.4m (2022/06/10). Removal of the \xintdefefunc et al.macros deprecated at 1.4.

```
\def\XINT_tmpa #1#2#3#4#5%
{%
  \def #1##1(##2)##3={%
   \edef\XINT_deffunc_tmpa {##1}%
   \edef\XINT_deffunc_tmpa {\xint_zapspaces_o \XINT_deffunc_tmpa}%
   \def\XINT_deffunc_tmpb {0}%
   \edef\XINT_deffunc_tmpd {##2}%
   \edef\XINT_deffunc_tmpd {\xint_zapspaces_o\XINT_deffunc_tmpd}%
   \def\XINT_deffunc_tmpe {0}%
   \expandafter#5\romannumeral\XINT_expr_fetch_to_semicolon
  }% end of \xintdeffunc_a definition
  \def#5##1{%
   \def\XINT_deffunc_tmpc{(##1)}%
   \ifnum\xintLength:f:csv{\XINT_deffunc_tmpd}>\xint_c_
     \xintFor ####1 in {\XINT_deffunc_tmpd}\do
      {%
       \xintifForFirst{\let\XINT_deffunc_tmpd\empty}{}%
       \def\XINT_deffunc_tmpf{####1}%
       \if*\xintFirstItem{####1}%
         \xintifForLast
         {%
          \def\XINT_deffunc_tmpe{1}%
          \edef\XINT_deffunc_tmpf{\xintTrim{1}{####1}}%
         }%
         {%
          \edef\XINT_deffunc_tmpf{\xintTrim{1}{####1}}%
          \xintMessage{xintexpr}{Error}
          {Only the last positional argument can be variadic. Trimmed ####1 to
          \XINT_deffunc_tmpf}%
         }%
       \fi
       \XINT_expr_makedummy{\XINT_deffunc_tmpf}%
       \edef\XINT_deffunc_tmpd{\XINT_deffunc_tmpd{\XINT_deffunc_tmpf}}%
       \edef\XINT_deffunc_tmpb {\the\numexpr\XINT_deffunc_tmpb+\xint_c_i}%
       \edef\XINT_deffunc_tmpc {subs(\unexpanded\expandafter{\XINT_deffunc_tmpc},%
                            \XINT_deffunc_tmpf=################\XINT_deffunc_tmpb)}%
      }%
   \fi
```

Place holder for comments. Logic at 1.4 is simplified here compared to earlier releases.

```
   \ifcase\XINT_deffunc_tmpb\space
     \expandafter\XINT_expr_defuserfunc_none\csname
   \else
     \expandafter\XINT_expr_defuserfunc\csname
   \fi
          XINT_#2_func_\XINT_deffunc_tmpa\expandafter\endcsname
   \csname XINT_#2_userfunc_\XINT_deffunc_tmpa\expandafter\endcsname
   \expandafter{\XINT_deffunc_tmpa}{#2}%
   \expandafter#3\csname XINT_#2_userfunc_\XINT_deffunc_tmpa\endcsname
                              [\XINT_deffunc_tmpb]{\XINT_deffunc_tmpc}%
   \ifxintverbose\xintMessage {xintexpr}{Info}
        {Function \XINT_deffunc_tmpa\space for \string\xint #4 parser
         associated to \string\XINT_#2_userfunc_\XINT_deffunc_tmpa\space
```

```
        with \ifxintglobaldefs global \fi meaning \expandafter\meaning
        \csname XINT_#2_userfunc_\XINT_deffunc_tmpa\endcsname}%
  \fi
  \xintFor* ####1 in {\XINT_deffunc_tmpd}:{\xintrestorevariablesilently{####1}}%
  \xintexprRestoreCatcodes
 }% end of \xintdeffunc_b definition
}%
\def\xintdeffunc      {\xintexprSafeCatcodes\xintdeffunc_a}%
\def\xintdefiifunc    {\xintexprSafeCatcodes\xintdefiifunc_a}%
\def\xintdeffloatfunc {\xintexprSafeCatcodes\xintdeffloatfunc_a}%
\XINT_tmpa\xintdeffunc_a     {expr}  \XINT_NewFunc     {expr}\xintdeffunc_b
\XINT_tmpa\xintdefiifunc_a   {iiexpr}\XINT_NewIIFunc   {iiexpr}\xintdefiifunc_b
\XINT_tmpa\xintdeffloatfunc_a{flexpr}\XINT_NewFloatFunc{floatexpr}\xintdeffloatfunc_b
\def\XINT_expr_defuserfunc_none #1#2#3#4%
{%
    \XINT_global
    \def #1##1##2##3%
    {%
        \expandafter##1\expandafter##2\expanded{%
          {\XINT:NEhook:usernoargfunc\csname XINT_#4_userfunc_#3\endcsname}%
        }%
    }%
}%
\let\XINT:NEhook:usernoargfunc \empty
\def\XINT_expr_defuserfunc #1#2#3#4%
{%
    \if0\XINT_deffunc_tmpe
    \XINT_global
    \def #1##1##2%##3%
    {%
        \expandafter ##1\expandafter##2\expanded\bgroup{\iffalse}\fi
        \XINT:NEhook:userfunc{XINT_#4_userfunc_#3}#2%##3%
    }%
    \else
```

Last argument in the call signature is variadic (was prefixed by *).

```
    \def #1##1{%
    \XINT_global\def #1####1####2%####3%
    {%
        \expandafter ####1\expandafter####2\expanded\bgroup{\iffalse}\fi
        \XINT:NEhook:userfunc:argv{##1}{XINT_#4_userfunc_#3}#2%####3%
    }}\expandafter#1\expandafter{\the\numexpr\XINT_deffunc_tmpb-1}%
    \fi
}%
```

Deliberate brace stripping of #3 to reveal the elements of the ople, which may be atoms i.e. numeric data such as {1}, or again oples, which means that the corresponding item was a nutple, for example it came from input syntax such as foo(1, 2, [1, 2], 3), so (up to details of raw encoding) {1}{2}{{1}{2}}{3}, which gives 4 braced arguments to macro #2.

```
\def\XINT:NEhook:userfunc #1#2#3{#2#3\iffalse{{\fi}}}%
```

Here #1 indicates the number k-1 of standard positional arguments of the call signature, the kth and last one having been declared of variadic type. The braces around \xintTrim{#1}{#4} have the effect to gather all these remaining elements to provide a single one to the TeX macro.

For example input was foo(1,2,3,4,5) and call signature was foo(a,b,*z). Then #4 will fetch {{1}{2}{3}{4}{5}}, with one level of brace removal. We will have \xintKeep{2}{{1}{2}{3}{4}{5}} which produces {1}{2}. Then {\xintTrim{2}{{1}{2}{3}{4}{5}}} which produces {{3}{4}{5}}. So the macro will be used as \macro{1}{2}{{3}{4}{5}} having been declared as a macro with 3 arguments.

The above comments were added in June 2021 but the code was done on January 19, 2020 for 1.4.

Note on June 10, 2021: at core level \XINT_NewFunc is used which is derived from \XINT_NewExpr which has always prepared TeX macros with non-delimited parameters. A refactoring could add a final delimiter, for example \relax. The macro with 3 arguments would be defined as \def\macro#1#2#3\relax{...} for example. Then we could transfer to TeX core processing what is achieved here via \xintKeep/\xintTrim, of course adding efficiency, via insertion of the delimiter. In the case of foo(1,2,3,4,5) we would have the #3 of delimited \macro fetch {3}{4}{5}, no brace removal, which is equivalent to current situation fetching {{3}{4}{5}} with brace removal. But let's see in case of foo(1,2,3) then. This would lead to delimited \macro{1}{2}{3}\relax and #3 will fetch {3}, removing one brace pair. Whereas current non-delimited \macro is used as \macro{1}{2}{{3}} from the Keep/Trim, then #3 fetches {{3}}, removing one brace pair. Not the same thing. So it seems there is a stumbling-block here to adopt such an alternative method, in relation with brace removal. Rather relieved in fact, as my head starts spinning in ople world. Seems better to stop thinking about doing something like that, and what it would imply as consequences for user declarative interface also. Oples are dangerous to mental health, let's stick with one-ples: « named arguments in function body declaration must stand for one-ples », even the last one, although a priori it could be envisioned if foo has been declared with call signature (x,y,z) and is used with more items that z is mapped to the ople of extra elements beyond the first two ones. For my sanity I stick with my January 2020 concept of (x,y,*z) which makes z stand for a nutple always and having to be used as such in the function body (possibly unpacked there using *z).

```
\def\XINT:NEhook:userfunc:argv #1#2#3#4%
  {\expandafter#3\expanded{\xintKeep{#1}{#4}{\xintTrim{#1}{#4}}}\iffalse{{\fi}}}%
```

12.30.2 \xintdefufunc, \xintdefiiufunc, \xintdeffloatufunc

Added at 1.4

Modified at 1.4k (2022/05/18). The \xintexprSafeCatcodes was not paired correctly with \xintexprRestoreCatcodes which was in only one branch of \xint_defufunc_b, and as a result sanitization of catcodes was never reverted. That the bug remained unseen and in particular did not break compilation of user manual (where the | must be active), was a sort of unhappy miracle due to the | ending up recovering its active catcode from some ulterior \xintdefiifunc whose Safe/Restore behaved as described in the user manual, i.e. it did a restore to the state before the first unpaired Safe, and this miraculous recovery happened before breakage had happened, by sheer luck, or rather lack of luck, else I would have seen and solved the problem two years ago...

```
\def\XINT_tmpa #1#2#3#4#5#6%
{%
 \def #1##1(##2)##3={%
  \edef\XINT_defufunc_tmpa {##1}%
  \edef\XINT_defufunc_tmpa {\xint_zapspaces_o \XINT_defufunc_tmpa}%
  \edef\XINT_defufunc_tmpd {##2}%
  \edef\XINT_defufunc_tmpd {\xint_zapspaces_o\XINT_defufunc_tmpd}%
  \expandafter#5\romannumeral\XINT_expr_fetch_to_semicolon
 }% end of \xint_defufunc_a
 \def#5##1{%
  \def\XINT_defufunc_tmpc{(##1)}%
  \ifnum\xintLength:f:csv{\XINT_defufunc_tmpd}=\xint_c_i
    \expandafter#6%
  \else
```

```
      \xintMessage {xintexpr}{ERROR}
         {Universal functions must be functions of one argument only,
          but the declaration of \XINT_defufunc_tmpa\space
          has \xintLength:f:csv{\XINT_defufunc_tmpd} of them. Canceled.}%
      \xintexprRestoreCatcodes
    \fi
    }% end of \xint_defufunc_b
  \def #6{%
    \XINT_expr_makedummy{\XINT_defufunc_tmpd}%
    \edef\XINT_defufunc_tmpc {subs(\unexpanded\expandafter{\XINT_defufunc_tmpc},%
                              \XINT_defufunc_tmpd=########1)}%
    \expandafter\XINT_expr_defuserufunc
    \csname XINT_#2_func_\XINT_defufunc_tmpa\expandafter\endcsname
    \csname XINT_#2_userufunc_\XINT_defufunc_tmpa\expandafter\endcsname
    \expandafter{\XINT_defufunc_tmpa}{#2}%
    \expandafter#3\csname XINT_#2_userufunc_\XINT_defufunc_tmpa\endcsname
                               [1]{\XINT_defufunc_tmpc}%
    \ifxintverbose\xintMessage {xintexpr}{Info}
         {Universal function \XINT_defufunc_tmpa\space for \string\xint #4 parser
          associated to \string\XINT_#2_userufunc_\XINT_defufunc_tmpa\space
          with \ifxintglobaldefs global \fi meaning \expandafter\meaning
          \csname XINT_#2_userufunc_\XINT_defufunc_tmpa\endcsname}%
    \fi
    \xintexprRestoreCatcodes
  }% end of \xint_defufunc_c
}%
\def\xintdefufunc      {\xintexprSafeCatcodes\xintdefufunc_a}%
\def\xintdefiiufunc    {\xintexprSafeCatcodes\xintdefiiufunc_a}%
\def\xintdeffloatufunc {\xintexprSafeCatcodes\xintdeffloatufunc_a}%
\XINT_tmpa\xintdefufunc_a      {expr}  \XINT_NewFunc     {expr}%
          \xintdefufunc_b\xintdefufunc_c
\XINT_tmpa\xintdefiiufunc_a   {iiexpr}\XINT_NewIIFunc   {iiexpr}%
          \xintdefiiufunc_b\xintdefiiufunc_c
\XINT_tmpa\xintdeffloatufunc_a{flexpr}\XINT_NewFloatFunc{floatexpr}%
          \xintdeffloatufunc_b\xintdeffloatufunc_c
\def\XINT_expr_defuserufunc #1#2#3#4%
{%
    \XINT_global
    \def #1##1##2%##3%
    {%
         \expandafter ##1\expandafter##2\expanded
         \XINT:NEhook:userufunc{XINT_#4_userufunc_#3}#2%##3%
    }%
}%
\def\XINT:NEhook:userufunc #1{\XINT:expr:mapwithin}%
```

12.30.3 \xintunassignexprfunc, \xintunassigniiexprfunc, \xintunassignfloatexprfunc

See the \xintunassignvar for the embarrassing explanations why I had not done that earlier. A bit lazy here, no warning if undefining something not defined, and attention no precaution respective built-in functions.

```
\def\XINT_tmpa #1{\expandafter\def\csname xintunassign#1func\endcsname ##1{%
   \edef\XINT_unfunc_tmpa{##1}%
```

```
  \edef\XINT_unfunc_tmpa {\xint_zapspaces_o\XINT_unfunc_tmpa}%
  \XINT_global\expandafter
    \let\csname XINT_#1_func_\XINT_unfunc_tmpa\endcsname\xint_undefined
  \XINT_global\expandafter
    \let\csname XINT_#1_userfunc_\XINT_unfunc_tmpa\endcsname\xint_undefined
  \XINT_global\expandafter
    \let\csname XINT_#1_userufunc_\XINT_unfunc_tmpa\endcsname\xint_undefined
  \ifxintverbose\xintMessage {xintexpr}{Info}
   {Function \XINT_unfunc_tmpa\space for \string\xint #1 parser now
    \ifxintglobaldefs globally \fi undefined.}%
  \fi}}%
\XINT_tmpa{expr}\XINT_tmpa{iiexpr}\XINT_tmpa{floatexpr}%
```

12.30.4 \xintNewFunction

1.2h (2016/11/20). Syntax is \xintNewFunction{<name>}[nb of arguments]{expression with #1, #2,... as in \xintNewExpr}. This defines a function for all three parsers but the expression parsing is delayed until function execution. Hence the expression admits all constructs, contrarily to \xintNewExpr or \xintdeffunc.

As the letters used for variables in \xintdeffunc, #1, #2, etc... can not stand for non numeric «oples», because at time of function call f(a, b, c, ...) how to decide if #1 stands for a or a, b etc... ? Or course «a» can be packed and thus the macro function can handle #1 as a «nutple» and for this be defined with the * unpacking operator being applied to it.

```
\def\xintNewFunction #1#2[#3]#4%
{%
  \edef\XINT_newfunc_tmpa {#1}%
  \edef\XINT_newfunc_tmpa {\xint_zapspaces_o \XINT_newfunc_tmpa}%
  \def\XINT_newfunc_tmpb ##1##2##3##4##5##6##7##8##9{#4}%
  \begingroup
    \ifcase #3\relax
        \toks0{}%
    \or \toks0{##1}%
    \or \toks0{##1##2}%
    \or \toks0{##1##2##3}%
    \or \toks0{##1##2##3##4}%
    \or \toks0{##1##2##3##4##5}%
    \or \toks0{##1##2##3##4##5##6}%
    \or \toks0{##1##2##3##4##5##6##7}%
    \or \toks0{##1##2##3##4##5##6##7##8}%
    \else \toks0{##1##2##3##4##5##6##7##8##9}%
    \fi
    \expandafter
  \endgroup\expandafter
  \XINT_global\expandafter
  \def\csname XINT_expr_macrofunc_\XINT_newfunc_tmpa\expandafter\endcsname
  \the\toks0\expandafter{\XINT_newfunc_tmpb
    {\XINTfstop.{{##1}}}{\XINTfstop.{{##2}}}{\XINTfstop.{{##3}}}%
    {\XINTfstop.{{##4}}}{\XINTfstop.{{##5}}}{\XINTfstop.{{##6}}}%
    {\XINTfstop.{{##7}}}{\XINTfstop.{{##8}}}{\XINTfstop.{{##9}}}}%
  \expandafter\XINT_expr_newfunction
    \csname XINT_expr_func_\XINT_newfunc_tmpa\expandafter\endcsname
    \expandafter{\XINT_newfunc_tmpa}\xintbareeval
  \expandafter\XINT_expr_newfunction
```

```
    \csname XINT_iiexpr_func_\XINT_newfunc_tmpa\expandafter\endcsname
    \expandafter{\XINT_newfunc_tmpa}\xintbareiieval
  \expandafter\XINT_expr_newfunction
    \csname XINT_flexpr_func_\XINT_newfunc_tmpa\expandafter\endcsname
    \expandafter{\XINT_newfunc_tmpa}\xintbarefloateval
  \ifxintverbose
    \xintMessage {xintexpr}{Info}
        {Function \XINT_newfunc_tmpa\space for the expression parsers is
         associated to \string\XINT_expr_macrofunc_\XINT_newfunc_tmpa\space
         with \ifxintglobaldefs global \fi meaning \expandafter\meaning
         \csname XINT_expr_macrofunc_\XINT_newfunc_tmpa\endcsname}%
  \fi
}%
\def\XINT_expr_newfunction #1#2#3%
{%
    \XINT_global
    \def#1##1##2##3%
      {\expandafter ##1\expandafter ##2%
       \romannumeral0\XINT:NEhook:macrofunc
       #3{\csname XINT_expr_macrofunc_#2\endcsname##3}\relax
      }%
}%
\let\XINT:NEhook:macrofunc\empty
```

12.30.5 Mysterious stuff

There was an \xintNewExpr already in 1.07 from May 2013, which was modified in September 2013 to work with the # macro parameter character, and then refactored into a more powerful version in June 2014 for 1.1 release of 2014/10/28.

It is always too soon to try to comment and explain. In brief, this attempts to hack into the *purely numeric* \xintexpr parsers to transform them into *symbolic* parsers, allowing to do once and for all the parsing job and inherit a gigantic nested macro. Originally only f-expandable nesting. The initial motivation was that the \csname encapsulation impacted the string pool memory. Later this work proved to be the basis to provide support for implementing user-defined functions and it is now its main purpose.

Deep refactorings happened at 1.3 and 1.4.

At 1.3 the crucial idea of the «hook» macros was introduced, reducing considerably the preparatory work done by \xintNewExpr.

At 1.4 further considerable simplifications happened, and it is possible that the author currently does at long last understand the code!

The 1.3 code had serious complications with trying to identify would-be «list» arguments, distinguishing them from «single» arguments (things like parsing #2+[[#1..[#3]..#4][#5:#6]]*#7 and convert it to a single nested f-exandable macro...)

The conversion at 1.4 is both more powerful and simpler, due in part to the new storage model which from \csname encapsulated comma separated values up to 1.3f became simply a braced list of braced values, and also crucially due to the possibilities opened up by usage of \expanded primitive.

```
\catcode`~ 12
\def\XINT:NE:hastilde#1~#2#3\relax{\unless\if !#21\fi}%
\def\XINT:NE:hashash#1{%
\def\XINT:NE:hashash##1#1##2##3\relax{\unless\if !##21\fi}%
}\expandafter\XINT:NE:hashash\string#%
\def\XINT:NE:unpack #1{%
```

```
\def\XINT:NE:unpack ##1%
{%
    \if0\XINT:NE:hastilde ##1~!\relax
        \XINT:NE:hashash  ##1#1!\relax 0\else
        \expandafter\XINT:NE:unpack:p\fi
    \xint_stop_atfirstofone{##1}%
}}\expandafter\XINT:NE:unpack\string#%
\def\XINT:NE:unpack:p#1#2%
    {{~romannumeral0~expandafter~xint_stop_atfirstofone~expanded{#2}}}%
\def\XINT:NE:f:one:from:one #1{%
\def\XINT:NE:f:one:from:one ##1%
{%
    \if0\XINT:NE:hastilde ##1~!\relax
        \XINT:NE:hashash  ##1#1!\relax 0\else
        \xint_dothis\XINT:NE:f:one:from:one_a\fi
    \xint_orthat\XINT:NE:f:one:from:one_b
    ##1&&A%
}}\expandafter\XINT:NE:f:one:from:one\string#%
\def\XINT:NE:f:one:from:one_a\romannumeral`&&@#1#2&&A%
{%
    \expandafter{\detokenize{\expandafter#1}#2}%
}%
\def\XINT:NE:f:one:from:one_b#1{%
\def\XINT:NE:f:one:from:one_b\romannumeral`&&@##1##2&&A%
{%
    \expandafter{\romannumeral`&&@%
        \if0\XINT:NE:hastilde ##2~!\relax
            \XINT:NE:hashash  ##2#1!\relax 0\else
        \expandafter\string\fi
    ##1{##2}}%
}}\expandafter\XINT:NE:f:one:from:one_b\string#%
\def\XINT:NE:f:one:from:one:direct #1#2{\XINT:NE:f:one:from:one:direct_a #2&&A{#1}}%
\def\XINT:NE:f:one:from:one:direct_a #1#2&&A#3%
{%
    \if ###1\xint_dothis {\detokenize{#3}}\fi
    \if  ~#1\xint_dothis {\detokenize{#3}}\fi
    \xint_orthat {#3}{#1#2}%
}%
\def\XINT:NE:f:one:from:two #1{%
\def\XINT:NE:f:one:from:two ##1%
{%
    \if0\XINT:NE:hastilde ##1~!\relax
        \XINT:NE:hashash  ##1#1!\relax 0\else
        \xint_dothis\XINT:NE:f:one:from:two_a\fi
    \xint_orthat\XINT:NE:f:one:from:two_b ##1&&A%
}}\expandafter\XINT:NE:f:one:from:two\string#%
\def\XINT:NE:f:one:from:two_a\romannumeral`&&@#1#2&&A%
{%
    \expandafter{\detokenize{\expandafter#1\expanded}{#2}}%
}%
\def\XINT:NE:f:one:from:two_b#1{%
\def\XINT:NE:f:one:from:two_b\romannumeral`&&@##1##2##3&&A%
```

```
{%
    \expandafter{\romannumeral`&&@%
        \if0\XINT:NE:hastilde ##2##3~!\relax
            \XINT:NE:hashash  ##2##3#1!\relax 0\else
        \expandafter\string\fi
    ##1{##2}{##3}}%
}}\expandafter\XINT:NE:f:one:from:two_b\string#%
\def\XINT:NE:f:one:from:two:direct #1#2#3{\XINT:NE:two_fork #2&&A#3&&A#1{#2}{#3}}%
\def\XINT:NE:two_fork #1#2&&A#3#4&&A{\XINT:NE:two_fork_nn#1#3}%
\def\XINT:NE:two_fork_nn #1#2%
{%
    \if #1##\xint_dothis\string\fi
    \if  #1~\xint_dothis\string\fi
    \if #2##\xint_dothis\string\fi
    \if  #2~\xint_dothis\string\fi
    \xint_orthat{}%
}%
\def\XINT:NE:f:one:and:opt:direct#1{%
\def\XINT:NE:f:one:and:opt:direct##1!%
{%
    \if0\XINT:NE:hastilde ##1~!\relax
        \XINT:NE:hashash  ##1#1!\relax 0\else
        \xint_dothis\XINT:NE:f:one:and:opt_a\fi
    \xint_orthat\XINT:NE:f:one:and:opt_b ##1&&A%
}}\expandafter\XINT:NE:f:one:and:opt:direct\string#%
\def\XINT:NE:f:one:and:opt_a #1#2&&A#3#4%
{%
    \detokenize{\romannumeral-`0\expandafter#1\expanded{#2}$XINT_expr_exclam#3#4}%$
}%
\def\XINT:NE:f:one:and:opt_b\XINT:expr:f:one:and:opt #1#2#3&&A#4#5%
{%
    \if\relax#3\relax\expandafter\xint_firstoftwo\else
                    \expandafter\xint_secondoftwo\fi
    {\XINT:NE:f:one:from:one:direct#4}%
    {\expandafter\XINT:NE:f:onewithopttoone\expandafter#5%
        \expanded{{\XINT:NE:f:one:from:one:direct\xintNum{#2}}}}%
    {#1}%
}%
\def\XINT:NE:f:onewithopttoone#1#2#3{\XINT:NE:two_fork #2&&A#3&&A#1[#2]{#3}}%
\def\XINT:NE:f:tacitzeroifone:direct#1{%
\def\XINT:NE:f:tacitzeroifone:direct##1!%
{%
    \if0\XINT:NE:hastilde ##1~!\relax
        \XINT:NE:hashash  ##1#1!\relax 0\else
        \xint_dothis\XINT:NE:f:one:and:opt_a\fi
    \xint_orthat\XINT:NE:f:tacitzeroifone_b ##1&&A%
}}\expandafter\XINT:NE:f:tacitzeroifone:direct\string#%
\def\XINT:NE:f:tacitzeroifone_b\XINT:expr:f:tacitzeroifone #1#2#3&&A#4#5%
{%
    \if\relax#3\relax\expandafter\xint_firstoftwo\else
                     \expandafter\xint_secondoftwo\fi
    {\XINT:NE:f:one:from:two:direct#4{0}}%
```

```
    {\expandafter\XINT:NE:f:one:from:two:direct\expandafter#5%
        \expanded{{\XINT:NE:f:one:from:one:direct\xintNum{#2}}}}%
    {#1}%
}%
\def\XINT:NE:f:iitacitzeroifone:direct#1{%
\def\XINT:NE:f:iitacitzeroifone:direct##1!%
{%
    \if0\XINT:NE:hastilde ##1~!\relax
        \XINT:NE:hashash  ##1#1!\relax 0\else
        \xint_dothis\XINT:NE:f:iitacitzeroifone_a\fi
    \xint_orthat\XINT:NE:f:iitacitzeroifone_b ##1&&A%
}}\expandafter\XINT:NE:f:iitacitzeroifone:direct\string#%
\def\XINT:NE:f:iitacitzeroifone_a #1#2&&A#3%
{%
    \detokenize
    {\romannumeral`$XINT_expr_null\expandafter#1\expanded{#2}$XINT_expr_exclam#3}%
}%
\def\XINT:NE:f:iitacitzeroifone_b\XINT:expr:f:iitacitzeroifone #1#2#3&&A#4%
{%
    \if\relax#3\relax\expandafter\xint_firstoftwo\else
                    \expandafter\xint_secondoftwo\fi
    {\XINT:NE:f:one:from:two:direct#4{0}}%
    {\XINT:NE:f:one:from:two:direct#4{#2}}%
    {#1}%
}%
\def\XINT:NE:x:one:from:two #1#2#3{\XINT:NE:x:one:from:two_fork #2&&A#3&&A#1{#2}{#3}}%
\def\XINT:NE:x:one:from:two_fork #1{%
\def\XINT:NE:x:one:from:two_fork ##1##2&&A##3##4&&A%
{%
    \if0\XINT:NE:hastilde ##1##3~!\relax\XINT:NE:hashash ##1##3#1!\relax 0%
    \else
        \expandafter\XINT:NE:x:one:from:two:p
    \fi
}}\expandafter\XINT:NE:x:one:from:two_fork\string#%
\def\XINT:NE:x:one:from:two:p #1#2#3%
   {~expanded{\detokenize{\expandafter#1}~expanded{{#2}{#3}}}}%
\def\XINT:NE:x:listsel #1{%
\def\XINT:NE:x:listsel ##1##2&%
{%
    \if0\expandafter\XINT:NE:hastilde\detokenize{##2}~!\relax
        \expandafter\XINT:NE:hashash\detokenize{##2}#1!\relax 0%
    \else
        \expandafter\XINT:NE:x:listsel:p
    \fi
    ##1##2&%
}}\expandafter\XINT:NE:x:listsel\string#%
\def\XINT:NE:x:listsel:p #1#2_#3&(#4%
{%
    \detokenize{\expanded\XINT:expr:ListSel{{#3}{#4}}}%
}%
\def\XINT:expr:ListSel{\expandafter\XINT:expr:ListSel_i\expanded}%
\def\XINT:expr:ListSel_i #1#2{{\XINT_ListSel_top #2_#1&({#2}}}%
```

```
\def\XINT:NE:f:reverse #1{%
\def\XINT:NE:f:reverse ##1^%
{%
    \if0\expandafter\XINT:NE:hastilde\detokenize\expandafter{\xint_gobble_i##1}~!\relax
        \expandafter\XINT:NE:hashash\detokenize{##1}#1!\relax 0%
    \else
        \expandafter\XINT:NE:f:reverse:p
    \fi
    ##1^%
}}\expandafter\XINT:NE:f:reverse\string#%
\def\XINT:NE:f:reverse:p #1^#2\xint_bye
{%
    \expandafter\XINT:NE:f:reverse:p_i\expandafter{\xint_gobble_i#1}%
}%
\def\XINT:NE:f:reverse:p_i #1%
{%
    \detokenize{\romannumeral0\XINT:expr:f:reverse{{#1}}}%
}%
\def\XINT:expr:f:reverse{\expandafter\XINT:expr:f:reverse_i\expanded}%
\def\XINT:expr:f:reverse_i #1%
{%
    \XINT_expr_reverse #1^^#1\xint:\xint:\xint:\xint:
                         \xint:\xint:\xint:\xint:\xint_bye
}%
\def\XINT:NE:f:from:delim:u #1{%
\def\XINT:NE:f:from:delim:u ##1##2^%
{%
    \if0\expandafter\XINT:NE:hastilde\detokenize{##2}~!\relax
        \expandafter\XINT:NE:hashash\detokenize{##2}#1!\relax 0%
        \xint_afterfi{\expandafter\XINT_fooof_checkifnumber\expandafter##1\string}%
    \else
        \xint_afterfi{\XINT:NE:f:from:delim:u:p##1\empty}%
    \fi
    ##2^%
}}\expandafter\XINT:NE:f:from:delim:u\string#%
\def\XINT:NE:f:from:delim:u:p #1#2^%
{%
    \detokenize
    {\expandafter\XINT:fooof:checkifnumber\expandafter#1}~expanded{#2}$XINT_expr_caret%$
}%
\def\XINT:fooof:checkifnumber#1{\expandafter\XINT_fooof_checkifnumber\expandafter#1\string}%
\def\XINT:NE:f:LFL#1#2{\expandafter\XINT:NE:f:LFL_a\expandafter#1#2\XINT:NE:f:LFL_a}%
\def\XINT:NE:f:LFL_a#1#2%
{%
    \if#2i\else\expandafter\XINT:NE:f:LFL_p
    \fi #1%
}%
\def\XINT:NE:r:check#1{%
\def\XINT:NE:r:check##1\XINT:NE:f:LFL_a
{%
    \if0\expandafter\XINT:NE:hastilde\detokenize{##1}~!\relax%
        \expandafter\XINT:NE:hashash\detokenize{##1}#1!\relax 0%
```

```
    \else
        \expandafter\XINT:NE:r:check:p
    \fi
    1\expandafter{\romannumeral\XINT:NEsaved:r:check##1}%
}}\expandafter\XINT:NE:r:check\string#%
\def\XINT:NE:r:check:p 1\expandafter#1{\XINT:NE:r:check:p_i#1}%
\def\XINT:NE:r:check:p_i\romannumeral\XINT:NEsaved:r:check{\XINT:NE:r:check:p_ii\empty}%
\def\XINT:NE:r:check:p_ii#1^%
{%
    5~expanded{{~romannumeral~XINT:NEsaved:r:check#1$XINT_expr_caret}}%$
}%
\def\XINT:NE:f:LFL_p#1%
{%
    \detokenize{\romannumeral`$XINT_expr_null\expandafter#1}%$
}%
\catcode`- 11
\def\XINT:NE:exec_? #1#2%
{%
    \XINT:NE:exec_?_b #2&&A#1{#2}%
}%
\def\XINT:NE:exec_?_b #1{%
\def\XINT:NE:exec_?_b ##1&&A%
{%
    \if0\XINT:NE:hastilde ##1~!\relax
        \XINT:NE:hashash  ##1#1!\relax 0%
    \xint_dothis\XINT:NE:exec_?:x\fi
    \xint_orthat\XINT:NE:exec_?:p
}}\expandafter\XINT:NE:exec_?_b\string#%
\def\XINT:NE:exec_?:x #1#2#3%
{%
    \expandafter\XINT_expr_check-_after?\expandafter#1%
    \romannumeral`&&@\expandafter\XINT_expr_getnext\romannumeral0\xintiiifnotzero#3%
}%
\def\XINT:NE:exec_?:p #1#2#3#4#5%
{%
    \csname XINT_expr_func_*If\expandafter\endcsname
    \romannumeral`&&@#2\XINTfstop.{#3},[#4],[#5])%
}%
\expandafter\def\csname XINT_expr_func_*If\endcsname #1#2#3%
{%
    #1#2{~expanded{~xintiiifNotZero#3}}%
}%
\def\XINT:NE:exec_?? #1#2#3%
{%
    \XINT:NE:exec_??_b #2&&A#1{#2}%
}%
\def\XINT:NE:exec_??_b #1{%
\def\XINT:NE:exec_??_b ##1&&A%
{%
    \if0\XINT:NE:hastilde ##1~!\relax
        \XINT:NE:hashash  ##1#1!\relax 0%
    \xint_dothis\XINT:NE:exec_??:x\fi
```

```
    \xint_orthat\XINT:NE:exec_??:p
}}\expandafter\XINT:NE:exec_??_b\string#%
\def\XINT:NE:exec_??:x #1#2#3%
{%
    \expandafter\XINT_expr_check-_after?\expandafter#1%
    \romannumeral`&&@\expandafter\XINT_expr_getnext\romannumeral0\xintiiifsgn#3%
}%
\def\XINT:NE:exec_??:p #1#2#3#4#5#6%
{%
    \csname XINT_expr_func_*IfSgn\expandafter\endcsname
    \romannumeral`&&@#2\XINTfstop.{#3},[#4],[#5],[#6])%
}%
\expandafter\def\csname XINT_expr_func_*IfSgn\endcsname #1#2#3%
{%
    #1#2{~expanded{~xintiiifSgn#3}}%
}%
\catcode`- 12
\def\XINT:NE:branch #1%
{%
    \if0\XINT:NE:hastilde #1~!\relax 0\else
        \xint_dothis\XINT:NE:branch_a\fi
    \xint_orthat\XINT:NE:branch_b #1&&A%
}%
\def\XINT:NE:branch_a\romannumeral`&&@#1#2&&A%
{%
    \expandafter{\detokenize{\expandafter#1\expanded}{#2}}%
}%
\def\XINT:NE:branch_b#1{%
\def\XINT:NE:branch_b\romannumeral`&&@##1##2##3&&A%
{%
    \expandafter{\romannumeral`&&@%
        \if0\XINT:NE:hastilde ##2~!\relax
            \XINT:NE:hashash  ##2#1!\relax 0\else
        \expandafter\string\fi
    ##1{##2}##3}%
}}\expandafter\XINT:NE:branch_b\string#%
\def\XINT:NE:seqx#1{%
\def\XINT:NE:seqx\XINT_allexpr_seqx##1##2%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##2}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##2}#1!\relax 0%
    \else
      \expandafter\XINT:NE:seqx:p
    \fi \XINT_allexpr_seqx{##1}{##2}%
}}\expandafter\XINT:NE:seqx\string#%
\def\XINT:NE:seqx:p\XINT_allexpr_seqx #1#2#3#4%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded {%
    {%
        \detokenize
        {%
```

```
            \expanded\bgroup
            \expanded
            {\unexpanded{\XINT_expr_seq:_b{#1#4\relax $XINT_expr_exclam #3}}%
              #2$XINT_expr_caret}%
         }%
    }%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT:NE:opx#1{%
\def\XINT:NE:opx\XINT_allexpr_opx ##1##2##3##4%##5##6##7##8%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##4}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##4}#1!\relax 0%
    \else
      \expandafter\XINT:NE:opx:p
    \fi \XINT_allexpr_opx ##1{##2}{##3}{##4}% en fait ##2 = \xint_c_, ##3 = \relax
}}\expandafter\XINT:NE:opx\string#%
\def\XINT:NE:opx:p\XINT_allexpr_opx #1#2#3#4#5#6#7#8%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded {%
    {%
        \detokenize
        {%
            \expanded\bgroup
            \expanded{\unexpanded{\XINT_expr_iter:_b
               {#1\expandafter\XINT_allexpr_opx_ifnotomitted
                  \romannumeral0#1#6\relax#7@\relax $XINT_expr_exclam #5}}%
                      #4$XINT_expr_caret$XINT_expr_tilde{{#8}}}%$
        }%
    }%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT:NE:iter{\expandafter\XINT:NE:itery\expandafter}%
\def\XINT:NE:itery#1{%
\def\XINT:NE:itery\XINT_expr_itery##1##2%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##1##2}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##1##2}#1!\relax 0%
    \else
      \expandafter\XINT:NE:itery:p
    \fi \XINT_expr_itery{##1}{##2}%
}}\expandafter\XINT:NE:itery\string#%
\def\XINT:NE:itery:p\XINT_expr_itery #1#2#3#4#5%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded {%
    {%
        \detokenize
        {%
          \expanded\bgroup
          \expanded{\unexpanded{\XINT_expr_iter:_b {#5#4\relax $XINT_expr_exclam #3}}%
```

```
                      #1$XINT_expr_caret$XINT_expr_tilde{#2}}%$
        }%
    }%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT:NE:rseq{\expandafter\XINT:NE:rseqy\expandafter}%
\def\XINT:NE:rseqy#1{%
\def\XINT:NE:rseqy\XINT_expr_rseqy##1##2%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##1##2}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##1##2}#1!\relax 0%
    \else
      \expandafter\XINT:NE:rseqy:p
    \fi \XINT_expr_rseqy{##1}{##2}%
}}\expandafter\XINT:NE:rseqy\string#%
\def\XINT:NE:rseqy:p\XINT_expr_rseqy #1#2#3#4#5%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded {%
    {%
        \detokenize
        {%
          \expanded\bgroup
          \expanded{#2\unexpanded{\XINT_expr_rseq:_b {#5#4\relax $XINT_expr_exclam #3}}%
                      #1$XINT_expr_caret$XINT_expr_tilde{#2}}%$
         }%
    }%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT:NE:iterr{\expandafter\XINT:NE:iterry\expandafter}%
\def\XINT:NE:iterry#1{%
\def\XINT:NE:iterry\XINT_expr_iterry##1##2%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##1##2}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##1##2}#1!\relax 0%
    \else
      \expandafter\XINT:NE:iterry:p
    \fi \XINT_expr_iterry{##1}{##2}%
}}\expandafter\XINT:NE:iterry\string#%
\def\XINT:NE:iterry:p\XINT_expr_iterry #1#2#3#4#5%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded {%
    {%
        \detokenize
        {%
          \expanded\bgroup
          \expanded{\unexpanded{\XINT_expr_iterr:_b {#5#4\relax $XINT_expr_exclam #3}}%
                      #1$XINT_expr_caret$XINT_expr_tilde #20$XINT_expr_qmark}%
        }%
    }%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
```

```
}%
\def\XINT:NE:rrseq{\expandafter\XINT:NE:rrseqy\expandafter}%
\def\XINT:NE:rrseqy#1{%
\def\XINT:NE:rrseqy\XINT_expr_rrseqy##1##2%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##1##2}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##1##2}#1!\relax 0%
    \else
      \expandafter\XINT:NE:rrseqy:p
    \fi \XINT_expr_rrseqy{##1}{##2}%
}}\expandafter\XINT:NE:rrseqy\string#%
\def\XINT:NE:rrseqy:p\XINT_expr_rrseqy #1#2#3#4#5#6%
{%
    \expandafter\XINT_expr_put_op_first
    \expanded {%
    {%
        \detokenize
        {%
           \expanded\bgroup
           \expanded{#2\unexpanded{\XINT_expr_rrseq:_b {#6#5\relax $XINT_expr_exclam #4}}%
                        #1$XINT_expr_caret$XINT_expr_tilde #30$XINT_expr_qmark}%
         }%
    }%
    \expandafter}\romannumeral`&&@\XINT_expr_getop
}%
\def\XINT:NE:x:toblist#1{%
\def\XINT:NE:x:toblist\XINT:expr:toblistwith##1##2%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##2}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##2}#1!\relax 0%
    \else
      \expandafter\XINT:NE:x:toblist:p
    \fi \XINT:expr:toblistwith{##1}{##2}%
}}\expandafter\XINT:NE:x:toblist\string#%
\def\XINT:NE:x:toblist:p\XINT:expr:toblistwith #1#2{{\XINTfstop.{#2}}}%
\def\XINT:NE:x:flatten#1{%
\def\XINT:NE:x:flatten\XINT:expr:flatten##1%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##1}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##1}#1!\relax 0%
    \else
      \expandafter\XINT:NE:x:flatten:p
    \fi \XINT:expr:flatten{##1}%
}}\expandafter\XINT:NE:x:flatten\string#%
\def\XINT:NE:x:flatten:p\XINT:expr:flatten #1%
{%
    {{%
     \detokenize
     {%
         \expandafter\XINT:expr:flatten_checkempty
         \detokenize\expandafter{\expanded{#1}}$XINT_expr_caret%$
     }%
```

```
    }}%
}%
\def\XINT:NE:x:zip#1{%
\def\XINT:NE:x:zip\XINT:expr:zip##1%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##1}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##1}#1!\relax 0%
    \else
      \expandafter\XINT:NE:x:zip:p
    \fi \XINT:expr:zip{##1}%
}}\expandafter\XINT:NE:x:zip\string#%
\def\XINT:NE:x:zip:p\XINT:expr:zip #1%
{%
    \expandafter{%
     \detokenize
     {%
        \expanded\expandafter\XINT_zip_A\expanded{#1}\xint_bye\xint_bye
     }%
    }%
}%
\def\XINT:NE:x:mapwithin#1{%
\def\XINT:NE:x:mapwithin\XINT:expr:mapwithin ##1##2%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##2}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##2}#1!\relax 0%
    \else
      \expandafter\XINT:NE:x:mapwithin:p
    \fi \XINT:expr:mapwithin {##1}{##2}%
}}\expandafter\XINT:NE:x:mapwithin\string#%
\def\XINT:NE:x:mapwithin:p \XINT:expr:mapwithin  #1#2%
{%
    {{%
     \detokenize
     {%
```

Attention (2022/06/10) I do not remember why I left these two commented lines which docstrip will not remove, I hope this is not a forgotten left=over from some debugging session.

```
%%       \expanded
%%       {%
          \expandafter\XINT:expr:mapwithin_checkempty
          \expanded{\noexpand#1$XINT_expr_exclam\expandafter}%$
          \detokenize\expandafter{\expanded{#2}}$XINT_expr_caret%$
```

This is is the matching one.

```
%%       }%
     }%
    }}%
}%
\def\XINT:NE:x:ndmapx#1{%
\def\XINT:NE:x:ndmapx\XINT_allexpr_ndmapx_a ##1##2^%
{%
    \if 0\expandafter\XINT:NE:hastilde\detokenize{##2}~!\relax
         \expandafter\XINT:NE:hashash \detokenize{##2}#1!\relax 0%
    \else
```

```
      \expandafter\XINT:NE:x:ndmapx:p
    \fi \XINT_allexpr_ndmapx_a ##1##2^%
}}\expandafter\XINT:NE:x:ndmapx\string#%
\def\XINT:NE:x:ndmapx:p #1#2#3^\relax
{%
    \detokenize
    {%
      \expanded{%
      \expandafter#1\expandafter#2\expanded{#3}$XINT_expr_caret\relax %$
                 }%
    }%
}%
```

Attention here that user function names may contain digits, so we don't use a \detokenize or ~ approach.

This syntax means that a function defined by \xintdeffunc never expands when used in another definition, so it can implement recursive definitions.

\XINT:NE:userefunc et al. added at 1.3e.

I added at \xintdefefunc, \xintdefiiefunc, \xintdeffloatefunc at 1.3e to on the contrary expand if possible (i.e. if used only with numeric arguments) in another definition.

The \XINTusefunc uses \expanded. Its ancestor \xintExpandArgs (xinttools 1.3) had some more primitive f-expansion technique.

```
\def\XINTusenoargfunc #1%
{%
    0\csname #1\endcsname
}%
\def\XINT:NE:usernoargfunc\csname #1\endcsname
{%
    ~romannumeral~XINTusenoargfunc{#1}%
}%
\def\XINTusefunc #1%
{%
    0\csname #1\expandafter\endcsname\expanded
}%
\def\XINT:NE:usefunc #1#2#3%
{%
    ~romannumeral~XINTusefunc{#1}{#3}\iffalse{{\fi}}%
}%
\def\XINTuseufunc #1%
{%
    \expanded\expandafter\XINT:expr:mapwithin\csname #1\expandafter\endcsname\expanded
}%
\def\XINT:NE:useufunc #1#2#3%
{%
    {{~expanded~XINTuseufunc{#1}{#3}}}%
}%
\def\XINT:NE:userfunc #1{%
\def\XINT:NE:userfunc ##1##2##3%
{%
    \if0\expandafter\XINT:NE:hastilde\detokenize{##3}~!\relax
        \expandafter\XINT:NE:hashash\detokenize{##3}#1!\relax 0%
      \expandafter\XINT:NE:userfunc_x
    \else
```

```
      \expandafter\XINT:NE:usefunc
    \fi {##1}{##2}{##3}%
}}\expandafter\XINT:NE:userfunc\string#%
\def\XINT:NE:userfunc_x #1#2#3{#2#3\iffalse{{\fi}}}%
\def\XINT:NE:userufunc #1{%
\def\XINT:NE:userufunc ##1##2##3%
{%
    \if0\expandafter\XINT:NE:hastilde\detokenize{##3}~!\relax
        \expandafter\XINT:NE:hashash\detokenize{##3}#1!\relax 0%
      \expandafter\XINT:NE:userufunc_x
    \else
      \expandafter\XINT:NE:useufunc
    \fi {##1}{##2}{##3}%
}}\expandafter\XINT:NE:userufunc\string#%
\def\XINT:NE:userufunc_x #1{\XINT:expr:mapwithin}%
\def\XINT:NE:macrofunc #1#2%
   {\expandafter\XINT:NE:macrofunc:a\string#1#2\empty&}%
\def\XINT:NE:macrofunc:a#1\csname #2\endcsname#3&%
   {{~XINTusemacrofunc{#1}{#2}{#3}}}%
\def\XINTusemacrofunc #1#2#3%
{%
    \romannumeral0\expandafter\xint_stop_atfirstofone
    \romannumeral0#1\csname #2\endcsname#3\relax
}%
```

12.30.6 \XINT_expr_redefinemacros

Completely refactored at 1.3.

Again refactored at 1.4. The availability of \expanded allows more powerful mechanisms and more importantly I better thought out the root problems caused by the handling of list operations in this context and this helped simplify considerably the code.

```
\catcode`- 11
\def\XINT_expr_redefinemacros {%
  \let\XINT:NEhook:unpack          \XINT:NE:unpack
  \let\XINT:NEhook:f:one:from:one        \XINT:NE:f:one:from:one
  \let\XINT:NEhook:f:one:from:one:direct \XINT:NE:f:one:from:one:direct
  \let\XINT:NEhook:f:one:from:two        \XINT:NE:f:one:from:two
  \let\XINT:NEhook:f:one:from:two:direct \XINT:NE:f:one:from:two:direct
  \let\XINT:NEhook:x:one:from:two        \XINT:NE:x:one:from:two
  \let\XINT:NEhook:f:one:and:opt:direct      \XINT:NE:f:one:and:opt:direct
  \let\XINT:NEhook:f:tacitzeroifone:direct   \XINT:NE:f:tacitzeroifone:direct
  \let\XINT:NEhook:f:iitacitzeroifone:direct \XINT:NE:f:iitacitzeroifone:direct
  \let\XINT:NEhook:x:listsel             \XINT:NE:x:listsel
  \let\XINT:NEhook:f:reverse             \XINT:NE:f:reverse
  \let\XINT:NEhook:f:from:delim:u        \XINT:NE:f:from:delim:u
  \let\XINT:NEhook:f:LFL           \XINT:NE:f:LFL
  \let\XINT:NEhook:r:check         \XINT:NE:r:check
  \let\XINT:NEhook:branch          \XINT:NE:branch
  \let\XINT:NEhook:seqx            \XINT:NE:seqx
  \let\XINT:NEhook:opx             \XINT:NE:opx
  \let\XINT:NEhook:rseq            \XINT:NE:rseq
  \let\XINT:NEhook:iter            \XINT:NE:iter
  \let\XINT:NEhook:rrseq           \XINT:NE:rrseq
```

```
  \let\XINT:NEhook:iterr            \XINT:NE:iterr
  \let\XINT:NEhook:x:toblist        \XINT:NE:x:toblist
  \let\XINT:NEhook:x:flatten        \XINT:NE:x:flatten
  \let\XINT:NEhook:x:zip            \XINT:NE:x:zip
  \let\XINT:NEhook:x:mapwithin      \XINT:NE:x:mapwithin
  \let\XINT:NEhook:x:ndmapx         \XINT:NE:x:ndmapx
  \let\XINT:NEhook:userfunc         \XINT:NE:userfunc
  \let\XINT:NEhook:userufunc        \XINT:NE:userufunc
  \let\XINT:NEhook:usernoargfunc    \XINT:NE:usernoargfunc
  \let\XINT:NEhook:macrofunc        \XINT:NE:macrofunc
  \def\XINTinRandomFloatSdigits{~XINTinRandomFloatSdigits }%
  \def\XINTinRandomFloatSixteen{~XINTinRandomFloatSixteen }%
  \def\xintiiRandRange{~xintiiRandRange }%
  \def\xintiiRandRangeAtoB{~xintiiRandRangeAtoB }%
  \def\xintRandBit{~xintRandBit }%
  \let\XINT_expr_exec_?  \XINT:NE:exec_?
  \let\XINT_expr_exec_?? \XINT:NE:exec_??
  \def\XINT_expr_op_?  {\XINT_expr_op__?{\XINT_expr_op_-xii\XINT_expr_oparen}}%
  \def\XINT_flexpr_op_?{\XINT_expr_op__?{\XINT_flexpr_op_-xii\XINT_flexpr_oparen}}%
  \def\XINT_iiexpr_op_?{\XINT_expr_op__?{\XINT_iiexpr_op_-xii\XINT_iiexpr_oparen}}%
}%
\catcode`- 12
```

12.30.7 \xintNewExpr, \xintNewIExpr, \xintNewFloatExpr, \xintNewIIExpr

1.2c modifications to accomodate \XINT_expr_deffunc_newexpr etc..

1.2f adds token \XINT_newexpr_clean to be able to have a different \XINT_newfunc_clean.

As \XINT_NewExpr always execute \XINT_expr_redefineprints since 1.3e whether with \xintNewExpr or \XINT_NewFunc, it has been moved from argument to hardcoded in replacement text.

NO MORE \XINT_expr_redefineprints at 1.4 ! This allows better support for \xinteval, \xinttheexpr as sub-entities inside an \xintNewExpr. And the «cleaning» will remove the new \XINTfstop (detokenized from \meaning output), to maintain backwards compatibility with former behaviour that created macros expand to explicit digits and not an encapsulated result.

The #2#3 in clean stands for \noexpand\XINTfstop (where the actual scantoken-ized input uses $ originally with catcode letter as the escape character).

```
\def\xintNewExpr      {\XINT_NewExpr\xint_firstofone\xintexpr      \XINT_newexpr_clean}%
\def\xintNewFloatExpr{\XINT_NewExpr\xint_firstofone\xintfloatexpr\XINT_newexpr_clean}%
\def\xintNewIExpr     {\XINT_NewExpr\xint_firstofone\xintiexpr     \XINT_newexpr_clean}%
\def\xintNewIIExpr    {\XINT_NewExpr\xint_firstofone\xintiiexpr    \XINT_newexpr_clean}%
\def\xintNewBoolExpr {\XINT_NewExpr\xint_firstofone\xintboolexpr \XINT_newexpr_clean}%
\def\XINT_newexpr_clean #1>#2#3{\noexpand\expanded\noexpand\xintNEprinthook}%
\def\xintNEprinthook#1.#2{\expanded{\unexpanded{#1.}{#2}}}%
```

1.2c for \xintdeffunc, \xintdefiifunc, \xintdeffloatfunc.

At 1.3, NewFunc does not use anymore a comma delimited pattern for the arguments to the macro being defined.

At 1.4 we use \xintthebareeval, whose meaning now does not mean unlock from csname but firstofone to remove a level of braces This is involved in functioning of expr:userfunc and expr:userefunc

```
\def\XINT_NewFunc      {\XINT_NewExpr\xint_gobble_i\xintthebareeval\XINT_newfunc_clean}%
\def\XINT_NewFloatFunc{\XINT_NewExpr\xint_gobble_i\xintthebarefloateval\XINT_newfunc_clean}%
\def\XINT_NewIIFunc    {\XINT_NewExpr\xint_gobble_i\xintthebareiieval\XINT_newfunc_clean}%
\def\XINT_newfunc_clean #1>{}%
```

1.2c adds optional logging. For this needed to pass to _NewExpr_a the macro name as parameter.

Up to and including 1.2c the definition was global. Starting with 1.2d it is done locally.

The \xintexprSafeCatcodes inserted here by \xintNewExpr is not paired with an \xintexprRestoreCatcodes, but this happens within a scope limiting group so does not matter. At 1.3c, \XINT_NewFunc et al. do not even execute the \xintexprSafeCatcodes, as it gets already done by \xintdeffunc prior to arriving here.

```
\def\XINT_NewExpr #1#2#3#4#5[#6]%
{%
 \begingroup
    \ifcase #6\relax
        \toks0 {\endgroup\XINT_global\def#4}%
    \or \toks0 {\endgroup\XINT_global\def#4##1}%
    \or \toks0 {\endgroup\XINT_global\def#4##1##2}%
    \or \toks0 {\endgroup\XINT_global\def#4##1##2##3}%
    \or \toks0 {\endgroup\XINT_global\def#4##1##2##3##4}%
    \or \toks0 {\endgroup\XINT_global\def#4##1##2##3##4##5}%
    \or \toks0 {\endgroup\XINT_global\def#4##1##2##3##4##5##6}%
    \or \toks0 {\endgroup\XINT_global\def#4##1##2##3##4##5##6##7}%
    \or \toks0 {\endgroup\XINT_global\def#4##1##2##3##4##5##6##7##8}%
    \or \toks0 {\endgroup\XINT_global\def#4##1##2##3##4##5##6##7##8##9}%
    \fi
    #1\xintexprSafeCatcodes
    \XINT_expr_redefinemacros
    \XINT_NewExpr_a #1#2#3#4%
}%
```

1.2d's \xintNewExpr makes a local definition. In earlier releases, the definition was global.

\the\toks0 inserts the \endgroup, but this will happen after \XINT_tmpa has already been expanded...

The %1 is \xint_firstofone for \xintNewExpr, \xint_gobble_i for \xintdeffunc.

Attention that at 1.4, there might be entire sub-xintexpressions embedded in detokenized form. They are re-tokenized and the main thing is that the parser should not mis-interpret catcode 11 characters as starting variable names. As some macros use : in their names, the retokenization must be done with : having catcode 11. To not break embedded non-evaluated sub-expressions, the \XINT_expr_getop was extended to intercept the : (alternative would have been to never inject any macro with : in its name... too late now). On the other hand the ! is not used in the macro names potentially kept as is non expanded by the \xintNewExpr/\xintdeffunc process; it can thus be retokenized with catcode 12. But the «hooks» of seq(), iter(), etc... if deciding they can't evaluate immediately will inject a full sub-expression (possibly arbitrarily complicated) and append to it for its delayed expansion a catcode 11 ! character (as well as possibly catcode 3 ~ and ? and catcode 11 caret ^ and even catcode 7 &). The macros \XINT_expr_tilde etc... below serve for this injection (there are *two* successive \scantokens using different catcode regimes and these macros remain detokenized during the first pass!) and as consequence the final meaning may have characters such as ! or & present with both standard and special catcodes depending on where they are located. It may thus not be possible to (easily) retokenize the meaning as printed in the log file if \xintverbosetrue was issued.

If a defined function is used in another expression it would thus break things if its meaning was included pre-expanded ; a mechanism exists which keeps only the name of the macro associated to the function (this name may contain digits by the way), when the macro can not be immediately fully expanded. Thus its meaning (with its possibly funny catcodes) is not exposed. And this gives opportunity to pre-expand its arguments before actually expanding the macro.

```
\catcode`~ 3 \catcode`? 3
\def\XINT_expr_tilde{~}\def\XINT_expr_qmark{?}% catcode 3
\def\XINT_expr_caret{^}\def\XINT_expr_exclam{!}% catcode 11
```

```
\def\XINT_expr_tab{&}% catcode 7
\def\XINT_expr_null{&&@}%
\catcode`~ 13 \catcode`@ 14 \catcode`\% 6 \catcode`# 12 \catcode`$ 11 @ $
\def\XINT_NewExpr_a %1%2%3%4%5@
{@
    \def\XINT_tmpa %%1%%2%%3%%4%%5%%6%%7%%8%%9{%5}@
    \def~{$noexpand$}@
    \catcode`: 11 \catcode`_ 11 \catcode`\@ 11
    \catcode`# 12 \catcode`~ 13 \escapechar 126
    \endlinechar -1 \everyeof {\noexpand }@
    \edef\XINT_tmpb
    {\scantokens\expandafter{\romannumeral`&&@\expandafter
     %2\XINT_tmpa{#1}{#2}{#3}{#4}{#5}{#6}{#7}{#8}{#9}\relax}@
    }@
    \escapechar 92 \catcode`# 6 \catcode`$ 0 @ $
    \edef\XINT_tmpa %%1%%2%%3%%4%%5%%6%%7%%8%%9@
      {\scantokens\expandafter{\expandafter%3\meaning\XINT_tmpb}}@
    \the\toks0\expandafter
      {\XINT_tmpa{%%1}{%%2}{%%3}{%%4}{%%5}{%%6}{%%7}{%%8}{%%9}}@
    %1{\ifxintverbose
        \xintMessage{xintexpr}{Info}@
                   {\string%4\space now with @
                    \ifxintglobaldefs global \fi meaning \meaning%4}@
       \fi}@
}@
\catcode`% 14
\XINTsetcatcodes % clean up to avoid surprises if something changes
```

12.30.8 \xintexprSafeCatcodes, \xintexprRestoreCatcodes

Modified at 1.3c (2018/06/17). Added \ifxintexprsafecatcodes to allow nesting

Modified at 1.4k (2022/05/18). The "allow nesting" from the 2018 comment was strange, because the behaviour, as correctly documented in user manual, was that in case of a series of \xintexprSafeCatcodes, the \xintexprRestoreCatcodes would set catcodes to what they were before the *first* sanitization. But as \xintdefvar and \xintdeffunc used such a pair this meant that they would incomprehensibly for user reset catcodes to what they were before a possible user \xintexprSafeCatcodes located before... very lame situation. Anyway. I finally fix at 1.4k that by removing the silly \ifxintexprsafecatcodes thing and replace it by some stack-like method, avoiding extra macros thanks to the help of \unexpanded.

Modified at 1.4m (2022/06/10). Use \protected rather than \unexpanded mechanism, for lisibility.

```
\protected\def\xintexprRestoreCatcodes{}%
\def\xintexprSafeCatcodes
{%
    \protected\edef\xintexprRestoreCatcodes{%
        \endlinechar=\the\endlinechar
        \catcode59=\the\catcode59   % ;
        \catcode34=\the\catcode34   % "
        \catcode63=\the\catcode63   % ?
        \catcode124=\the\catcode124 % |
        \catcode38=\the\catcode38   % &
        \catcode33=\the\catcode33   % !
        \catcode93=\the\catcode93   % ]
```

```
        \catcode91=\the\catcode91   % [
        \catcode94=\the\catcode94   % ^
        \catcode95=\the\catcode95   % _
        \catcode47=\the\catcode47   % /
        \catcode41=\the\catcode41   % )
        \catcode40=\the\catcode40   % (
        \catcode42=\the\catcode42   % *
        \catcode43=\the\catcode43   % +
        \catcode62=\the\catcode62   % >
        \catcode60=\the\catcode60   % <
        \catcode58=\the\catcode58   % :
        \catcode46=\the\catcode46   % .
        \catcode45=\the\catcode45   % -
        \catcode44=\the\catcode44   % ,
        \catcode61=\the\catcode61   % =
        \catcode96=\the\catcode96   % `
        \catcode32=\the\catcode32\relax  % space
        \protected\odef\xintexprRestoreCatcodes{\xintexprRestoreCatcodes}%
    }%
        \endlinechar=13 %
        \catcode59=12  % ;
        \catcode34=12  % "
        \catcode63=12  % ?
        \catcode124=12 % |
        \catcode38=4   % &
        \catcode33=12  % !
        \catcode93=12  % ]
        \catcode91=12  % [
        \catcode94=7   % ^
        \catcode95=8   % _
        \catcode47=12  % /
        \catcode41=12  % )
        \catcode40=12  % (
        \catcode42=12  % *
        \catcode43=12  % +
        \catcode62=12  % >
        \catcode60=12  % <
        \catcode58=12  % :
        \catcode46=12  % .
        \catcode45=12  % -
        \catcode44=12  % ,
        \catcode61=12  % =
        \catcode96=12  % `
        \catcode32=10  % space
}%
\let\XINT_tmpa\undefined \let\XINT_tmpb\undefined \let\XINT_tmpc\undefined
\let\XINT_tmpd\undefined \let\XINT_tmpe\undefined
```

1.4l makes \usepackage{xintlog} with no prior \usepackage{xintexpr} not abort but attempt to do the right thing. We have to work-around the fact that LaTeX will ignore a \usepackage here. Simpler for non-LaTeX.

In all cases, notice that the input of xintlog.sty and xinttrig.sty is done with xintexpr catcodes in place. And xintlog will sanitize catcodes at time of loading poormanlog. Attention also to not mix-up things at time of restoring catcodes. This is reason why xintlog.sty and xinttrig.sty have their own endinput wrappers. And that the rescue attempt of loading xintexpr (which will load xintlog) from xintlog itself is done carefully.

```
\ifdefined\RequirePackage
 \ifcsname ver@xinttrig.sty\endcsname
```

We end up here since 1.4l with LaTeX if the user has issued \usepackage{xinttrig} or \RequirePackage{xinttrig} with no prior loading of xintexpr. In such (not officially supported) case, the loading of xintexpr was launched from this first instance of xinttrig. This first xinttrig will abort itself, once this input conludes. But before that a second instance of xinttrig is \input and will do all its macro definitions. We can not do \RequirePackage{xinttrig} or \usepackage{xinttrig} as it has occurred already under the user responsability, so we use \@@input.

```
    \@@input xinttrig.sty\relax
 \else
```

Here this is either the normal case with LaTeX (or other formats providing \RequirePackage) and xintexpr requested by user directly, or some more exotic possibility such as ε-TeX with the miniltx loaded and then \input xintexpr.sty\relax was done. As \RequirePackage appears to be defined we use it.

```
    \RequirePackage{xinttrig}%
 \fi
```

Same situation with xintlog.

```
 \ifcsname ver@xintlog.sty\endcsname
    \@@input xintlog.sty\relax
 \else
    \RequirePackage{xintlog}%
 \fi
\else
```

Here we are not with LaTeX and not with miniltx either. Let's just use \input. Perhaps there was an \input xinttrig.sty earlier which triggered \input xintexpr.sty after a warning to the user. The second \input xinttrig.sty issued here will execute the macro definitions, and the former one will abort its own input after that.

```
  \input xinttrig.sty
  \input xintlog.sty
\fi
\XINTrestorecatcodesendinput%
```

13 Package xinttrig implementation

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A preliminary implementation was done only late in the development of xintexpr, as an example of the high level user interface, in January 2019. In March and April 2019 I improved the algorithm for the inverse trigonometrical functions and included the whole as a new \xintexpr module. But, as the high level interface provided no way to have intermediate steps executed with guard digits, the whole scheme could only target say P-2 digits where P is the prevailing precision, and only with a moderate requirement on what it means to have P-2 digits about correct.

Finally in April 2021, after having at long last added exponential and logarithm up to 62 digits and at a rather strong precision requirement (something like, say with inputs in normal ranges: targeting at most 0.505ulp distance to exact result), I revisited the code here.

We keep most of the high level usage of \xintdeffloatfunc, but hack into its process in order to let it map the 4 operations and some functions such as square-root to macros using 4 extra digits. This hack is enough to support the used syntax here, but is not usable generally. All functions and their auxiliaries defined during the time the hack applies are named with @ as first letter.

Later the public functions, without the @, are defined as wrappers of the @-named ones, which float-round to P digits on output.

Apart from that the sine and cosine series were implemented at macro level, bypassing the \xintdeffloatfunc interface. This is done mainly for handling Digits at high value (24 or more) as it then becomes beneficial to float-round the variable to less and less digits, the deeper one goes into the series.

And regarding the arcsine I modified a bit my original idea in order to execute the first step in a single \numexpr. It turns out that that for 16 digits the algorithm then ``only'' needs one sine and one cosine evaluation (and a square-root), and there is no need for an arcsine series auxiliary then. I am aware this is by far not the ``best'' approach but the problem is that I am a bit enamored into the idea of the algorithm even though it is at least twice as costly than a sine evaluation! Actually, for many digits, it turns out the arcsine is less costly than two random sine evaluations, probably because the latter have the overhead of range reduction.

Speaking of this, the range reduction is rather naive and not extremely ambitious. I wrote it initially having only sind() and cosd() in mind, and in 2019 reduced degrees to radians in the most naive way possible. I have only slighly improved this for this 1.4e 2021 release, the announced precision for inputs less than say 1e6, but at 1e8 and higher, one will start feeling the gradual loss of precision compared to the task of computing the exact mathematical result correctly rounded. Also, I do not worry here about what happens when the input is very near a big multiple of π, and one computes a sine for example. Maybe I will improve in future this aspect but I decided I was seriously running out of steam for the 1.4e release.

As commented in xintlog regarding exponential and logarithms, even though we have instilled here some dose of lower level coding, the whole suffers from xintfrac not yet having made floating point numbers a native type. Thus inefficiencies accumulate...

At 8 digits, the gain was only about 40% compared to 16 digits. So at the last minute, on the day I was going to do the release I decided to implement a poorman way for sine and cosine, for "speed". I transferred the idea from the arcsine numexpr to sine and cosine. Indeed there is an interesting speed again of about 4X compared to applying the same approach as for higher values of Digits. Correct rounding during random testing is still obtained reasonably often (at any rate more than 95% of cases near 45 degrees and always faithful rounding), although at less than the 99% reached for the main branch handling Digits up to 62. But the precision is more than enough for usage in plots for example. I am keeping the guard digits, as removing then would add a further speed gain of about 20% to 40% but the precision then would drop dramatically, and this is not acceptable at the time of our 2021 standards (not a period of enlightenment generally speaking, though).

13.1 Catcodes, ε-TeX and reload detection

Modified at 1.4l (2022/05/29). Silly paranoid modification of \z in case { and } do not have their normal catcodes when xinttrig.sty is reloaded (initial loading via xintexpr.sty does not need this), to define \XINTtrigendinput there and not after the \endgroup from \z has already restored possibly bad catcodes.

1.4l handles much better the situation with \usepackage{xinttrig} without previous loading of xintexpr (or same with \input and etex). cf comments in xintlog.sty.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5     % ^^M
  \endlinechar=13 %
  \catcode123=1    % {
  \catcode125=2    % }
  \catcode64=11    % @
  \catcode35=6     % #
  \catcode44=12    % ,
  \catcode46=12    % .
  \catcode58=12    % :
  \catcode94=7     % ^
```

```
 \def\empty{}\def\space{ }\newlinechar10
 \def\z{\endgroup}%
 \expandafter\let\expandafter\x\csname ver@xinttrig.sty\endcsname
 \expandafter\let\expandafter\w\csname ver@xintexpr.sty\endcsname
 \expandafter
   \ifx\csname PackageWarningNoLine\endcsname\relax
     \def\y#1#2{\immediate\write128{^^JPackage #1 Warning:^^J%
                \space\space\space\space#2.^^J}}%
   \else
     \def\y#1#2{\PackageWarningNoLine{#1}{#2}}%
   \fi
 \expandafter
 \ifx\csname numexpr\endcsname\relax
    \y{xinttrig}{\numexpr not available, aborting input}%
    \def\z{\endgroup\endinput}%
 \else
   \ifx\w\relax % xintexpr.sty not yet loaded.
       \edef\MsgBrk{^^J\space\space\space\space}%
       \y{xinttrig}%
         {\ifx\x\empty
            xinttrig should not be loaded directly\MessageBreak
            The correct way is \string\usepackage{xintexpr}.\MessageBreak
            Will try that now%
          \else
            First loading of xinttrig.sty should be via
            \string\input\space xintexpr.sty\relax\MsgBrk
            Will try that now%
          \fi
         }%
       \ifx\x\empty
         \def\z{\endgroup\RequirePackage{xintexpr}\endinput}%
       \else
         \def\z{\endgroup\input xintexpr.sty\relax\endinput}%
       \fi
   \else
     \def\z{\endgroup\edef\XINTtrigendinput{\XINTrestorecatcodes\noexpand\endinput}}%
   \fi
 \fi
\z%
\XINTsetcatcodes%
\catcode`? 12
```

13.2 Library identification

If the file has already been loaded, let's skip the \ProvidesPackage. Else let's do it and set a flag to indicate loading happened at least once already.

Modified at 1.4l (2022/05/29). Message also to Terminal not only log file.

```
\ifcsname xintlibver@trig\endcsname
  \expandafter\xint_firstoftwo
\else
  \expandafter\xint_secondoftwo
\fi
```

```
{\immediate\write128{Reloading xinttrig library using Digits=\xinttheDigits.}}%
{\expandafter\gdef\csname xintlibver@trig\endcsname{2022/06/10 v1.4m}%
  \XINT_providespackage
  \ProvidesPackage{xinttrig}%
  [2022/06/10 v1.4m Trigonometrical functions for xintexpr (JFB)]%
}%
```

13.3 Ensure used letters are dummy letters

```
\xintFor* #1 in {iDTVtuwxyzX}\do{\xintensuredummy{#1}}%
```

13.4 \xintreloadxinttrig

Much simplified at 1.4e, from a modified catcode regime management.

```
\def\xintreloadxinttrig{\input xinttrig.sty }%
```

13.5 Auxiliary variables

The variables with private names have extra digits. Whether private or public, the variables can all be redefined without impacting the defined functions, whose meanings will contain already the variable values.

Formerly variables holding the 1/n! were defined, but this got removed at 1.4e.

13.5.1 @twoPi, @threePiover2, @Pi, @Piover2

At 1.4e we need more digits, also \xintdeffloatvar changed and always rounds to P=Digits precision so we use another path to store values with extra digits.

```
\xintdefvar @twoPi :=
    float(
6.2831853071795864769252867665590057683943387987502116419498891846156328125724180
    ,\XINTdigitsormax+4);%
\xintdefvar @threePiover2 :=
    float(
4.7123889803846898576939650749192543262957540990626587314624168884617246094293135
    ,\XINTdigitsormax+4);%
\xintdefvar @Pi :=
    float(
3.1415926535897932384626433832795028841971693993751058209749445923078164062862090
    ,\XINTdigitsormax+4);%
\xintdefvar @Piover2 :=
    float(
1.5707963267948966192313216916397514420985846996875529104874722961539082031431045
    ,\XINTdigitsormax+4);%
```

13.5.2 @oneDegree, @oneRadian

Those are needed for range reduction, particularly @oneRadian. We define it with 12 extra digits. But the whole process of range reduction in radians is very naive one.

```
\xintdefvar @oneDegree :=
    float(
0.017453292519943295769236907684886127134428718885417254560971914401710091146034494
    ,\XINTdigitsormax+4);%
\xintdefvar @oneRadian :=
```

```
    float(
57.295779513082320876798154814105170332405472466564321549160243861202847148321553
    ,\XINTdigitsormax+12);%
```

13.6 Hack \xintdeffloatfunc for inserting usage of guard digits

1.4e. This is not a general approach, but it sufficient for the limited use case done here of \xintdeffloatfunc. What it does is to let \xintdeffloatfunc hardcode usage of macros which will execute computations with an elevated number of digits. But for example if 5/3 is encountered in a float expression it will remain unevaluated so one would have to use alternate input syntax for efficiency (\xintexpr float(5/3,\xinttheDigits+4)\relax as a subexpression, for example).

```
\catcode`~ 12
\def\XINT_tmpa#1#2#3.#4.%
{%
  \let #1#2%
  \def #2##1##2##3##4%
      {##2##3{{~expanded{~unexpanded{#4[#3]}~expandafter}~expanded{##1##4}}}}%
}%
\expandafter\XINT_tmpa
    \csname XINT_flexpr_exec_+_\expandafter\endcsname
    \csname XINT_flexpr_exec_+\expandafter\endcsname
    \the\numexpr\XINTdigitsormax+4.~XINTinFloatAdd_wopt.%
\expandafter\XINT_tmpa
    \csname XINT_flexpr_exec_-_\expandafter\endcsname
    \csname XINT_flexpr_exec_-\expandafter\endcsname
    \the\numexpr\XINTdigitsormax+4.~XINTinFloatSub_wopt.%
\expandafter\XINT_tmpa
    \csname XINT_flexpr_exec_*_\expandafter\endcsname
    \csname XINT_flexpr_exec_*\expandafter\endcsname
    \the\numexpr\XINTdigitsormax+4.~XINTinFloatMul_wopt.%
\expandafter\XINT_tmpa
    \csname XINT_flexpr_exec_/_\expandafter\endcsname
    \csname XINT_flexpr_exec_/\expandafter\endcsname
    \the\numexpr\XINTdigitsormax+4.~XINTinFloatDiv_wopt.%
\def\XINT_tmpa#1#2#3.#4.%
{%
  \let #1#2%
  \def #2##1##2##3{##1##2{{~expanded{~unexpanded{#4[#3]}~expandafter}##3}}}%
}%
\expandafter\XINT_tmpa
    \csname XINT_flexpr_sqrfunc\expandafter\endcsname
    \csname XINT_flexpr_func_sqr\expandafter\endcsname
    \the\numexpr\XINTdigitsormax+4.~XINTinFloatSqr_wopt.%
\expandafter\XINT_tmpa
    \csname XINT_flexpr_sqrtfunc\expandafter\endcsname
    \csname XINT_flexpr_func_sqrt\expandafter\endcsname
    \the\numexpr\XINTdigitsormax+4.~XINTinFloatSqrt.%
\expandafter\XINT_tmpa
    \csname XINT_flexpr_invfunc\expandafter\endcsname
    \csname XINT_flexpr_func_inv\expandafter\endcsname
    \the\numexpr\XINTdigitsormax+4.~XINTinFloatInv_wopt.%
\catcode`~ 3
```

13.7 The sine and cosine series

Old pending question: should I rather use successive divisions by (2n+1)(2n), or rather multiplication by their precomputed inverses, in a modified Horner scheme ? The \ifnum tests are executed at time of definition.

Update at last minute: this is actually exactly what I do if Digits is at most 8.

Small values of the variable are very badly handled here because a much shorter truncation of the series should be used.

At 1.4e the original \xintdeffloatfunc was converted into macros, whose principle can be seen also at work in xintlog.sty. We prepare the input variables with shorter and shorter mantissas for usage deep in the series.

This divided by about 3 the execution cost of the series for P about 60.

Originally, the thresholds were computed a priori with 0.79 as upper bound of the variable, but then for 1.4e I developped enough test files to try to adjust heuristically with a target of say 99,5% of correct rounding, and always at most 1ulp error. The numerical analysis is not easy due to the complications of the implementation...

Also, random testing never explores the weak spots...

The 0.79 (a bit more than Pi/4) upper bound induces a costly check of variable on input, if Digits is big. Much faster would be to check if input is less than 10 degrees or 1 radian as done in xfp. But using enough coefficients for allowing up to 1 radian, which is without pain for Digits=16 starts being annoying for higher values such as Digits=48.

But the main reason I don't do it now is that I spend too much time fine-tuning the table of thresholds... maybe in next release.

13.7.1 Support macros for the sine and cosine series

Computing the 1/n! from n! then inverting would require costly divisions and significantly increase the loading time.

So a method is employed to simply divide by 2k(2k-1) or (2k+1)(2k) step by step, with what we hope are enough 8 security digits, and reducing the sizes of the mantissas at each step.

This whole section is conditional on Digits being at least nine.

```
\ifnum\XINTdigits>8
\edef\XINT_tmpG % 1/3!
  {1\xintReplicate{\XINTdigitsormax+2}{6}7[\the\numexpr-\XINTdigitsormax-4]}%
\edef\XINT_tmpH % 1/5!
  {8\xintReplicate{\XINTdigitsormax+1}{3}[\the\numexpr-\XINTdigitsormax-4]}%
\edef\XINT_tmpd % 1/5!
  {8\xintReplicate{\XINTdigitsormax+9}{3}[\the\numexpr-\XINTdigitsormax-12]}%
\def\XINT_tmpe#1.#2.#3.#4.#5#6#7%
{%
\def#5##1\xint:
{%
    \expandafter#6\romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def#6##1\xint:
{%
    \expandafter#7\romannumeral0\xintsub{#4}{\XINTinFloat[#2]{\xintMul{#3}{##1}}}\xint:
}%
\def#7##1\xint:##2\xint:
{%
    \xintSub{1/1[0]}{\XINTinFloat[#1]{\xintMul{##1}{##2}}}%
}%
}%
```

```
\expandafter\XINT_tmpe
  \the\numexpr\XINTdigitsormax+4\expandafter.%
  \the\numexpr\XINTdigitsormax+2\expandafter.\expanded{%
  \XINT_tmpH.% 1/5!
  \XINT_tmpG.% 1/3!
  \expandafter}%
  \csname XINT_SinAux_series_a_iii\expandafter\endcsname
  \csname XINT_SinAux_series_b\expandafter\endcsname
  \csname XINT_SinAux_series_c_i\endcsname
\def\XINT_tmpa #1 #2 #3 #4 #5 #6 #7 #8 %
{%
 \def\XINT_tmpb ##1##2##3##4##5%
 {%
  \def\XINT_tmpc####1.####2.####3.####4.####5.%
  {%
   \def##1########1\xint:
   {%
       \expandafter##2%
       \romannumeral0\XINTinfloatS[####1]{########1}\xint:########1\xint:
   }%
   \def##2########1\xint:
   {%
       \expandafter##3%
       \romannumeral0\XINTinfloatS[####2]{########1}\xint:########1\xint:
   }%
   \def##3########1\xint:
   {%
       \expandafter##4%
       \romannumeral0\xintsub{####4}{\XINTinFloat[####2]{\xintMul{####3}{########1}}}\xint:
   }%
   \def##4########1\xint:########2\xint:
   {%
       \expandafter##5%
       \romannumeral0\xintsub{####5}%
                              {\XINTinFloat[####1]{\xintMul{########1}{########2}}}\xint:
   }%
  }%
 }%
 \expandafter\XINT_tmpb
 \csname XINT_#8Aux_series_a_\romannumeral\numexpr#1-1\expandafter\endcsname
 \csname XINT_#8Aux_series_a_\romannumeral\numexpr#1\expandafter\endcsname
 \csname XINT_#8Aux_series_b\expandafter\endcsname
 \csname XINT_#8Aux_series_c_\romannumeral\numexpr#1-2\expandafter\endcsname
 \csname XINT_#8Aux_series_c_\romannumeral\numexpr#1-3\endcsname
 \edef\XINT_tmpd
   {\XINTinFloat[\XINTdigitsormax-#2+8]{\xintDiv{\XINT_tmpd}{\the\numexpr#5*(#5-1)\relax}}}%
 \let\XINT_tmpF\XINT_tmpG
 \let\XINT_tmpG\XINT_tmpH
 \edef\XINT_tmpH{\XINTinFloat[\XINTdigitsormax-#2]{\XINT_tmpd}}%
 \expandafter\XINT_tmpc
 \the\numexpr\XINTdigitsormax-#3\expandafter.%
 \the\numexpr\XINTdigitsormax-#2\expandafter.\expanded{%
```

```
  \XINT_tmpH.%
  \XINT_tmpG.%
  \XINT_tmpF.%
 }%
}%
\XINT_tmpa 4 -1 -2 -4 7 5 3 Sin %
\ifnum\XINTdigits>3  \XINT_tmpa  5  1 -1 -2  9  7  5 Sin \fi
\ifnum\XINTdigits>5  \XINT_tmpa  6  3  1 -1 11  9  7 Sin \fi
\ifnum\XINTdigits>8  \XINT_tmpa  7  6  3  1 13 11  9 Sin \fi
\ifnum\XINTdigits>11 \XINT_tmpa  8  9  6  3 15 13 11 Sin \fi
\ifnum\XINTdigits>14 \XINT_tmpa  9 12  9  6 17 15 13 Sin \fi
\ifnum\XINTdigits>16 \XINT_tmpa 10 14 12  9 19 17 15 Sin \fi
\ifnum\XINTdigits>19 \XINT_tmpa 11 17 14 12 21 19 17 Sin \fi
\ifnum\XINTdigits>22 \XINT_tmpa 12 20 17 14 23 21 19 Sin \fi
\ifnum\XINTdigits>25 \XINT_tmpa 13 23 20 17 25 23 21 Sin \fi
\ifnum\XINTdigits>28 \XINT_tmpa 14 26 23 20 27 25 23 Sin \fi
\ifnum\XINTdigits>31 \XINT_tmpa 15 29 26 23 29 27 25 Sin \fi
\ifnum\XINTdigits>34 \XINT_tmpa 16 32 29 26 31 29 27 Sin \fi
\ifnum\XINTdigits>37 \XINT_tmpa 17 35 32 29 33 31 29 Sin \fi
\ifnum\XINTdigits>40 \XINT_tmpa 18 38 35 32 35 33 31 Sin \fi
\ifnum\XINTdigits>44 \XINT_tmpa 19 42 38 35 37 35 33 Sin \fi
\ifnum\XINTdigits>47 \XINT_tmpa 20 45 42 38 39 37 35 Sin \fi
\ifnum\XINTdigits>51 \XINT_tmpa 21 49 45 42 41 39 37 Sin \fi
\ifnum\XINTdigits>55 \XINT_tmpa 22 53 49 45 43 41 39 Sin \fi
\ifnum\XINTdigits>58 \XINT_tmpa 23 56 53 49 45 43 41 Sin \fi
\edef\XINT_tmpd % 1/4!
  {41\xintReplicate{\XINTdigitsormax+8}{6}7[\the\numexpr-\XINTdigitsormax-12]}%
\edef\XINT_tmpH % 1/4!
  {41\xintReplicate{\XINTdigitsormax}{6}7[\the\numexpr-\XINTdigitsormax-4]}%
\def\XINT_tmpG{5[-1]}% 1/2!
\expandafter\XINT_tmpe
  \the\numexpr\XINTdigitsormax+4\expandafter.%
  \the\numexpr\XINTdigitsormax+3\expandafter.\expanded{%
  \XINT_tmpH.%
  \XINT_tmpG.%
  \expandafter}%
  \csname XINT_CosAux_series_a_iii\expandafter\endcsname
  \csname XINT_CosAux_series_b\expandafter\endcsname
  \csname XINT_CosAux_series_c_i\endcsname
\XINT_tmpa 4 -2 -3 -4 6 4 2 Cos %
\ifnum\XINTdigits>2  \XINT_tmpa  5  0 -2 -3  8  6  4 Cos \fi
\ifnum\XINTdigits>4  \XINT_tmpa  6  2  0 -2 10  8  6 Cos \fi
\ifnum\XINTdigits>7  \XINT_tmpa  7  5  2  0 12 10  8 Cos \fi
\ifnum\XINTdigits>9  \XINT_tmpa  8  7  5  2 14 12 10 Cos \fi
\ifnum\XINTdigits>12 \XINT_tmpa  9 10  7  5 16 14 12 Cos \fi
\ifnum\XINTdigits>15 \XINT_tmpa 10 13 10  7 18 16 14 Cos \fi
\ifnum\XINTdigits>18 \XINT_tmpa 11 16 13 10 20 18 16 Cos \fi
\ifnum\XINTdigits>20 \XINT_tmpa 12 18 16 13 22 20 18 Cos \fi
\ifnum\XINTdigits>24 \XINT_tmpa 13 22 18 16 24 22 20 Cos \fi
\ifnum\XINTdigits>27 \XINT_tmpa 14 25 22 18 26 24 22 Cos \fi
\ifnum\XINTdigits>30 \XINT_tmpa 15 28 25 22 28 26 24 Cos \fi
\ifnum\XINTdigits>33 \XINT_tmpa 16 31 28 25 30 28 26 Cos \fi
```

```
\ifnum\XINTdigits>36 \XINT_tmpa 17 34 31 28 32 30 28 Cos \fi
\ifnum\XINTdigits>39 \XINT_tmpa 18 37 34 31 34 32 30 Cos \fi
\ifnum\XINTdigits>42 \XINT_tmpa 19 40 37 34 36 34 32 Cos \fi
\ifnum\XINTdigits>45 \XINT_tmpa 20 43 40 37 38 36 34 Cos \fi
\ifnum\XINTdigits>49 \XINT_tmpa 21 47 43 40 40 38 36 Cos \fi
\ifnum\XINTdigits>53 \XINT_tmpa 22 51 47 43 42 40 38 Cos \fi
\ifnum\XINTdigits>57 \XINT_tmpa 23 55 51 47 44 42 40 Cos \fi
\ifnum\XINTdigits>60 \XINT_tmpa 24 58 55 51 46 44 42 Cos \fi
\let\XINT_tmpH\xint_undefined\let\XINT_tmpG\xint_undefined\let\XINT_tmpF\xint_undefined
\let\XINT_tmpd\xint_undefined\let\XINT_tmpe\xint_undefined
\def\XINT_SinAux_series#1%
{%
    \expandafter\XINT_SinAux_series_a_iii
    \romannumeral0\XINTinfloatS[\XINTdigitsormax+4]{#1}\xint:
}%
\def\XINT_CosAux_series#1%
{%
    \expandafter\XINT_CosAux_series_a_iii
    \romannumeral0\XINTinfloatS[\XINTdigitsormax+4]{#1}\xint:
}%
\fi % end of \XINTdigits>8
```

13.7.2 The poor man approximate but speedier approach for Digits at most 8

```
\ifnum\XINTdigits<9
\def\XINT_SinAux_series#1%
{%
    \the\numexpr\expandafter\XINT_SinAux_b\romannumeral0\xintiround9{#1}.[-9]%
}%
\def\XINT_SinAux_b#1.%
{%
  (((((((((((%(\xint_c_x^ix/-210)
  -4761905*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -156)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -110)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -72)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -42)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -20)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -6)*#1/\xint_c_x^ix+\xint_c_x^ix
}%
\def\XINT_CosAux_series#1%
{%
    \the\numexpr\expandafter\XINT_CosAux_b\romannumeral0\xintiround9{#1}.[-9]%
}%
\def\XINT_CosAux_b#1.%
{%
  (((((((((((((%(\xint_c_x^ix/-240)
  -4166667*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -182)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -132)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -90)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -56)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
  -30)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
```

```
 -12)*#1/\xint_c_x^ix+\xint_c_x^ix)/%
 -2)*#1/\xint_c_x^ix+\xint_c_x^ix
}%
\fi
```

13.7.3 Declarations of the @sin_aux() and @cos_aux() functions

```
\def\XINT_flexpr_func_@sin_aux#1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINT_SinAux_series#3}}%
}%
\def\XINT_flexpr_func_@cos_aux#1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINT_CosAux_series#3}}%
}%
```

13.7.4 @sin_series(), @cos_series()

```
\xintdeffloatfunc @sin_series(x) := x * @sin_aux(sqr(x));%
\xintdeffloatfunc @cos_series(x) := @cos_aux(sqr(x));%
```

13.8 Range reduction for sine and cosine using degrees

As commented in the package introduction, Range reduction is a demanding domain and we handle it semi-satisfactorily. The main problem is that in January 2019 I had done only support for degrees, and when I added radians I used the most naive approach. But one can find worse: in 2019 I was surprised to observe important divergences with Maple's results at 16 digits near $-\pi$. Turns out that Maple probably adds π in the floating point sense causing catastrophic loss of digits when one is near $-\pi$. On the other hand even though the approach here is still naive, it behaves much better.

The @sind_rr() and @cosd_rr() sine and cosine "doing range reduction" are coded directly at macro level via \xintSind and \xintCosd which will dispatch to usage of the sine or cosine series, depending on case.

Old note from 2019: attention that \xintSind and \xintCosd must be used with a positive argument.

We start with an auxiliary macro to reduce modulo 360 quickly.

13.8.1 Low level modulo 360 helper macro \XINT_mod_ccclx_i

input: \the\numexpr\XINT_mod_ccclx_i k.N. (delimited by dots)

output: (N times 10^k) modulo 360. (with a final dot)

Attention that N must be non-negative (I could make it accept negative but the fact that numexpr / is not periodical in numerator adds overhead).

360 divides 9000 hence 10^{k} is 280 for k at least 3 and the additive group generated by it modulo 360 is the set of multiples of 40.

```
\def\XINT_mod_ccclx_i #1.%
{%
    \expandafter\XINT_mod_ccclx_e\the\numexpr
    \expandafter\XINT_mod_ccclx_j\the\numexpr1\ifcase#1 \or0\or00\else000\fi.%
}%
```

```
\def\XINT_mod_ccclx_j 1#1.#2.%
{%
    (\XINT_mod_ccclx_ja {++}#2#1\XINT_mod_ccclx_jb 0000000\relax
}%
\def\XINT_mod_ccclx_ja #1#2#3#4#5#6#7#8#9%
{%
    #9+#8+#7+#6+#5+#4+#3+#2\xint_firstoftwo{+\XINT_mod_ccclx_ja{+#9+#8+#7}}{#1}%
}%
\def\XINT_mod_ccclx_jb #1\xint_firstoftwo#2#3{#1+0)*280\XINT_mod_ccclx_jc #1#3}%
```

Attention that \XINT_cclcx_e wants non negative input because \numexpr division is not periodical ...

```
\def\XINT_mod_ccclx_jc  +#1+#2+#3#4\relax{+80*(#3+#2+#1)+#3#2#1.}%
\def\XINT_mod_ccclx_e#1.{\expandafter\XINT_mod_ccclx_z\the\numexpr(#1+180)/360-1.#1.}%
\def\XINT_mod_ccclx_z#1.#2.{#2-360*#1.}%
```

13.8.2 @sind_rr() function and its support macro \xintSind

```
\def\XINT_flexpr_func_@sind_rr #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one{\romannumeral`&&@\xintSind#3}}%
}%
```

old comment: Must be f-expandable for nesting macros from \xintNewExpr

This is where the prize of using the same macros for two distinct use cases has serious disadvantages. The reason of Digits+12 is only to support an input which contains a multiplication by @oneRadian with its extended digits.

Then we do a somewhat strange truncation to a fixed point of fractional digits, which is ok in the "Degrees" case, but causes issues of its own in the "Radians" case. Please consider this whole thing as marked for future improvement, when times allows.

ATTENTION \xintSind ONLY FOR POSITIVE ARGUMENTS

```
\def\XINT_tmpa #1.{%
\def\xintSind##1%
{%
    \romannumeral`&&@\expandafter\xintsind\romannumeral0\XINTinfloatS[#1]{##1}}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax+12.%
\def\xintsind #1[#2#3]%
{%
    \xint_UDsignfork
      #2\XINT_sind
       -\XINT_sind_int
    \krof#2#3.#1..%
}%
\def\XINT_tmpa #1.{%
\def\XINT_sind ##1.##2.%
{%
    \expandafter\XINT_sind_a
    \romannumeral0\xinttrunc{#1}{##2[##1]}%
}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax+5.%
\def\XINT_sind_a{\expandafter\XINT_sind_i\the\numexpr\XINT_mod_ccclx_i0.}%
\def\XINT_sind_int
{%
```

```
    \expandafter\XINT_sind_i\the\numexpr\expandafter\XINT_mod_ccclx_i
}%
\def\XINT_sind_i #1.%
{%
    \ifcase\numexpr#1/90\relax
       \expandafter\XINT_sind_A
    \or\expandafter\XINT_sind_B\the\numexpr-90+%
    \or\expandafter\XINT_sind_C\the\numexpr-180+%
    \or\expandafter\XINT_sind_D\the\numexpr-270+%
    \else\expandafter\XINT_sind_E\the\numexpr-360+%
    \fi#1.%
}%
\def\XINT_tmpa #1.#2.{%
\def\XINT_sind_A##1.##2.%
{%
    \XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@sin_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{##1.##2}#2}}%
}%
\def\XINT_sind_B_n-##1.##2.%
{%
    \XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@cos_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{\xintSub{##1[0]}{.##2}}#2}}%
}%
\def\XINT_sind_B_p##1.##2.%
{%
    \XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@cos_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{##1.##2}#2}}%
}%
\def\XINT_sind_C_n-##1.##2.%
{%
    \XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@sin_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{\xintSub{##1[0]}{.##2}}#2}}%
}%
\def\XINT_sind_C_p##1.##2.%
{%
    \xintiiopp\XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@sin_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{##1.##2}#2}}%
}%
\def\XINT_sind_D_n-##1.##2.%
{%
    \xintiiopp\XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@cos_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{\xintSub{##1[0]}{.##2}}#2}}%
}%
\def\XINT_sind_D_p##1.##2.%
{%
    \xintiiopp\XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@cos_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{##1.##2}#2}}%
}%
\def\XINT_sind_E-##1.##2.%
{%
    \xintiiopp\XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@sin_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{\xintSub{##1[0]}{.##2}}#2}}%
```

```
}%
}\expandafter\XINT_tmpa
    \the\numexpr\XINTdigitsormax+4\expandafter.%
    \romannumeral`&&@\xintbarefloateval @oneDegree\relax.%
\def\XINT_sind_B#1{\xint_UDsignfork#1\XINT_sind_B_n-\XINT_sind_B_p\krof #1}%
\def\XINT_sind_C#1{\xint_UDsignfork#1\XINT_sind_C_n-\XINT_sind_C_p\krof #1}%
\def\XINT_sind_D#1{\xint_UDsignfork#1\XINT_sind_D_n-\XINT_sind_D_p\krof #1}%
```

13.8.3 @cosd_rr() function and its support macro \xintCosd

```
\def\XINT_flexpr_func_@cosd_rr #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one{\romannumeral`&&@\xintCosd#3}}%
}%
```

ATTENTION ONLY FOR POSITIVE ARGUMENTS

```
\def\XINT_tmpa #1.{%
\def\xintCosd##1%
{%
    \romannumeral`&&@\expandafter\xintcosd\romannumeral0\XINTinfloatS[#1]{##1}}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax+12.%
\def\xintcosd #1[#2#3]%
{%
    \xint_UDsignfork
      #2\XINT_cosd
       -\XINT_cosd_int
    \krof#2#3.#1..%
}%
\def\XINT_tmpa #1.{%
\def\XINT_cosd ##1.##2.%
{%
    \expandafter\XINT_cosd_a
    \romannumeral0\xinttrunc{#1}{##2[##1]}%
}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax+5.%
\def\XINT_cosd_a{\expandafter\XINT_cosd_i\the\numexpr\XINT_mod_ccclx_i0.}%
\def\XINT_cosd_int
{%
    \expandafter\XINT_cosd_i\the\numexpr\expandafter\XINT_mod_ccclx_i
}%
\def\XINT_cosd_i #1.%
{%
    \ifcase\numexpr#1/90\relax
       \expandafter\XINT_cosd_A
    \or\expandafter\XINT_cosd_B\the\numexpr-90+%
    \or\expandafter\XINT_cosd_C\the\numexpr-180+%
    \or\expandafter\XINT_cosd_D\the\numexpr-270+%
    \else\expandafter\XINT_cosd_E\the\numexpr-360+%
    \fi#1.%
}%
```

#2 will be empty in the "integer" branch, but attention in general branch to handling of negative integer part after the subtraction of 90, 180, 270, or 360.

```
\def\XINT_tmpa#1.#2.{%
\def\XINT_cosd_A##1.##2.%
{%
    \XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@cos_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{##1.##2}#2}}%
}%
\def\XINT_cosd_B_n-##1.##2.%
{%
    \XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@sin_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{\xintSub{##1[0]}{.##2}}#2}}%
}%
\def\XINT_cosd_B_p##1.##2.%
{%
    \xintiiopp\XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@sin_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{##1.##2}#2}}%
}%
\def\XINT_cosd_C_n-##1.##2.%
{%
    \xintiiopp\XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@cos_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{\xintSub{##1[0]}{.##2}}#2}}%
}%
\def\XINT_cosd_C_p##1.##2.%
{%
    \xintiiopp\XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@cos_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{##1.##2}#2}}%
}%
\def\XINT_cosd_D_n-##1.##2.%
{%
    \xintiiopp\XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@sin_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{\xintSub{##1[0]}{.##2}}#2}}%
}%
\def\XINT_cosd_D_p##1.##2.%
{%
    \XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@sin_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{##1.##2}#2}}%
}%
\def\XINT_cosd_E-##1.##2.%
{%
    \XINT_expr_unlock\expandafter\XINT_flexpr_userfunc_@cos_series\expandafter
         {\romannumeral0\XINTinfloat[#1]{\xintMul{\xintSub{##1[0]}{.##2}}#2}}%
}%
}\expandafter\XINT_tmpa
    \the\numexpr\XINTdigitsormax+4\expandafter.%
    \romannumeral`&&@\xintbarefloateval @oneDegree\relax.%
\def\XINT_cosd_B#1{\xint_UDsignfork#1\XINT_cosd_B_n-\XINT_cosd_B_p\krof #1}%
\def\XINT_cosd_C#1{\xint_UDsignfork#1\XINT_cosd_C_n-\XINT_cosd_C_p\krof #1}%
\def\XINT_cosd_D#1{\xint_UDsignfork#1\XINT_cosd_D_n-\XINT_cosd_D_p\krof #1}%
```

13.9 @sind(), @cosd()

The -45 is stored internally as -45/1[0] from the action of the unary minus operator, which float macros then parse faster. The 45e0 is to let it become 45[0] and not simply 45.

Here and below the \ifnum\XINTdigits>8 45\else60\fi will all be resolved at time of definition.

This is the charm and power of expandable parsers!

```
\xintdeffloatfunc @sind(x) := (x)??
                              {(x>=-\ifnum\XINTdigits>8 45\else60\fi)?
                                {@sin_series(x*@oneDegree)}
                                {-@sind_rr(-x)}
                              }
                              {0e0}
                              {(x<=\ifnum\XINTdigits>8 45\else60\fi e0)?
                                {@sin_series(x*@oneDegree)}
                                {@sind_rr(x)}
                              }
                              ;%
\xintdeffloatfunc @cosd(x) := (x)??
                              {(x>=-\ifnum\XINTdigits>8 45\else60\fi)?
                                {@cos_series(x*@oneDegree)}
                                {@cosd_rr(-x)}
                              }
                              {1e0}
                              {(x<=\ifnum\XINTdigits>8 45\else60\fi e0)?
                                {@cos_series(x*@oneDegree)}
                                {@cosd_rr(x)}
                              }
                              ;%
```

13.10 `@sin()`, `@cos()`

For some reason I did not define sin() and cos() in January 2019 ??

The sub \xintexpr x*@oneRadian\relax means that the multiplication will be done exactly @oneRadian having its 12 extra digits (and x its 4 extra digits), before being rounded in entrance of \xintSind, respectively \xintCosd, to P+12 mantissa.

The strange 79e-2 could be 0.79 which would give 79[-2] internally too.

```
\xintdeffloatfunc @sin(x):= (abs(x)<\ifnum\XINTdigits>8 79e-2\else1e0\fi)?
                            {@sin_series(x)}
                            {(x)??
                              {-@sind_rr(-\xintexpr x*@oneRadian\relax)}
                              {0}
                              {@sind_rr(\xintexpr x*@oneRadian\relax)}
                            }
                            ;%
\xintdeffloatfunc @cos(x):= (abs(x)<\ifnum\XINTdigits>8 79e-2\else1e0\fi)?
                             {@cos_series(x)}
                             {@cosd_rr(abs(\xintexpr x*@oneRadian\relax))}
                             ;%
```

13.11 `@sinc()`

Should I also consider adding (1-cos(x))/(x^2/2) ? it is sinc^2(x/2) but avoids a square.

```
\xintdeffloatfunc @sinc(x):= (abs(x)<\ifnum\XINTdigits>8 79e-2\else1e0\fi) ?
                             {@sin_aux(sqr(x))}
                             {@sind_rr(\xintexpr abs(x)*@oneRadian\relax)/abs(x)}
                             ;%
```

13.12 `@tan()`, `@tand()`, `@cot()`, `@cotd()`

The 0 in cot(x) is a dummy place holder. We don't have a notion of Inf yet.

```
\xintdeffloatfunc @tand(x):= @sind(x)/@cosd(x);%
\xintdeffloatfunc @cotd(x):= @cosd(x)/@sind(x);%
\xintdeffloatfunc @tan(x) := (x)??
                             {(x>-\ifnum\XINTdigits>8 79e-2\else1e0\fi)?
                               {@sin(x)/@cos(x)}
                               {-@cotd(\xintexpr9e1+x*@oneRadian\relax)
                               }
                             }
                             {0e0}
                             {(x<\ifnum\XINTdigits>8 79e-2\else1e0\fi)?
                               {@sin(x)/@cos(x)}
                               {@cotd(\xintexpr9e1-x*@oneRadian\relax)}
                             }
                             ;%
\xintdeffloatfunc @cot(x) := (abs(x)<\ifnum\XINTdigits>8 79e-2\else1e0\fi)?
                              {@cos(x)/@sin(x)}
                              {(x)??
                                {-@tand(\xintexpr9e1+x*@oneRadian\relax)}
                                {0}
                                {@tand(\xintexpr9e1-x*@oneRadian\relax)}
                              };%
```

13.13 `@sec()`, `@secd()`, `@csc()`, `@cscd()`

```
\xintdeffloatfunc @sec(x) := inv(@cos(x));%
\xintdeffloatfunc @csc(x) := inv(@sin(x));%
\xintdeffloatfunc @secd(x):= inv(@cosd(x));%
\xintdeffloatfunc @cscd(x):= inv(@sind(x));%
```

13.14 Core routine for inverse trigonometry

I always liked very much the general algorithm whose idea I found in 2019. But it costs a square root plus a sine plus a cosine all at target precision. For the arctangent the square root will be avoided by a trick. (memo: it is replaced by a division and I am not so sure now this is advantageous in fact)

And now I like it even more as I have re-done the first step entirely in a single \numexpr... Thus the inverse trigonometry got a serious improvement at 1.4e...

Here is the idea. We have 0<t<sqrt(2)/2 and we want a = Arcsin t.

Imagine we have some very good approximation b = a - h. We know b, and don't know yet h. No problem h is a-b so sin(h)=sin(a)cos(b)- cos(a)sin(b). And we know everything here: sin(a) is t, cos(a) is u = sqrt(1-t^2), and we can compute cos(b) and sin(b).

I said h was small so the computation of sin(a)cos(b)-cos(a)sin(b) will involve a lot of cancellation, no problem with xint, as it knows how to compute exactly... and if we wanted to go very low level we could do cos(a)sin(b) paying attention only on least significant digits.

Ok, so we have sin(h), but h is small, so the series of Arcsine can be used with few terms!

In fact h will be at most of the order of 1e-9, so it is no problem to simply replace sin(h) with h if the target precision is 16 !

Ok, so how do we obtain b, the good approximation to Arcsin t ? Simply by using its Taylor series, embedded in a single \numexpr working with nine digits numbers... I like this one! Notice that it reminisces with my questioning about how to best do Horner like for sine and cosine. Here in \numexpr we can only manipulate whole integers and simply can't do things such as ...)*x + 5/112)*x + 3/40)*x + 1/6)*x +1 .... But I found another way, see the code, which uses extensively the "scaling" operations in \numexpr.

I have not proven rigorously that b-a is always less or equal in absolute value than 1e-9, but it is possible for example in Python to program it and go through all possible (less than) 1e9 inputs and check what happens.

Very small inputs will give b=0 (first step is a fixed point rounding of t to nine fractional digits, so this rounding gives zero for input <0.5e-9, others will give b=t, because the arcsine numexpr will end up with 1000000000 (last time I checked that was for t a bit less than 5e-5, the latter gives 1000000001). All seems to work perfectly fine, in practice...

First we let the @sin_aux() and @cos_aux() functions be usable in exact \xintexpr context.

The @asin_II() function will be used only for Digits>16.

```
\expandafter\let\csname XINT_expr_func_@sin_aux\expandafter\endcsname
                \csname XINT_flexpr_func_@sin_aux\endcsname
\expandafter\let\csname XINT_expr_func_@cos_aux\expandafter\endcsname
                \csname XINT_flexpr_func_@cos_aux\endcsname
\ifnum\XINTdigits>16
\def\XINT_flexpr_func_@asin_II#1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINT_Arcsin_II_a#3}}%
}%
\def\XINT_tmpc#1.%
{%
\def\XINT_Arcsin_II_a##1%
{%
    \expandafter\XINT_Arcsin_II_c_i\romannumeral0\XINTinfloatS[#1]{##1}%
}%
\def\XINT_Arcsin_II_c_i##1[##2]%
{%
    \xintAdd{1/1[0]}{##1/6[##2]}%
}%
}%
\expandafter\XINT_tmpc\the\numexpr\XINTdigitsormax-14.%
\fi
\ifnum\XINTdigits>34
\def\XINT_tmpc#1.#2.#3.#4.%
{%
\def\XINT_Arcsin_II_a##1%
{%
    \expandafter\XINT_Arcsin_II_a_iii\romannumeral0\XINTinfloatS[#1]{##1}\xint:
}%
\def\XINT_Arcsin_II_a_iii##1\xint:
{%
    \expandafter\XINT_Arcsin_II_b\romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_Arcsin_II_b##1\xint:
{%
    \expandafter\XINT_Arcsin_II_c_i
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{#3}{##1}}}\xint:
```

```
}%
\def\XINT_Arcsin_II_c_i##1\xint:##2\xint:
{%
    \xintAdd{1/1[0]}{\XINTinFloat[#1]{\xintMul{##1}{##2}}}%
}%
}%
\expandafter\XINT_tmpc
  \the\numexpr\XINTdigitsormax-14\expandafter.%
  \the\numexpr\XINTdigitsormax-32\expandafter.\expanded{%
  \XINTinFloat[\XINTdigitsormax-32]{3/40[0]}.%
  \XINTinFloat[\XINTdigitsormax-14]{1/6[0]}.%
  }%
\fi
\ifnum\XINTdigits>52
\def\XINT_tmpc#1.#2.#3.#4.#5.%
{%
\def\XINT_Arcsin_II_a_iii##1\xint:
{%
    \expandafter\XINT_Arcsin_II_a_iv\romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_Arcsin_II_a_iv##1\xint:
{%
    \expandafter\XINT_Arcsin_II_b\romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_Arcsin_II_b##1\xint:
{%
    \expandafter\XINT_Arcsin_II_c_ii
    \romannumeral0\xintadd{#4}{\XINTinfloat[#2]{\xintMul{#3}{##1}}}\xint:
}%
\def\XINT_Arcsin_II_c_ii##1\xint:##2\xint:
{%
    \expandafter\XINT_Arcsin_II_c_i
    \romannumeral0\xintadd{#5}{\XINTinFloat[#1]{\xintMul{##1}{##2}}}\xint:
}%
}%
\expandafter\XINT_tmpc
  \the\numexpr\XINTdigitsormax-32\expandafter.%
  \the\numexpr\XINTdigitsormax-50\expandafter.\expanded{%
  \XINTinFloat[\XINTdigitsormax-50]{5/112[0]}.%
  \XINTinFloat[\XINTdigitsormax-32]{3/40[0]}.%
  \XINTinFloat[\XINTdigitsormax-14]{1/6[0]}.%
  }%
\fi
\def\XINT_flexpr_func_@asin_I#1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINT_Arcsin_I#3}}%
}%
\def\XINT_Arcsin_I#1%
{%
    \the\numexpr\expandafter\XINT_Arcsin_Ia\romannumeral0\xintiround9{#1}.%
```

```
}%
\def\XINT_Arcsin_Ia#1.%
{%
  (\expandafter\XINT_Arcsin_Ib\the\numexpr#1*#1/\xint_c_x^ix.)*%
  #1/\xint_c_x^ix[-9]%
}%
\def\XINT_Arcsin_Ib#1.%
{%(((((((((((((((
  % 3481/3660)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  % 3249/3422)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  % 3025/3192)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  % 2809/2970)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  % 2601/2756)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  % 2401/2550)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  % 2209/2352)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  % 2025/2162)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
(((((((((((((((((((((((((((((((((((((((((((%
  %(\xint_c_x^ix*1849/1980)*%
  933838384*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  1681/1806)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  1521/1640)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  1369/1482)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  1225/1332)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  1089/1190)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  961/1056)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  841/930)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  729/812)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  625/702)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  529/600)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  441/506)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  361/420)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  289/342)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  225/272)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  169/210)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  121/156)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  81/110)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  49/72)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  25/42)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  9/20)*#1/\xint_c_x^ix+\xint_c_x^ix)*%
  1/6)*#1/\xint_c_x^ix+\xint_c_x^ix
}%
\ifnum\XINTdigits>16
  \xintdeffloatfunc @asin_o(D, T) := T + D*@asin_II(sqr(D));%
  \xintdeffloatfunc @asin_n(V, T, t, u) :=%
           @asin_o(\xintexpr t*@cos_aux(V) - u*T*@sin_aux(V)\relax, T);%
\else
  \xintdeffloatfunc @asin_n(V, T, t, u) :=%
                   \xintexpr t*@cos_aux(V) - u*T*@sin_aux(V)\relax + T;%
\fi
\xintdeffloatfunc @asin_m(T, t, u) := @asin_n(sqr(T), T, t, u);%
\xintdeffloatfunc @asin_l(t, u)    := @asin_m(@asin_I(t), t, u);%
```

13.15 @asin(), @asind()

Only non-negative arguments t and u for asin_a(t,u), and asind_a(t,u).

```
\xintdeffloatfunc @asin_a(t, u) := (t<u)?
                                   {@asin_l(t, u)}
                                   {@Piover2 - @asin_l(u, t)}
                                   ;%
\xintdeffloatfunc @asind_a(t, u):= (t<u)?
                                   {@asin_l(t, u) * @oneRadian}
                                   {9e1 - @asin_l(u, t) * @oneRadian}
                                   ;%
\xintdeffloatfunc @asin(t) := (t)??
                              {-@asin_a(-t, sqrt(1e0-sqr(t)))}
                              {0e0}
                              {@asin_a(t, sqrt(1e0-sqr(t)))}
                              ;%
\xintdeffloatfunc @asind(t) := (t)??
                               {-@asind_a(-t, sqrt(1e0-sqr(t)))}
                               {0e0}
                               {@asind_a(t, sqrt(1e0-sqr(t)))}
                               ;%
```

13.16 @acos(), @acosd()

```
\xintdeffloatfunc @acos(t) := @Piover2 - @asin(t);%
\xintdeffloatfunc @acosd(t):= 9e1 - @asind(t);%
```

13.17 @atan(), @atand()

Uses same core routine asin_l() as for asin(), but avoiding a square-root extraction in preparing its arguments (to the cost of computing an inverse, rather).

radians

```
\xintdeffloatfunc @atan_b(t, w, z):= 5e-1 * (w< 0)?
                                        {@Pi - @asin_a(2e0*z * t, -w*z)}
                                        {@asin_a(2e0*z * t, w*z)}
                                        ;%
\xintdeffloatfunc @atan_a(t, T) := @atan_b(t, 1e0-T, inv(1e0+T));%
\xintdeffloatfunc @atan(t):= (t)??
                             {-@atan_a(-t, sqr(t))}
                             {0}
                             {@atan_a(t, sqr(t))}
                             ;%
```

degrees

```
\xintdeffloatfunc @atand_b(t, w, z) := 5e-1 * (w< 0)?
                                          {18e1 - @asind_a(2e0*z * t, -w*z)}
                                          {@asind_a(2e0*z * t, w*z)}
                                          ;%
\xintdeffloatfunc @atand_a(t, T) := @atand_b(t, 1e0-T, inv(1e0+T));%
\xintdeffloatfunc @atand(t) := (t)??
                               {-@atand_a(-t, sqr(t))}
                               {0}
                               {@atand_a(t, sqr(t))}
                               ;%
```

13.18 @Arg(), @atan2(), @Argd(), @atan2d(), @pArg(), @pArgd()

Arg(x,y) function from $-\pi$ (excluded) to $+\pi$ (included)

```
\xintdeffloatfunc @Arg(x, y):= (y>x)?
                              {(y>-x)?
                                {@Piover2 - @atan(x/y)}
                                {(y<0)?
                                  {-@Pi + @atan(y/x)}
                                  {@Pi + @atan(y/x)}
                                }
                              }
                              {(y>-x)?
                                {@atan(y/x)}
                                {-@Piover2 + @atan(x/-y)}
                              }
                              ;%
```

atan2(y,x) = Arg(x,y) ... (some people have atan2 with arguments reversed but the convention here seems the most often encountered)

```
\xintdeffloatfunc @atan2(y,x) := @Arg(x, y);%
```

Argd(x,y) function from -180 (excluded) to +180 (included)

```
\xintdeffloatfunc @Argd(x, y):= (y>x)?
                               {(y>-x)?
                                 {9e1 - @atand(x/y)}
                                 {(y<0)?
                                   {-18e1 + @atand(y/x)}
                                   {18e1 + @atand(y/x)}
                                 }
                               }
                               {(y>-x)?
                                 {@atand(y/x)}
                                 {-9e1 + @atand(x/-y)}
                               }
                               ;%
```

atan2d(y,x) = Argd(x,y)

```
\xintdeffloatfunc @atan2d(y,x) := @Argd(x, y);%
```

pArg(x,y) function from 0 (included) to 2π (excluded) I hesitated between pArg, Argpos, and Argplus. Opting for pArg in the end.

```
\xintdeffloatfunc @pArg(x, y):= (y>x)?
                               {(y>-x)?
                                 {@Piover2 - @atan(x/y)}
                                 {@Pi + @atan(y/x)}
                               }
                               {(y>-x)?
                                 {(y<0)?
                                   {@twoPi + @atan(y/x)}
                                   {@atan(y/x)}
                                 }
                                 {@threePiover2 + @atan(x/-y)}
                               }
                               ;%
```

pArgd(x,y) function from 0 (included) to 360 (excluded)

```
\xintdeffloatfunc @pArgd(x, y):=(y>x)?
                                {(y>-x)?
                                  {9e1 - @atan(x/y)*@oneRadian}
                                  {18e1 + @atan(y/x)*@oneRadian}
                                }
                                {(y>-x)?
                                  {(y<0e0)?
                                    {36e1 + @atan(y/x)*@oneRadian}
                                    {@atan(y/x)*@oneRadian}
                                  }
                                  {27e1 + @atan(x/-y)*@oneRadian}
                                }
                                ;%
```

13.19 Restore \xintdeffloatfunc to its normal state, with no extra digits

```
\expandafter\let
    \csname XINT_flexpr_exec_+\expandafter\endcsname
    \csname XINT_flexpr_exec_+_\endcsname
\expandafter\let
    \csname XINT_flexpr_exec_-\expandafter\endcsname
    \csname XINT_flexpr_exec_-_\endcsname
\expandafter\let
    \csname XINT_flexpr_exec_*\expandafter\endcsname
    \csname XINT_flexpr_exec_*_\endcsname
\expandafter\let
    \csname XINT_flexpr_exec_/\expandafter\endcsname
    \csname XINT_flexpr_exec_/_\endcsname
\expandafter\let
    \csname XINT_flexpr_func_sqr\expandafter\endcsname
    \csname XINT_flexpr_sqrfunc\endcsname
\expandafter\let
    \csname XINT_flexpr_func_sqrt\expandafter\endcsname
    \csname XINT_flexpr_sqrtfunc\endcsname
\expandafter\let
    \csname XINT_flexpr_func_inv\expandafter\endcsname
    \csname XINT_flexpr_invfunc\endcsname
```

13.20 Let the functions be known to the \xintexpr parser

We use here float_dgtormax which uses the smaller of Digits and 64.

```
\edef\XINTinFloatdigitsormax{\noexpand\XINTinFloat[\the\numexpr\XINTdigitsormax]}%
\edef\XINTinFloatSdigitsormax{\noexpand\XINTinFloatS[\the\numexpr\XINTdigitsormax]}%
\xintFor #1 in {sin, cos, tan, sec, csc, cot,
                asin, acos, atan}\do
{%
    \xintdeffloatfunc #1(x) := float_dgtormax(@#1(x));%
    \xintdeffloatfunc #1d(x) := float_dgtormax(@#1d(x));%
    \xintdeffunc #1(x) := float_dgtormax(\xintfloatexpr @#1(sfloat_dgtormax(x))\relax);%
    \xintdeffunc #1d(x):= float_dgtormax(\xintfloatexpr @#1d(sfloat_dgtormax(x))\relax);%
}%
```

```
\xintFor #1 in {Arg, pArg, atan2}\do
{%
    \xintdeffloatfunc #1(x, y)  := float_dgtormax(@#1(x, y));%
    \xintdeffloatfunc #1d(x, y) := float_dgtormax(@#1d(x, y));%
    \xintdeffunc #1(x, y) :=
         float_dgtormax(\xintfloatexpr @#1(sfloat_dgtormax(x), sfloat_dgtormax(y))\relax);%
    \xintdeffunc #1d(x, y):=
         float_dgtormax(\xintfloatexpr @#1d(sfloat_dgtormax(x), sfloat_dgtormax(y))\relax);%
}%
\xintdeffloatfunc sinc(x):= float_dgtormax(@sinc(x));%
\xintdeffunc      sinc(x):= float_dgtormax(\xintfloatexpr @sinc(sfloat_dgtormax(x))\relax);%
```

13.21 Synonyms: @tg(), @cotg()

These are my childhood notations and I am attached to them. In radians only, and for \xintfloateval only. We skip some overhead here by using a \let at core level.

```
\expandafter\let\csname XINT_flexpr_func_tg\expandafter\endcsname
                \csname XINT_flexpr_func_tan\endcsname
\expandafter\let\csname XINT_flexpr_func_cotg\expandafter\endcsname
                \csname XINT_flexpr_func_cot\endcsname
```

13.22 Final clean-up

Restore used dummy variables to their status prior to the package reloading. On first loading this is not needed, but I have not added a way to check here whether this a first loading or a re-loading.

```
\xintdefvar twoPi := float_dgtormax(@twoPi);%
\xintdefvar threePiover2 := float_dgtormax(@threePiover2);%
\xintdefvar Pi := float_dgtormax(@Pi);%
\xintdefvar Piover2 := float_dgtormax(@Piover2);%
\xintdefvar oneDegree := float_dgtormax(@oneDegree);%
\xintdefvar oneRadian := float_dgtormax(@oneRadian);%
\xintunassignvar{@twoPi}\xintunassignvar{@threePiover2}%
\xintunassignvar{@Pi}\xintunassignvar{@Piover2}%
\xintunassignvar{@oneRadian}\xintunassignvar{@oneDegree}%
\xintFor* #1 in {iDTVtuwxyzX}\do{\xintrestorevariable{#1}}%
\XINTtrigendinput%
```

14 Package xintlog implementation

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In 2019, at 1.3e release I almost included extended precision for log() and exp() but the time I could devote to xint expired. Finally, at long last, (and I had procrastinated far more than the two years since 2019) the 1.4e release in April 2021 brings log10(), pow10(), log(), pow() to P=Digits precision: up to 62 digits with at least (said roughly) 99% chances of correct rounding (the design is targeting less than about 0.005ulp distance to mathematical value, before rounding).

Implementation is EXPERIMENTAL.

For up to Digits=8, it is simply based upon the poormanlog package. The probability of correct rounding will be less than for Digits>8, especially in the cases of Digits=8 and to a lesser extent Digits=7. And, for all Digits<=8, there is a systematic loss of rounding precision in the floating point sense in the case of log10(x) for inputs close to 1:

Summary of limitations of log10() and pow10() in the case of Digits<=8:

- For log10(x) with x near 1, the precision of output as floating point will be mechanically reduced from the fact that this is based on a fixed point result, for example log10(1.0011871) is produced as 5.15245e-4, which stands for 0.000515145 having indeed 9 correct fractional digits, but only 6 correct digits in the floating point sense.

This feature affects the entire range Digits<=8.

- Even if limiting to inputs x with 1.26<x<10 (1.26 is a bit more than 10^0.1 hence its choice as lower bound), the poormanlog documentation mentions an absolute error possibly up to about 1e-9. In practice a test of 10000 random inputs 1.26<x<10 revealed 9490 correctly rounded log10(x) at 8 digits (and the 510 non-correctly rounded ones with an error of 1 in last digit compared to correct rounding). So correct rounding achieved only in about 95% of cases here.

At 7 digits the same 10000 random inputs are correctly rounded in 99.4% of cases, and at 6 digits it is 99.94% of cases.

Again with Digits=8, the log10(i) for i in 1..1000 are all correctly rounded to 8 digits with two exceptions: log10(3) and log10(297) with a 1ulp error. And the log(i) in the same range are correctly rounded to 8 digits with the 15 exceptions i= 99, 105, 130, 178, 224, 329, 446, 464, 564, 751, 772, 777, 886, 907, 962, whose natural logarithms are obtained with a 1ulp error.

- Regarding the computation of 10^x, I obtained for -1<x<1 the following with 10000 random inputs: 518/10000 errors at 1ulp, 60/10000, and 8/10000, at respectively Digits = 8, 7, 6 so chances of correct rounding are respectively about 95%, 99.4% and more than 99.9%.

Despite its limitations the poormanlog based approach used for Digits up to 8 has the advantage of speed (at least 8X compared to working with 16 digits) and is largely precise enough for plots.

For 9 digits or more, the observed precision in some random tests appears to be at least of 99.9% chances of correct rounding, and the log10(x) with x near 1 are correctly (if not really efficiently) handled in the floating point sense for the output. The poormanlog approximate log10() is still used to boot-strap the process, generally. The pow10() at Digits=9 or more is done independently of poormanlog.

All of this is done on top of my 2013 structures for floating point computations which have always been marked as provisory and rudimentary and instills intrinsic non-efficiency:

- no internal data format for a ``floating point number at P digits'',
- mantissa lengths are again and again computed,
- digits are not pre-organized say in blocks of 4 by 4 or 8 by 8,
- floating point multiplication is done via an *exact* multiplication, then rounding to P digits!

This is legacy of the fact that the project was initially devoted to big integers only, but in the weeks that followed its inception in March 2013 I added more and more functionalities without a well laid out preliminary plan.

Anyway, for years I have felt a better foundation would help achieve at least something such as 2X gain (perhaps the last item by itself, if improved upon, would bring most of such 2X gain?)

I did not try to optimize for the default 16 digits, the goal being more of having a general scalable structure in place and there is no difficulty to go up to 100 digits precision if one stores extended pre-computed constants and increases the length of the ``series'' support.

Apart from log(10) and its inverse, no other logarithms are stored or pre-computed: the rest of the stored data is the same for pow10() and log10() and consists of the fractional powers 10^±0.i, 10^±0.0i, ..., 10^±0.00000i at P+5 and also at P+10 digits.

In order to reduce the loading time of the package the inverses are not computed internally (as this would require costly divisions) but simply hard-coded with enough digits to cover the allowed Digits range.

14.1 Catcodes, ε-TEX and reload detection

Modified at 1.4l (2022/05/29). Silly paranoid modification of \z in case { and } do not have their normal catcodes when xintlog.sty is reloaded (initial loading via xintexpr.sty does not need this), to define \XINTlogendinput there and not after the \endgroup from \z has already restored possibly bad catcodes.

1.4l handles much better the situation with \usepackage{xintlog} without previous loading of xintexpr (or same with \input and etex). Instead of aborting with a message (which actually was wrong with LaTeX since 1.4e, mentioning \input in place of \usepackage), it will initiate loading xintexpr itself. This required an adaptation at end of xintexpr and some care to not leave bad catcodes.

```
\begingroup\catcode61\catcode48\catcode32=10\relax%
  \catcode13=5     % ^^M
  \endlinechar=13 %
  \catcode123=1    % {
  \catcode125=2    % }
  \catcode64=11    % @
  \catcode35=6     % #
```

```
\catcode44=12   % ,
\catcode46=12   % .
\catcode58=12   % :
\catcode94=7    % ^
\def\empty{}\def\space{ }\newlinechar10
\def\z{\endgroup}%
\expandafter\let\expandafter\x\csname ver@xintlog.sty\endcsname
\expandafter\let\expandafter\w\csname ver@xintexpr.sty\endcsname
\expandafter
  \ifx\csname PackageWarningNoLine\endcsname\relax
    \def\y#1#2{\immediate\write128{^^JPackage #1 Warning:^^J%
                \space\space\space\space#2.^^J}}%
  \else
    \def\y#1#2{\PackageWarningNoLine{#1}{#2}}%
  \fi
\expandafter
\ifx\csname numexpr\endcsname\relax
   \y{xintlog}{\numexpr not available, aborting input}%
   \def\z{\endgroup\endinput}%
\else
  \ifx\w\relax % xintexpr.sty not yet loaded.
      \edef\MsgBrk{^^J\space\space\space\space}%
      \y{xintlog}%
        {\ifx\x\empty
           xintlog should not be loaded directly\MessageBreak
           The correct way is \string\usepackage{xintexpr}.\MessageBreak
           Will try that now%
         \else
           First loading of xintlog.sty should be via
           \string\input\space xintexpr.sty\relax\MsgBrk
           Will try that now%
         \fi
        }%
      \ifx\x\empty
        \def\z{\endgroup\RequirePackage{xintexpr}\endinput}%
      \else
        \def\z{\endgroup\input xintexpr.sty\relax\endinput}%
      \fi
  \else
    \def\z{\endgroup\edef\XINTlogendinput{\XINTrestorecatcodes\noexpand\endinput}}%
  \fi
\fi
\z%
```

Here we set catcodes to the package values, the current settings having been saved in the \XINTlogendinput macro. We arrive here only if xintlog is either loaded from xintexpr or is being reloaded via an \input from \xintreloadxintlog. Else we aborted right before via \endinput and do not modify catcodes. As xintexpr inputs xintlog.sty at a time the catcode configuration is already the package one we pay attention to not use \XINTsetupcatcodes which would badly redefine \XINTrestorecatcodesendinput as executed at end of xintexpr.sty. There is slight inefficiency here to execute \XINTsetcatcodes when xintexpr initiated the xintlog loading, but let's live with it.

```
\XINTsetcatcodes%
```

14.2 Library identification

If the file has already been loaded, let's skip the \ProvidesPackage. Else let's do it and set a flag to indicate loading happened at least once already.

Modified at 1.4l (2022/05/29). Message also to Terminal not only log file.

```
\ifcsname xintlibver@log\endcsname
  \expandafter\xint_firstoftwo
\else
  \expandafter\xint_secondoftwo
\fi
{\immediate\write128{Reloading xintlog library using Digits=\xinttheDigits.}}%
{\expandafter\gdef\csname xintlibver@log\endcsname{2022/06/10 v1.4m}%
  \XINT_providespackage
  \ProvidesPackage{xintlog}%
  [2022/06/10 v1.4m Logarithms and exponentials for xintexpr (JFB)]%
}%
```

14.3 \xintreloadxintlog

Now needed at 1.4e.

```
\def\xintreloadxintlog{\input xintlog.sty }%
```

14.4 Loading the **poormanlog** package

Attention to the catcode regime when loading poormanlog.

Also, for xintlog.sty to be multiple-times loadable, we need to avoid using LaTeX's \RequirePackage twice.

```
\xintexprSafeCatcodes
\unless\ifdefined\XINTinFloatPowTen
\ifdefined\RequirePackage
  \RequirePackage{poormanlog}%
\else
  \input poormanlog.tex
\fi\fi
\xintexprRestoreCatcodes
```

14.5 Macro layer on top of the poormanlog package

This was moved here with some macro renames from xintfrac on occasion of 1.4e release.

Breaking changes at 1.4e:

- \poormanloghack now a no-op (removed at 1.4m),
- \xintLog was used for \xinteval and differed slightly from its counterpart used for \xintfloateval, the latter float-rounded to P = Digits, the former did not and kept completly meaning-less digits in output. Both macros now replaced by a \PoorManLog which will always float round the output to P = Digits. Because xint does not really implement a fixed point interface anyhow.
- \xintExp (used in \xinteval) and another macro (used in \xintfloateval) did not use a sufficiently long approximation to 1/log(10) to support precisely enough exp(x) if output of the order of 10^10000 for example, (last two digits wrong then) and situation became worse for very high values such as exp(1e8) which had only 4 digits correct.

The new \PoorManExp which replaces them is more careful... and for example exp(12345678) obtains correct rounding (Digits=8).

- \XINTinFloatxintLog and \XINTinFloatxintExp were removed; they were used for log() and exp() in \xintfloateval, and differed from \xintLog and \xintExp a bit, now renamed to \PoorManLog and \PoorManExp.
- \PoorManPower has simply disappeared, see \XINTinFloatSciPow and \xintPow.

See the general xintlog introduction for some comments on the achieved precision and probabilities of correct rounding.

14.5.1 \PoorManLogBaseTen, \PoorManLog

1.3f. Code originally in poormanlog v0.04 got transferred here. It produces the logarithm in base 10 with an error (believed to be at most) of the order of 1 unit in the 9th (i.e. last, fixed point) fractional digit. Testing seems to indicate the error is never exceeding 2 units in the 9th place, in worst cases.

These macros will still be the support macros for \xintfloatexpr log10(), pow10(), etc... up to Digits=8 and the poormanlog logarithm is used as starting point for higher precision if Digits is at least 9.

Notice that \PML@999999999. expands (in \numexpr) to 1000000000 (ten digits), which is the only case with the output having ten digits. But there is no need here to treat this case especially, it works fine in \PML@logbaseten.

Breaking change at 1.4e: for consistency with various considerations on floats, the output will be float rounded to P=Digits.

One could envision the \xinteval variant to keep 9 fractional digits (it is known the last one may very well be off by 1 unit). But this creates complications of principles.

All of this is very strange because the logarithm clearly shows the deficiencies of the whole idea of floating point arithmetic, logarithm goes from floating point to fixed point, and coercing it into pure floating point has moral costs. Anyway, I shall obide.

```
\def\PoorManLogBaseTen{\romannumeral0\poormanlogbaseten}%
\def\poormanlogbaseten #1%
{%
    \XINTinfloat[\XINTdigits]%
    {\romannumeral0\expandafter\PML@logbaseten\romannumeral0\XINTinfloat[9]{#1}}%
}%
\def\PoorManLogBaseTen_raw%#1
{%
    \romannumeral0\expandafter\PML@logbaseten\romannumeral0\XINTinfloat[9]%{#1}%
}%
\def\PML@logbaseten#1[#2]%
{%
    \xintiiadd{\xintDSx{-9}{\the\numexpr#2+8\relax}}{\the\numexpr\PML@#1.}[-9]%
}%
\def\PoorManLog#1%
{%
    \XINTinFloat[\XINTdigits]{\xintMul{\PoorManLogBaseTen_raw{#1}}{23025850923[-10]}}%
}%
```

14.5.2 \PoorManPowerOfTen, \PoorManExp

Originally in poormanlog v0.04, got transferred into xintfrac.sty at 1.3f, then here into xintlog.sty at 1.4e.

Produces 10^x with 9 digits of float precision, with an error (believed to be) at most 2 units in the last place, when 0<x<1. Of course for this the input must be precise enough to have 9 fractional digits of **fixed point** precision.

Breaking change at 1.4e: output always float-rounded at P=Digits.

The 1.3f definition for \xintExp (now \PoorManExp) was not careful enough (see comments above) for very large exponents. This has been corrected at 1.4e. Formerly exp(12345678) produced shameful 6.3095734e5361659 where only the first digit (and exponent...) is correct! Now, with \xintDigits*:=8;, exp(12345678) will produce 6.7725836e5361659 which is correct rounding to 8 digits. Sorry if your rover expedition to Mars ended in failure due to using my software. I was not expecting anyone to use it so I did back then in 2019 a bit too expeditively the \xintExp thing on top of 10^x.

The 1.4e \PoorManExp replaces and amends deceased \xintExp.

Before using \xintRound we screen out the case of zero as \xintRound in this case outputs no fractional digits.

```
\def\PoorManPowerOfTen{\romannumeral0\poormanpoweroften}%
\def\poormanpoweroften #1%
{%
    \expandafter\PML@powoften@out
    \the\numexpr\expandafter\PML@powoften\romannumeral0\xintraw{#1}%
}%
\def\PML@powoften@out#1[#2]{\XINTinfloat[\XINTdigits]{#1[#2]}}%
\def\PML@powoften#1%
{%
    \xint_UDzerominusfork
      #1-\PML@powoften@zero
      0#1\PML@powoften@neg
       0-\PML@powoften@pos
    \krof #1%
}%
\def\PML@powoften@zero 0/1[0]{1\relax/1[0]}%
\def\PML@powoften@pos#1[#2]%
{%
    \expandafter\PML@powoften@pos@a\romannumeral0\xintround{9}{#1[#2]}.%
}%
\def\PML@powoften@pos@a#1.#2.{\PML@Pa#2.\expandafter[\the\numexpr-8+#1]}%
\def\PML@powoften@neg#1[#2]%
{%
    \expandafter\PML@powoften@neg@a\romannumeral0\xintround{9}{#1[#2]}.%
}%
\def\PML@powoften@neg@a#1.#2.%
{%
   \ifnum#2=\xint_c_ \xint_afterfi{1\relax/1[#1]}\else
   \expandafter\expandafter\expandafter
   \PML@Pa\expandafter\xint_gobble_i\the\numexpr2000000000-#2.%
   \expandafter[\the\numexpr-9+#1\expandafter]\fi
}%
\def\PoorManExp#1{\PoorManPowerOfTen{\xintMul{#1}{43429448190325182765[-20]}}}%
```

14.5.3 Removed: \PoorManPower, see \XINTinFloatSciPow

Removed at 1.4e. See \XINTinFloatSciPow.

14.6 Macro support for powers

14.6.1 \XINTinFloatSciPow

This is the new name and extension of \XINTinFloatPowerH which was a non user-documented macro used for a^b previously, and previously was located in xintfrac.

A check is done whether the exponent is integer or half-integer, and if positive, the legacy \xintFloatPower/\xintFloatSqrt macros are used. The rationale is that:

- they give faster evaluations for integer exponent b < 10000 (and beyond)
- they operate at any value of Digits
- they keep accuracy even with gigantic exponents, whereas the pow10()/log10() path starts losing accuracy for b about 1e8. In fact at 1.4e it was even for b about 1000, as log10(A) was not computed with enough fractional digits, except for 0.8<A<1.26 (roughly), for this usage. At the 1.4f bugfix we compute log10(A) with enough accuracy for A^b to be safe with b as large as 1e7, and show visible degradation only for b about 1e9.

The user documentation of \xintFloatPower mentions a 0.52 ulp(Z) error where Z is the computed result, which seems not as good as the kind of accuracy we target for pow10() (for -1<x<1) and log10() (for 1<x<10) which is more like about 0.505ulp. Perhaps in future I will examine if I need to increase a bit the theoretical accuracy of \xintFloatPower but at time of 1.4e/1.4f release I have left it standing as is.

The check whether exponent is integer or half-integer is not on the value but on the representation. Even in \xintfloatexpr, input such 10^\xintexpr4/2\relax is possible, and 4/2 will not be recognized as integer to avoid costly overhead. 3/2 will not be recognized as half-integer. But 2.0 will be recognized as integer, 25e-1 as half-integer.

In the computation of A^b, A will be float-rounded to Digits, but the exponent b will be handled "as is" until last minute. Recall that the \xintfloatexpr parser does not automatically float round isolated inputs, this happens only once involved in computations.

In the Digits<=8 branch we do the same as for Digits>8 since 1.4f. At 1.4e I had strangely chosen (for "speed", but that was anyhow questionable for integer exponents less than 10 for example) to always use log10()/pow10()... But with only 9 fractional digits for the logarithms, exponents such as 1000 naturally led to last 2 or 3 digits being wrong and let's not even mention when the exponent was of the order or 1e6... now A^1000 and A^1000.5 are accurately computed and one can handle a^1000.1 as a^1000*a^0.1

I wrote the code during 1.4e to 1.4f transition for doing this split of exponent automatically, but it induced a very significant time penalty down the line for fractional exponents, whereas currently a^b is computed at Digits=8 with perfectly acceptable accuracy for fractional abs(b)<10, and at high speed, and accuracy for big exponents can be obtained by manually splitting as above (although the above has no user interface for keeping each contribution with its extra digits; a single one for a^h, -1<h<1).

```
\def\XINTinFloatSciPow{\romannumeral0\XINTinfloatscipow}%
\def\XINTinfloatscipow#1#2%
{%
    \expandafter\XINT_scipow_a\romannumeral0\xintrez{#2}\XINT_scipow_int{#1}%
}%
\def\XINT_scipow_a #1%
{%
    \xint_gob_til_zero#1\XINT_scipow_Biszero0\XINT_scipow_b#1%
}%
\def\XINT_scipow_Biszero#1]#2#3{ 1[0]}%
\def\XINT_scipow_b #1#2/#3[#4]#5%
{%
    \unless\if1\XINT_is_One#3XY\xint_dothis\XINT_scipow_c\fi
    \ifnum#4<\xint_c_mone\xint_dothis\XINT_scipow_c\fi
```

```
    \ifnum#4=\xint_c_mone
      \if5\xintLDg{#1#2} %
       \xint_afterfi{\xint_dothis\XINT_scipow_halfint}\else
       \xint_afterfi{\xint_dothis\XINT_scipow_c}%
      \fi
    \fi
    \xint_orthat#5#1#2/#3[#4]%
}%
\def\XINT_scipow_int #1/1[#2]#3%
{%
    \expandafter\XINT_flpower_checkB_a
    \romannumeral0\XINT_dsx_addzeros{#2}#1;.\XINTdigits.{#3}{\XINTinfloatS[\XINTdigits]}%
}%
```

The \XINT_flpowerh_finish is the sole remnant of \XINTinFloatPowerH which was formerly stitched to \xintFloatPower and checked for half-integer exponent.

```
\def\XINT_scipow_halfint#1/1[#2]#3%
{%
    \expandafter\XINT_flpower_checkB_a
    \romannumeral0\xintdsr{\xintDouble{#1}}.\XINTdigits.{#3}\XINT_flpowerh_finish
}%
\def\XINT_flpowerh_finish #1%
{%
    \XINTinfloatS[\XINTdigits]{\XINTinFloatSqrt[\XINTdigits+\xint_c_iii]{#1}}%
}%
\def\XINT_tmpa#1.{%
\def\XINT_scipow_c ##1[##2]##3%
{%
    \expandafter\XINT_scipow_d\romannumeral0\XINTinfloatS[#1]{##3}\xint:##1[##2]\xint:
}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigits.%
\def\XINT_scipow_d #1%
{%
    \xint_UDzerominusfork
       #1-\XINT_scipow_Aiszero
       0#1\XINT_scipow_Aisneg
        0-\XINT_scipow_Aispos
    \krof #1%
}%
\def\XINT_scipow_Aiszero #1\xint:#2#3\xint:
{%
```

Missing NaN and Infinity causes problems. Inserting something like 1["7FFF8000] is risky as certain macros convert [N] into N zeros... so the run can appear to stall and will crash possibly badly if we do that. There is some usage in relation to ilog10 in xint.sty and xintfrac.sty of "7FFF8000 but here I will stay prudent and insert the usual 0 value (changed at 1.4g)

```
    \if-#2\xint_dothis
      {\XINT_signalcondition{InvalidOperation}{0 raised to power #2#3.}{}{ 0[0]}}\fi
    \xint_orthat{ 0[0]}%
}%
\def\XINT_scipow_Aispos #1\xint:#2\xint:
{%
    \XINTinfloatpowten{\xintMul{#2}{\XINTinFloatLogTen_xdgout#1}}%
}%
```

If a^b with a<0, we arrive here only if b was not considered to be an integer exponent. So let's raise an error.

```
\def\XINT_scipow_Aisneg #1#2\xint:#3\xint:
{%
  \XINT_signalcondition{InvalidOperation}%
       {Fractional power #3 of negative #1#2.}{}{ 0[0]}%
}%
\ifnum\XINTdigits<9
```

At 1.4f we only need for Digits up to 8 to insert usage of poormanlog for non integer, non half-integer exponents. At 1.4e the code was more complicated because I had strangely opted for using always the log10() path. However we have to be careful to use \PML@logbaseten with 9 digits always.

As the legacy macros used for integer and half-integer exponents float-round the input to Digits digits, we must do the same here for coherence. Which induces some small complications here.

```
  \def\XINT_tmpa#1.#2.#3.{%
  \def\XINT_scipow_c ##1[##2]##3%
  {%
      \expandafter\XINT_scipow_d
      \romannumeral0\expandafter\XINT_scipow_c_i
      \romannumeral0\XINTinfloat[#1]{##3}\xint:##1[##2]\xint:
  }%
  \def\XINT_scipow_c_i##1[##2]{ ##1#3[##2-#2]}%
  }\expandafter\XINT_tmpa\the\numexpr\XINTdigits\expandafter.%
   \the\numexpr9-\XINTdigits\expandafter.%
   \romannumeral\xintreplicate{9-\XINTdigits}0.%
  \def\XINT_scipow_Aispos #1\xint:#2\xint:
  {%
      \poormanpoweroften{\xintMul{#2}{\romannumeral0\expandafter\PML@logbaseten#1}}%
  }%
\fi
```

14.6.2 \xintPow

Support macro for a^b in \xinteval. This overloads the original xintfrac macro, keeping its original meaning only for integer exponents, which are not too big: for exact evaluation of A^b, we want the output to not have more than about 10000 digits (separately for numerator and denominator). For this we limit b depending on the length of A, simply we want b to be smaller than the rounded value of 10000 divided by the length of A. For one-digit A, this would give 10000 as maximal exponent but due to organization of code related to avoir arithmetic overflow (we can't immediately operate in \numexpr with b as it is authorized to be beyond TeX bound), the maximal exponent is 9999.

The criterion, which guarantees output (numerator and denominator separately) does not exceed by much 10000 digits if at all is that the exponent should be less than the (rounded in the sense of \numexpr) quotient of 10000 by the number of digits of a (considering separately numerator and denominator).

The decision whether to compute A^b exactly depends on the length of internal representation of A. So 9^9999 is evaluated exactly (in \xinteval) but for 9.0 it is 9.0^5000 the maximal power. This may change in future.

1.4e had the following bug (for Digits>8): big integer exponents used the log10()/pow10() based approach rather than the legacy macro path which goes via \xintFloatPower, as done by \xintfloateval! As a result powers with very large integer exponents were more precise in \xintfloateval than in \xinteval!

1.4f fixes this. Also, it handles Digits<=8 as Digits>8, bringing much simplification here.

```
\def\xintPow{\romannumeral0\xintpow}%
\def\xintpow#1#2%
{%
    \expandafter\XINT_scipow_a\romannumeral0\xintrez{#2}\XINT_pow_int{#1}%
}%
```

In case of half-integer exponent the \XINT_scipow_a will have triggered usage of the (new incarnation) of \XINTinFloatPowerH which combines \xintFloatPower and square root extraction. So we only have to handle here the case of integer exponents which will trigger execution of this \XINT_pow_int macro passed as parameter to \xintpow.

```
\def\XINT_pow_int #1/1[#2]%
{%
  \expandafter\XINT_pow_int_a\romannumeral0\XINT_dsx_addzeros{#2}#1;.%
}%
```

1.4e had a bug here for integer exponents >= 10000: they triggered going back to the floating point routine but at a late location where the log10()/pow10() approach is used.

```
\def\XINT_pow_int_a #1#2.%
{%
  \ifnum\if-#1\xintLength{#2}\else\xintLength{#1#2}\fi>\xint_c_iv
       \expandafter\XINT_pow_bigint
  \else\expandafter\XINT_pow_int_b
  \fi #1#2.%
}%
```

At 1.4f we correctly jump to the appropriate entry point into the \xintFloatPower routine of xintfrac, in case of a big integer exponent.

```
\def\XINT_pow_bigint #1.#2%
{%
    \XINT_flpower_checkB_a#1.\XINTdigits.{#2}{\XINTinfloatS[\XINTdigits]}%
}%
\def\XINT_pow_int_b #1.#2%
{%
```

We now check if the output will not be too bulky. We use here (on the a of a^b) \xintraw, not \xintrez, on purpose so that for example 9.0^9999 is computed in floating point sense but 9^9999 is computed exactly. However 9.0^5000 will be computed exactly. And if I used \xintrez here \xinteval{100^2} would print 10000.0 and \xinteval{100^3} would print 1.0e6. Thus situation is complex.

By the way I am happy to see that 9.0*9.0 in \xinteval does print 81.0 but the truth is that internally it does have the more bulky 8100/1[-2] maybe I should make some revision of this, i.e. use rather systematically \xintREZ on input rather than \xintRaw (note taken on 2021/05/08 at time of doing 1.4f bugfix release).

```
    \expandafter\XINT_pow_int_c\romannumeral0\xintraw{#2}\xint:#1\xint:
}%
```

The \XINT_fpow_fork is (quasi top level) entry point we have found into the legacy \xintPow routine of xintfrac. Its interface is a bit weird, but let's not worry about this now.

```
\def\XINT_pow_int_c#1#2/#3[#4]\xint:#5\xint:
{%
    \if0\ifnum\numexpr\xint_c_x^iv/%
           (\xintLength{#1#2}\if-#1-\xint_c_i\fi)<\XINT_Abs#5 %
       1\else
        \ifnum\numexpr\xint_c_x^iv/\xintLength{#3}<\XINT_Abs#5 %
       1\else
```

```
    0\fi\fi
      \expandafter\XINT_fpow_fork\else\expandafter\XINT_pow_bigint_i
    \fi
    #5\Z{#4}{#1#2}{#3}%
}%
```

\XINT_pow_bigint_i is like \XINT_pow_bigint but has its parameters organized differently.

```
\def\XINT_pow_bigint_i#1\Z#2#3#4%
{%
    \XINT_flpower_checkB_a#1.\XINTdigits.{#3/#4[#2]}{\XINTinfloatS[\XINTdigits]}%
}%
```

14.7 Macro support for \xintexpr and \xintfloatexpr syntax

14.7.1 The log10() and pow10() functions

Up to 8 digits included we use the poormanlog based ones.

```
\ifnum\XINTdigits<9
\expandafter\def\csname XINT_expr_func_log10\endcsname#1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\PoorManLogBaseTen#3}}%
}%
\expandafter\def\csname XINT_expr_func_pow10\endcsname#1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\PoorManPowerOfTen#3}}%
}%
\else
\expandafter\def\csname XINT_expr_func_log10\endcsname#1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatLogTen#3}}%
}%
\expandafter\def\csname XINT_expr_func_pow10\endcsname#1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatPowTen#3}}%
}%
\fi
\expandafter\let\csname XINT_flexpr_func_log10\expandafter\endcsname
                \csname XINT_expr_func_log10\endcsname
\expandafter\let\csname XINT_flexpr_func_pow10\expandafter\endcsname
                \csname XINT_expr_func_pow10\endcsname
```

14.7.2 The log(), exp() functions

```
\ifnum\XINTdigits<9
\def\XINT_expr_func_log #1#2#3%
{%
```

```
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\PoorManLog#3}}%
}%
\def\XINT_expr_func_exp #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\PoorManExp#3}}%
}%
\let\XINT_flexpr_func_log\XINT_expr_func_log
\let\XINT_flexpr_func_exp\XINT_expr_func_exp
\else
\def\XINT_expr_func_log #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatLog#3}}%
}%
\def\XINT_expr_func_exp #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:one
    {\romannumeral`&&@\XINTinFloatExp#3}}%
}%
\let\XINT_flexpr_func_log\XINT_expr_func_log
\let\XINT_flexpr_func_exp\XINT_expr_func_exp
\fi
```

14.7.3 The pow() function

The mapping of ** and ^ to \XINTinFloatSciPow (in \xintfloatexpr context) and \xintPow (in \xintexpr context), is done in xintexpr.

```
\def\XINT_expr_func_pow #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\xintPow#3}}%
}%
\def\XINT_flexpr_func_pow #1#2#3%
{%
    \expandafter #1\expandafter #2\expandafter{%
    \romannumeral`&&@\XINT:NEhook:f:one:from:two
    {\romannumeral`&&@\XINTinFloatSciPow#3}}%
}%
```

14.8 End of package loading for low Digits

```
\ifnum\XINTdigits<9 \expandafter\XINTlogendinput\fi%
```

14.9 Stored constants

The constants were obtained from Maple at 80 digits: fractional power of 10, but only one logarithm log(10).

Currently the code whether for exponential or logarihm will not screen out 0 digits and even will do silly multiplication by 10^0 = 1 in that case, and we need to store such silly values.

We add the data for the 10^-0.i etc... because pre-computing them on the fly significantly adds overhead to the package loading.

The fractional powers of ten with D+5 digits are used to compute pow10() function, those with D+10 digits are used to compute log10() function. This is done with an elevated precision for two reasons:

- handling of inputs near 1,
- in order for a^b = pow10(b*log10(a)) to keep accuracy even with large exponents, say in absolute value up to 1e7, degradation beginning to show-up at 1e8.

```
\def\XINT_tmpa{1[0]}%
\expandafter\let\csname XINT_c_1_0\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_2_0\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_3_0\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_4_0\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_5_0\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_6_0\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_1_0_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_2_0_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_3_0_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_4_0_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_5_0_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_6_0_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_1_0_inv\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_2_0_inv\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_3_0_inv\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_4_0_inv\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_5_0_inv\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_6_0_inv\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_1_0_inv_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_2_0_inv_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_3_0_inv_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_4_0_inv_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_5_0_inv_x\endcsname\XINT_tmpa
\expandafter\let\csname XINT_c_6_0_inv_x\endcsname\XINT_tmpa
\def\XINT_tmpa#1#2#3#4;%
  {\expandafter\edef\csname XINT_c_#1_#2\endcsname
                   {\XINTinFloat[\XINTdigitsormax+5]{#3#4[-79]}}%
   \expandafter\edef\csname XINT_c_#1_#2_x\endcsname
                   {\XINTinFloat[\XINTdigitsormax+10]{#3#4[-79]}}%
  }%
% 10^0.i
\XINT_tmpa 1 1 12589254117941672104239541063958006060936174094669310691079230195266476157825020;%
\XINT_tmpa 1 2 15848931924611134852021013733915070132694421338250390683162968123166568636684540;%
\XINT_tmpa 1 3 19952623149688796013524553967395355579862743154053460992299136670049309106980490;%
\XINT_tmpa 1 4 25118864315095801110850320677993273941585181007824754286798884209082432477235613;%
\XINT_tmpa 1 5 31622776601683793319988935444327185337195551393252168268575048527925944386392382;%
\XINT_tmpa 1 6 39810717055349725077025230508775204348767703729738044686528414806022485386945804;%
\XINT_tmpa 1 7 50118723362727228500155418688494576806047198983281926392969745588901125568883069;%
```

```
\XINT_tmpa 1 8 63095734448019324943436013662234386467294525718822872452772952883349494329768681;%
\XINT_tmpa 1 9 79432823472428150206591828283638793258896063175548433209232392931695569719148754;%
% 10^0.0i
\XINT_tmpa 2 1 10232929922807541309662751748198778273411640572379813085994255856738296458625172;%
\XINT_tmpa 2 2 10471285480508995334645020315281400790567914715039292120056525299012577641023719;%
\XINT_tmpa 2 3 10715193052376064174083022246945087339158659633422172707894501914136771607653870;%
\XINT_tmpa 2 4 10964781961431850131437136061411270464271158762483023169080841607885740984711300;%
\XINT_tmpa 2 5 11220184543019634355910389464779057367223085073605529624450744481701033026862244;%
\XINT_tmpa 2 6 11481536214968827515462246116628360182562102373996119340874991068894793593040890;%
\XINT_tmpa 2 7 11748975549395295417220677651268442278134317971793124791953875805007912852226246;%
\XINT_tmpa 2 8 12022644346174129058326127151935204486942664354881189151104892745683155052368222;%
\XINT_tmpa 2 9 12302687708123815342415404364750907389955639574572144413097319170011637639124482;%
% 10^0.00i
\XINT_tmpa 3 1 10023052380778996719154048893281105540536684535421606464116348523047431367720401;%
\XINT_tmpa 3 2 10046157902783951424046519858132787392010166060319618489538315083825599423438638;%
\XINT_tmpa 3 3 10069316688518041699296607872661381368099438247964820601930206419324524707606686;%
\XINT_tmpa 3 4 10092528860766844119155277641202580844111492027373621434478800545314309618714957;%
\XINT_tmpa 3 5 10115794542598985244409323144543146957419235215102899054703546688078254946034250;%
\XINT_tmpa 3 6 10139113857366794119988279023017296985954042032867436525450889437280417044987125;%
\XINT_tmpa 3 7 10162486928706956276733661150135543062420167220622552197768982666050994284378619;%
\XINT_tmpa 3 8 10185913880541169240797988673338257820431768224957171297560936579346433061037662;%
\XINT_tmpa 3 9 10209394837076799554149033101487543990018213667630072574873723356334069913329713;%
% 10^0.000i
\XINT_tmpa 4 1 10002302850208247526835942556719413318678216124626534526963475845228205382579041;%
\XINT_tmpa 4 2 10004606230728403216239656646745503559081482371024284871882409614422496765669196;%
\XINT_tmpa 4 3 10006910141682589957025973521996241909035914023642264228577379693841345823180462;%
\XINT_tmpa 4 4 10009214583192958761081718336761022426385537997384755843291864010938378093197023;%
\XINT_tmpa 4 5 10011519555381688769842032367472488618040778885656970999331288116685029387850446;%
\XINT_tmpa 4 6 10013825058370987260768186632475607982636715641432550952229573271596547716373358;%
\XINT_tmpa 4 7 10016131092283089653826887255241073941084503769368844606021481400409002185558343;%
\XINT_tmpa 4 8 10018437657240259517971072914549205297136779497498835020699531587537662833033174;%
\XINT_tmpa 4 9 10020744753364788577622204725249622301332888222801030351604197113557132455165040;%
% 10^0.0000i
\XINT_tmpa 5 1 1000230261160268806710649793464495797824846841503180050673957122443571394978721;%
\XINT_tmpa 5 2 10000460527622557806255008596155855743730116854295068547616656160734125748005947;%
\XINT_tmpa 5 3 10000690799386989083565213461287219981856579552059660369243804541364501659468630;%
\XINT_tmpa 5 4 10000921076453684726384543254593368743049141124080210677706489564626675960578367;%
\XINT_tmpa 5 5 10001151358822766825267483384008265483772370538793312970508590203623535763866465;%
\XINT_tmpa 5 6 10001381646494357473579790530833073090516914490540536234536867917078761046656260;%
\XINT_tmpa 5 7 10001611939468578767498557382394677469502542123237272447312733350028467607076918;%
\XINT_tmpa 5 8 10001842237745552806012277366194752842273812293689190856411757410911882303011468;%
\XINT_tmpa 5 9 10002072541325401690920909385549403068574626162727745910217443397959031898734024;%
% 10^0.00000i
\XINT_tmpa 6 1 10000023025877439451356029805459000097926504781151663770980171880313737943886754;%
\XINT_tmpa 6 2 10000046051807898005897723104514851394069452605882077809669546315010724085277647;%
\XINT_tmpa 6 3 10000069077791375785706217087438809625967243923218032821061587553353589726808164;%
\XINT_tmpa 6 4 10000092103827872912862930047032391734439796534302560512742030066798473305401477;%
\XINT_tmpa 6 5 10000115129917389509449561379274639104559958866285946533811801963402821672829477;%
\XINT_tmpa 6 6 10000138156059925697548091583969382297005329013199894805417325991907389143667949;%
\XINT_tmpa 6 7 10000161182255481599240782265392507269793911275470978276390154932321984777772469;%
\XINT_tmpa 6 8 10000184208504057336610176132939223090407041937631374389422968832433217547184883;%
\XINT_tmpa 6 9 10000207234805653031739097001771331138303016031686764989867510425362339583809842;%
```

```
\def\XINT_tmpa#1#2#3#4;%
  {\expandafter\edef
   \csname XINT_c_#1_#2_inv\endcsname{\XINTinFloat[\XINTdigitsormax+5]{#3#4[-80]}}%
   \expandafter\edef
   \csname XINT_c_#1_#2_inv_x\endcsname{\XINTinFloat[\XINTdigitsormax+10]{#3#4[-80]}}%
  }%
% 10^-0.i
\XINT_tmpa 1 1 79432823472428150206591828283638793258896063175548433209232392931695569719148754;%
\XINT_tmpa 1 2 63095734448019324943436013662234386467294525718822872452772952883349494329768681;%
\XINT_tmpa 1 3 50118723362727228500155418688494576806047198983281926392969745588901125568883069;%
\XINT_tmpa 1 4 39810717055349725077025230508775204348767703729738044686528414806022485386945804;%
\XINT_tmpa 1 5 31622776601683793319988935444327185337195551393252168268575048527925944386392382;%
\XINT_tmpa 1 6 25118864315095801110850320677993273941585181007824754286798884209082432477235613;%
\XINT_tmpa 1 7 19952623149688796013524553967395355579862743154053460992299136670049309106980490;%
\XINT_tmpa 1 8 15848931924611134852021013733915070132694421338250390683162968123166568636684540;%
\XINT_tmpa 1 9 12589254117941672104239541063958006060936174094669310691079230195266476157825020;%
% 10^-0.0i
\XINT_tmpa 2 1 97723722095581068269707600696156123863427170069897801526639004097175507042084888;%
\XINT_tmpa 2 2 95499258602143594972395937950148401513087269708053320302465127242741421479104601;%
\XINT_tmpa 2 3 93325430079699104353209661168364840720225485199736026149257155811788093771138272;%
\XINT_tmpa 2 4 91201083935590974212095940791872333509323858755696109214760361851771695487999100;%
\XINT_tmpa 2 5 89125093813374552995310868107829696398587478293004836994794349506746891059190135;%
\XINT_tmpa 2 6 87096358995608063751082742520877054774747128501284704090761796673224328569285177;%
\XINT_tmpa 2 7 85113803820237646781712631859248682794521725442067093899553745086385146367436049;%
\XINT_tmpa 2 8 83176377110267100616669140273840405263880767161887438462740286611379995442629360;%
\XINT_tmpa 2 9 81283051616409924654127879773132980187568851100062454636602325121954484722491710;%
% 10^-0.00i
\XINT_tmpa 3 1 99770006382255331719442194285376231055211861394573154624878230890945476532432225;%
\XINT_tmpa 3 2 99540541735152696244806147089510943107144177264574823668081299845609359857038344;%
\XINT_tmpa 3 3 99311604842093377157642607688515474663519162181123336122073822476734517364853150;%
\XINT_tmpa 3 4 99083194489276757440828314388392035249938006860819409201135652190410238171119287;%
\XINT_tmpa 3 5 98855309465693884028524792978202683686410726723055209558576898759166522286083202;%
\XINT_tmpa 3 6 98627948563121047157261523093421290951784086730437722805070296627452491731402556;%
\XINT_tmpa 3 7 98401110576113374484101831088824192144756194053451911515003663381199842081528019;%
\XINT_tmpa 3 8 98174794301998439937928161622872240632362817134775142288598128693131032909278350;%
\XINT_tmpa 3 9 97948998540869887269961493687844910565420716785032030061251916654655049965062649;%
% 10^-0.000i
\XINT_tmpa 4 1 99976976799815658635141604638981297541396466984477711459083930684685186989697929;%
\XINT_tmpa 4 2 99953958900308784552845777251512089759003230012954649234748668826546533498169555;%
\XINT_tmpa 4 3 99930946300258992168693777702512591351888960684418033717545524043693899420866954;%
\XINT_tmpa 4 4 99907938998446176870082987427724649318531547584410414997787083472394558389284098;%
\XINT_tmpa 4 5 99884936993650514951538205746462968844845952521633937925370747725933629958238429;%
\XINT_tmpa 4 6 99861940284652463550037839584112909891259691850983307437097305856727153967481065;%
\XINT_tmpa 4 7 99838948870232760580354983175435314251655958968480344701699631967048474751069525;%
\XINT_tmpa 4 8 99815962749172424670413384320528274471550942114263604264788586703624513163664479;%
\XINT_tmpa 4 9 99792981920252755096658293766085025870392854106037465990011216356523334125368417;%
% 10^-0.0000i
\XINT_tmpa 5 1 99997697441416293040019992468837639003787989306240470048763511538639048400765328;%
\XINT_tmpa 5 2 99995394935850346394065999228750187791584034668237852053859761641089829514536011;%
\XINT_tmpa 5 3 99993092483300939297147020491645017932348508508297743745039515152378182676736684;%
\XINT_tmpa 5 4 99990790083766851012380885556584619169980753943113396677545915245611923361705686;%
\XINT_tmpa 5 5 99988487737246860830993605587529673614422529030613405900998412734419982883669223;%
```

```
\XINT_tmpa 5 6 999861854437397480723187264059848015652685780447984757660256471872216596224506 51;%
```

14.10 April 2021: at last, \XINTinFloatPowTen, \XINTinFloatExp

Done April 2021. I have procrastinated (or did not have time to devote to this) at least 5 years, even more.

Speed improvements will have to wait to long delayed refactoring of core floating point support which is still in the 2013 primitive state !

I did not try to optimize for say 16 digits, as I was more focused on reaching 60 digits in a reasonably efficient manner (trigonometric functions achieved this since 2019) in the same coding framework. Finally, up to 62 digits.

The stored constants are log(10) at P+4 digits and the powers 10^0.d, 10^0.0d, etc, up to 10^0.00000d for d=1..9, as well as their inverses, at P+5 and P+10 digits. The constants were obtained from Maple at 80 digits.

Initially I constructed the exponential series exp(h) as one big unique nested macro. It contained pre-rounded values of the 1/i! but would float-round h to various numbers of digits, with always the full initial h as input.

After having experimented with the logarithm, I redid exp(h) = 1 + h(1 + h(1/2 + ...)) with many macros in order to have more readable code, and to dynamically cut-off more and more digits from h the deeper it is used. See the logarithm code for (perhaps) more comments.

The thresholds have been obtained from considerations including an hmax (a bit more than 0.5 log(10) 10^-6). Here is the table:

- maximal value of P: 8, 15, 21, 28, 35, 42, 48, 55, 62
- last included term: /1, /2, /6, /4!, /5!, /6!, /7!, /8!, /9!

Computations are done morally targeting P+4 fractional fixed point digits, with a stopping criteria at say about 5e(-P-4), which was used for the table above using only the worst case. As the used macros are a mix of exact operations and floating point reductions this is in practice a bit different. The h will be initially float rounded to P-1 digits. It is cut-off more and more, the deeper nested it is used.

The code for this evaluation of 10^x is very poor with x very near zero: it does silly multiplication by 1, and uses more terms of exponential series than would then be necessary.

For the computation of exp(x) as 10^(c*x) with c=log(10)^-1, we need more precise c the larger abs(x) is. For abs(x)<1 (or 2), the c with P+4 fractional digits is sufficient. But decimal exponents are more or less allowed to be near the TeX maximum 2^31-1, which means that abs(x) could be as big as 0.5e10, and we then need c with P+14 digits to cover that range.

I am hesitating whether to first examine integral part of abs(x) and for example to use c with either P+4, P+9 or P+14 digits, and also take this opportunity to inject an error message if x is too big before TeX arithmetic overflow happens later on. For time being I will use overhead of oneoverlogten having ample enough digits...

The exponent received as input is float rounded to P + 14 digits. In practice the input will be already a P-digits float. The motivation here is for low Digits situation: but this done so that for example with Digits=4, we want exp(12345) not to be evaluated as exp(12350) which would have no meaning at all. The +14 is because we have prepared 1/log(10) with that many significant digits. This conundrum is due to the inadequation of the world of floating point numbers with exp() and log(): clearly exp() goes from fixed point to floating point and log() goes from floating point to fixed point, and coercing them to work inside the sole floating point domain is not mathematically natural. Although admittedly it does create interesting mathematical questions! A similar situation applies to functions such as cos() and sin(), what sense is there in the expression cos(exp(50)) for example with 16 digits precision? My opinion is that it does not make ANY sense. Anyway, I shall obide.

As \XINTinFloatS will not add unnecessarily trailing zeros, the \XINTdigits+14 is not really an enormous overhead for integer exponents, such as in the example above the 12345, or more realistically small integer exponents, and if the input is already float rounded to P digits, the overhead is also not enormous (float-rounding is costly when the input is a fraction).

\XINTinfloatpowten will receive an input with at least P+14 and up to 2P+28 digits... fortunaltely with no fraction part and will start rounding it in the fixed point sense of its input to P+4 digits after decimal point, which is not enormously costly.

Of course all these things pile up...

```
\def\XINTinFloatExp{\romannumeral0\XINTinfloatexp}%
\def\XINT_tmpa#1.{%
\def\XINTinfloatexp##1%
{%
    \XINTinfloatpowten
    {\xintMul{\XINT_c_oneoverlogten_xx}{\XINTinFloatS[#1]{##1}}}%
}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax+14.%
```

Here is how the reduction to computations of an exp(h) via series is done.

Starting from x, after initial argument normalization, it is fixed-point rounded to 6 fractional digits giving x'' = ±n.d_1...d_6 (which may be 0).

I have to resist temptation using very low level routines here and wisely will employ the available user-level stuff. One computes then the difference x-x'' which gives some eta, and the h will be log(10).eta. The subtraction and multiplication are done exactly then float rounded to P-1 digits to obtain the h.

Then exp(h) is computed. And to finish it is multiplied with the stored 10^±0.d_1, 10^±0.0d_2, etc...., constants and its decimal exponent is increased by ±n. These operations are done at P+5 floating point digits. The final result is then float-rounded to the target P digits.

Currently I may use nested macros for some operations but will perhaps revise in future (it makes tracing very complicated if one does not have intermediate macros). The exponential series itself was initially only one single macro, but as commented above I have now modified it.

```
\def\XINTinFloatPowTen{\romannumeral0\XINTinfloatpowten}%
\def\XINT_tmpa#1.{%
```

```
\def\XINTinfloatpowten##1%
{%
    \expandafter\XINT_powten_fork
    \romannumeral0\xintiround{#1}{##1}[-#1]%
}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax+4.%
\def\XINT_powten_fork#1%
{%
    \xint_UDzerominusfork
       #1-\XINT_powten_zero
       0#1\XINT_powten_neg
        0-\XINT_powten_pos
    \krof #1%
}%
\def\XINT_powten_zero #1[#2]{ 1[0]}%
```

This rounding may produce 0.000000 but will always have 6 exactly fractional digits, because the special case of a zero input was filtered out preventively.

```
\def\XINT_powten_pos#1[#2]%
{%
    \expandafter\XINT_powten_pos_a\romannumeral0\xintround{6}{#1[#2]}#1[#2]%
}%
\def\XINT_tmpa #1.#2.#3.{%
\def\XINT_powten_pos_a ##1.##2##3##4##5##6##7##8[##9]%
{%
   \expandafter\XINT_infloate
    \romannumeral0\XINTinfloat[#3]{%
     \xintMul{\csname XINT_c_1_##2\endcsname}{%
      \XINTinFloat[#1]{%
       \xintMul{\csname XINT_c_2_##3\endcsname}{%
        \XINTinFloat[#1]{%
         \xintMul{\csname XINT_c_3_##4\endcsname}{%
          \XINTinFloat[#1]{%
           \xintMul{\csname XINT_c_4_##5\endcsname}{%
            \XINTinFloat[#1]{%
             \xintMul{\csname XINT_c_5_##6\endcsname}{%
              \XINTinFloat[#1]{%
               \xintMul{\csname XINT_c_6_##7\endcsname}{%
                \xintAdd{1[0]}{%
                 \expandafter\XINT_Exp_series_a_ii
                  \romannumeral0\XINTinfloat[#2]{%
                   \xintMul{\XINT_c_logten}%
                           {\xintAdd{-##1.##2##3##4##5##6##7}{##8[##9]}}%
                   }%
                 \xint:
                }%
               }}}}}}}}}}}{##1}%
}}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax+5\expandafter.%
  \the\numexpr\XINTdigitsormax-1\expandafter.%
  \the\numexpr\XINTdigitsormax.%
```

This rounding may produce -0.000000 but will always have 6 exactly fractional digits and a leading minus sign.

```
\def\XINT_powten_neg#1[#2]%
{%
    \expandafter\XINT_powten_neg_a\romannumeral0\xintround{6}{#1[#2]}#1[#2]%
}%
\def\XINT_tmpa #1.#2.#3.{%
\def\XINT_powten_neg_a -##1.##2##3##4##5##6##7##8[##9]%
{%
   \expandafter\XINT_infloate
    \romannumeral0\XINTinfloat[#3]{%
     \xintMul{\csname XINT_c_1_##2_inv\endcsname}{%
      \XINTinFloat[#1]{%
       \xintMul{\csname XINT_c_2_##3_inv\endcsname}{%
        \XINTinFloat[#1]{%
         \xintMul{\csname XINT_c_3_##4_inv\endcsname}{%
          \XINTinFloat[#1]{%
           \xintMul{\csname XINT_c_4_##5_inv\endcsname}{%
            \XINTinFloat[#1]{%
             \xintMul{\csname XINT_c_5_##6_inv\endcsname}{%
              \XINTinFloat[#1]{%
               \xintMul{\csname XINT_c_6_##7_inv\endcsname}{%
                \xintAdd{1[0]}{%
                 \expandafter\XINT_Exp_series_a_ii
                  \romannumeral0\XINTinfloat[#2]{%
                   \xintMul{\XINT_c_logten}%
                           {\xintAdd{##1.##2##3##4##5##6##7}{##8[##9]}}%
                   }%
                 \xint:
                }%
               }}}}}}}}}}}}{-##1}%
}}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax+5\expandafter.%
  \the\numexpr\XINTdigitsormax-1\expandafter.%
  \the\numexpr\XINTdigitsormax.%
```

14.10.1 Exponential series

Or rather here h(1 + h(1/2 + h (1/6 + ...))). Upto at most h^9/9! term.
  The used initial h has been float rounded to P-1 digits.

```
\def\XINT_tmpa#1.#2.{%
\def\XINT_Exp_series_a_ii##1\xint:
{%
    \expandafter\XINT_Exp_series_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_Exp_series_b##1[##2]\xint:
{%
    \expandafter\XINT_Exp_series_c_
    \romannumeral0\xintadd{1}{\xintHalf{##10}[##2-1]}\xint:
}%
\def\XINT_Exp_series_c_##1\xint:##2\xint:
{%
    \XINTinFloat[#2]{\xintMul{##1}{##2}}%
}%
```

```
}%
\expandafter\XINT_tmpa
            \the\numexpr\XINTdigitsormax-6\expandafter.%
            \the\numexpr\XINTdigitsormax-1.%
\ifnum\XINTdigits>15
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_Exp_series_a_ii##1\xint:
{%
    \expandafter\XINT_Exp_series_a_iii
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_Exp_series_a_iii##1\xint:
{%
    \expandafter\XINT_Exp_series_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_Exp_series_b##1[##2]\xint:
{%
    \expandafter\XINT_Exp_series_c_i
    \romannumeral0\xintadd{#3}{##1/6[##2]}\xint:
}%
\def\XINT_Exp_series_c_i##1\xint:##2\xint:
{%
    \expandafter\XINT_Exp_series_c_
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-13\expandafter.%
  \the\numexpr\XINTdigitsormax-6.%
  {5[-1]}.%
  {1[0]}.%
\fi
\ifnum\XINTdigits>21
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_Exp_series_a_iii##1\xint:
{%
    \expandafter\XINT_Exp_series_a_iv
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_Exp_series_a_iv##1\xint:
{%
    \expandafter\XINT_Exp_series_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_Exp_series_b##1[##2]\xint:
{%
    \expandafter\XINT_Exp_series_c_ii
    \romannumeral0\xintadd{#3}{##1/24[##2]}\xint:
}%
\def\XINT_Exp_series_c_ii##1\xint:##2\xint:
{%
    \expandafter\XINT_Exp_series_c_i
```

```
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-19\expandafter.%
  \the\numexpr\XINTdigitsormax-13\expandafter.%
  \romannumeral0\XINTinfloat[\XINTdigitsormax-13]{1/6[0]}.%
  {5[-1]}.%
\fi
\ifnum\XINTdigits>28
\def\XINT_tmpa #1 #2 #3 #4 #5 #6 #7 %
{%
 \def\XINT_tmpb ##1##2##3##4%
 {%
  \def\XINT_tmpc####1.####2.####3.####4.%
  {%
   \def##2########1\xint:
   {%
       \expandafter##1%
       \romannumeral0\XINTinfloatS[####2]{########1}\xint:########1\xint:
   }%
   \def##1########1\xint:
   {%
       \expandafter\XINT_Exp_series_b
       \romannumeral0\XINTinfloatS[####1]{########1}\xint:########1\xint:
   }%
   \def\XINT_Exp_series_b########1[########2]\xint:
   {%
       \expandafter##3%
       \romannumeral0\xintadd{####3}{########1/#5[########2]}\xint:
   }%
   \def##3########1\xint:########2\xint:
   {%
       \expandafter##4%
       \romannumeral0\xintadd{####4}%
                              {\XINTinFloat[####2]{\xintMul{########1}{########2}}}\xint:
   }%
  }%
 }%
 \expandafter\XINT_tmpb
 \csname XINT_Exp_series_a_\romannumeral\numexpr#1\expandafter\endcsname
 \csname XINT_Exp_series_a_\romannumeral\numexpr#1-1\expandafter\endcsname
 \csname XINT_Exp_series_c_\romannumeral\numexpr#1-2\expandafter\endcsname
 \csname XINT_Exp_series_c_\romannumeral\numexpr#1-3\endcsname
 \expandafter\XINT_tmpc
 \the\numexpr\XINTdigitsormax-#2\expandafter.%
 \the\numexpr\XINTdigitsormax-#3\expandafter.\expanded{%
 \XINTinFloat[\XINTdigitsormax-#3]{1/#6[0]}.%
 \XINTinFloat[\XINTdigitsormax-#4]{1/#7[0]}.%
 }%
}%
\XINT_tmpa 5 26 19 13 120 24 6 %<-- keep space
\ifnum\XINTdigits>35 \XINT_tmpa 6 33 26 19 720 120 24 \fi
```

```
\ifnum\XINTdigits>42 \XINT_tmpa 7 40 33 26 5040 720 120 \fi
\ifnum\XINTdigits>48 \XINT_tmpa 8 46 40 33 40320 5040 720 \fi
\ifnum\XINTdigits>55 \XINT_tmpa 9 53 46 40 362880 40320 5040 \fi
\fi
```

14.11 April 2021: at last \XINTinFloagLogTen, \XINTinFloatLog

Attention that this is not supposed to be used with \XINTdigits at 8 or less, it will crash if that is the case. The log10() and log() functions in case \XINTdigits is at most 8 are mapped to \PoormanLogBaseTen respectively \PoormanLog macros.

In the explications here I use the function names rather than the macro names.

Both log(x) and log10(x) are on top of an underlying macro which will produce z and h such that x is about 10^z e^h (with h being small is obtained via a log series). Then log(x) computes log(10)z+h whereas log10(x) computes as z+h/log(10).

There will be three branches [NO FINALLY ONLY TWO BRANCHES SINCE 1.4f] according to situation of x relative to 1. Let y be the math value log10(x) that we want to approximate to target precision P digits. P is assumed at least 9.

I will describe the algorithm roughly, but skip its underlying support analysis; at some point I mention "fixed point calculations", but in practice it is not done exactly that way, but describing it would be complicated so look at the code which is very readable (by the author, at the present time).

First we compute z = ±n.d_1d_2...d_6 as the rounded to 6 fractional digits approximation of y=log10(x) obtained by first using the poormanlog macros on x (float rounded to 9 digits) then rounding as above.

Warning: this description is not in sync with the code, now the case where d_1d_2...d_6 is 000000 is filtered out and one jumps directly either to case I if n≠0 or to case III if n=0. The case when rounding produces a z equal to zero is also handled especially.

WARNING: at 1.4f, the CASE I was REMOVED. Everything is handled as CASE II or exceptionally case III. Indeed this removal was observed to simply cost about 10% extra time at D=16 digits, which was deemed an acceptable cost. The cost is certainly higher at D=9 but also relatively lower at high D's. It means that logarithms are always computed with 9, not 4, safety **fractional** digits, and this allows to compute powers accurately with exponents say up to 1e7, degradation starting to show at 1e8 and for sure at 1e9. However for integer and half-integer exponents the old routine \xintFloatPower will still be used, and perhaps it will need some increased precision update as the documented 0.52ulp error bound is higher than our more stringent standards of 2021.

CASE I: [removed at 1.4f!] either n is NOT zero or d_1d_2....d_6 is at least 100001. Then we compute X = 10^(-z)*x which is near 1, by using the table of powers of 10, using P+5 digits significands. Then we compute (exactly) eta = X-1, (which is in absolute value less than 0.0000012) and obtain y as z + log(10)^(-1) times log(1+eta) where log(1+eta) = eta - eta^2/2 + eta^3/3- ... is "computed with P+4 fractional fixed point digits" [1]_ according to the following table:

- maximal value of P: 9, 15, 21, 27, 33, 39, 45, 51, 57, 63
- last included term: /1, /2, /3, /4, /5, /6, /7, /8, /9, /10

.. [1] this "P+4" includes leading fractional zeroes so in practice it will rather be done as eta(1 - eta(1/2 + eta(1/3-...))), and the inner sums will be done in various precisions, the top level (external) eta probably at P-1 digits, the first inner eta at P-7 digits, the next at P-13, something in this style. The heuristics is simple: at P=9 we don't need the first inner eta, so let's use there P-9 or rather P-7 digits by security. Similarly at P=3 we would not need at all the eta, so let's use the top level one rounded at P-3+2 = P-1 digits. And there is a shift by 6 less digits at each inner level. RÉFLÉCHIR SI C'EST PAS PLUTÔT P-2 ICI, suffisant au regard de la précision par ailleurs pour la réduction près de 1.

The sequence of maximal P's is simply an arithmetic progression.

The addition of z will trigger the final rounding to P digits. The inverse of log(10) is precomputed with P+4 digits.

This case I essentially handles x such as max(x,1/x)>10^0.1=1.2589...

CASE II: n is zero and d_1d_2....d_6 is not zero. We operate as in CASE I, up to the following differences:

- the table of fractional powers of 10 is used with P+10 significands.
- the X is also computed with P+10 digits, i.e. eta = X-1 (which obeys the given estimate) is estimated with P+9 [2]_ fractional fixed points digits and the log series will be evaluated in this sense.
- the constant log(10)^(-1) is still used with only P+4 digits

The log series is terminated according to the following table:

- maximal value of P: 4, 10, 16, 22, 28, 34, 40, 46, 52, 58, 64
- last included term: /1, /2, /3, /4, /5, /6, /7, /8, /9, /10

Again the P's are in arithmetic progression, the same as before shifted by 5.

.. [2] same remark as above. The top level eta in eta(1 - eta(1/2 - eta(...))) will use P+4 significant digits, but the first inner eta will be used with only P-2 digits, the next inner one with P-8 digits etc...

This case II handles the x which are near 1, but not as close as 10^±0.000001.

CASE III: z=0. In this case X = x = 1+eta and we use the log series in this sense : log(10)^(-1)*eta*(1 - eta/2 + eta^2/3-....) where again log(10)^(-1) has been precomputed with P+4 digits and morally the series uses P+4 fractional digits (P+3 would probably be enough for the precision I want, need to check my notes) and the thresholds table is:

- maximal value of P: 3, 9, 15, 21, 27, 33, 39, 45, 51, 57, 63
- last included term: /1, /2, /3, /4, /5, /6, /7, /8, /9, /10, /11

This is same progression but shifted by one.

To summarize some relevant aspects:

- this algorithm uses only log(10)^(-1) as precomputed logarithm
- in particular the logarithms of small integers 2, 3, 5,... are not pre-computed. Added note: I have now tested at 16, 32, 48 and 62 digits that all of the log10(n), for n = 1..1000, are computed with correct rounding. In fact, generally speaking, random testing of a about 20000 inputs has failed to reveal a single non-correct rounding. Naturally, randomly testing is not the way to corner the software into its weak points...
- it uses two tables of fractional powers of ten: one with P+5 digits and another one with extended precision at P+10 digits.
- it needs three distinct implementations of the log series.
- it does not use the well-known trick reducing to using only odd powers in the log series (somehow I have come to dread divisions, even though here as is well-known it could be replaced with some product, my impression was that what is gained on one side is lost on the other, for the range of P I am targeting, i.e. P up to about 60.)
- all of this is experimental (in particular the previous item was not done perhaps out of sheer laziness)

Absolutely no error check is done whether the input x is really positive. As seen above the maximal target precision is 63 (not 64).

Update for 1.4f: when the logarithm is computed via case I, i.e. basically always except roughly for 0.8<a<1.26, its fractional part has only about 4 safety digits. This is barely enough for a^b with b near 1000 and certainly not enough for a^b with b of the order 10000.

I hesitated with the option to always handle b as N+h with N integer for which we can use old \xintFloatPower (which perhaps I will have to update to ensure better than the 0.52ulp it mentions in its documentation). But in the end, I decided to simply add a variant where case I is handled as case II, i.e. with 9 not 4 safety fractional digits for the logarithm. This variant will be the one used by the power function for fractional exponents (non integer, non half-integer).

```
\def\XINT_tmpa#1.{%
\def\XINTinFloatLog{\romannumeral0\XINTinfloatlog}%
\def\XINTinfloatlog
```

```
{%
    \expandafter\XINT_log_out
    \romannumeral0\expandafter\XINT_logtenxdg_a
    \romannumeral0\XINTinfloat[#1]%{##1}
}%
\def\XINT_log_out ##1\xint:##2\xint:
{%
    \XINTinfloat[#1]%
     {\xintAdd{\xintMul{\XINT_c_logten}{##1}}{##2}}%
}%
\def\XINTinFloatLogTen{\romannumeral0\XINTinfloatlogten}%
\def\XINTinfloatlogten
{%
    \expandafter\XINT_logten_out
    \romannumeral0\expandafter\XINT_logtenxdg_a
    \romannumeral0\XINTinfloat[#1]%{##1}
}%
\def\XINT_logten_out ##1\xint:##2\xint:
{%
    \XINTinfloat[#1]%
     {\xintAdd{##1}{\xintMul{\XINT_c_oneoverlogten}{##2}}}%
}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax.%
\def\XINTinFloatLogTen_xdgout%#1[#2]
{%
    \romannumeral0\expandafter\XINT_logten_xdgout\romannumeral0\XINT_logtenxdg_a
}%
\def\XINT_logten_xdgout #1\xint:#2\xint:
{%
    \xintadd{#1}{\xintMul{\XINT_c_oneoverlogten_xx}{#2}}%
}%
```

No check is done whether input is negative or vanishes. We apply \XINTinfloat[9] which if input is not zero always produces 9 digits (and perhaps a minus sign) the first digit is non-zero. This is the expected input to \numexpr\PML@<digits><dot>.\relax

The variants xdg_a, xdg_b, xdg_c, xdg_d were added at 1.4f to always go via II or III, ensuring more fractional digits to the logarithm for accuracy of fractional powers with big exponents. "Old" 1.4e routines were removed.

```
\def\XINT_logtenxdg_a#1[#2]%
{%
    \expandafter\XINT_logtenxdg_b
    \romannumeral0\XINTinfloat[9]{#1[#2]}#1[#2]%
}%
\def\XINT_logtenxdg_b#1[#2]%
{%
    \expandafter\XINT_logtenxdg_c
      \romannumeral0\xintround{6}%
      {\xintiiAdd{\xintDSx{-9}{\the\numexpr#2+8\relax}}%
                             {\the\numexpr\PML@#1.\relax}%
       [-9]}%
    \xint:
}%
```

If we were either in 100000000[0] or 999999999[-1] for the #1[#2] \XINT_logten_b input, and only in those cases, the \xintRound{6} produced "0". We are very near 1 and will treat this as case III, but this is sub-optimal.

```
\def\XINT_logtenxdg_c #1#2%
{%
    \xint_gob_til_xint:#2\XINT_logten_IV\xint:
    \XINT_logtenxdg_d #1#2%
}%
\def\XINT_logten_IV\xint:\XINT_logtenxdg_d0{\XINT_logten_f_III}%
```

Here we are certain that \xintRound{6} produced a decimal point and 6 fractional digit tokens #2, but they can be zeros and also -0.000000 is possible.

If #1 vanishes and #2>100000 we are in case I.

If #1 vanishes and 100000>=#2>0 we are in case II.

If #1 and #2 vanish we are in case III.

If #1 does not vanish we are in case I with a direct quicker access if #2 vanishes.

Attention to the sign of #1, it is checked later on.

At 1.4f, we handle the case I with as many digits as case II (and exceptionnally case III).

```
\def\XINT_logtenxdg_d #1.#2\xint:
{%
    \ifcase
      \ifnum#1=\xint_c_
        \ifnum #2=\xint_c_ \xint_c_iii\else \xint_c_ii\fi
      \else
        \ifnum#2>\xint_c_ \xint_c_ii\else \xint_c_\fi
      \fi
       \expandafter\XINT_logten_f_Isp
    \or% never
    \or\expandafter\XINT_logten_f_IorII
    \else\expandafter\XINT_logten_f_III
    \fi
    #1.#2\xint:
}%
\def\XINT_logten_f_IorII#1%
{%
    \xint_UDsignfork
       #1\XINT_logten_f_IorII_neg
        -\XINT_logten_f_IorII_pos
    \krof #1%
}%
```

We are here only with a non-zero ##1, so no risk of a -0[0] which would be illegal usage of A[N] raw format. A negative ##1 is no trouble in ##3-##1.

```
\def\XINT_tmpa#1.{%
\def\XINT_logten_f_Isp##1.000000\xint:##2[##3]%
{%
    {##1[0]}\xint:
    {\expandafter\XINT_LogTen_serII_a_ii
        \romannumeral0\XINTinfloatS[#1]{\xintAdd{##2[##3-##1]}{-1[0]}}%
     \xint:
    }\xint:
}%
}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax.%
\def\XINT_tmpa#1.{%
```

```
\def\XINT_logten_f_III##1\xint:##2[##3]%
{%
    {0[0]}\xint:
    {\expandafter\XINT_LogTen_serIII_a_ii
        \romannumeral0\XINTinfloatS[#1]{\xintAdd{##2[##3]}{-1[0]}}%
     \xint:
    }\xint:
}}\expandafter\XINT_tmpa\the\numexpr\XINTdigitsormax+4.%
\def\XINT_tmpa#1.#2.{%
\def\XINT_logten_f_IorII_pos##1.##2##3##4##5##6##7\xint:##8[##9]%
{%
    {\the\numexpr##1##2##3##4##5##6##7[-6]}\xint:
    {\expandafter\XINT_LogTen_serII_a_ii
     \romannumeral0\XINTinfloat[#2]%
     {\xintAdd{-1[0]}%
     {\xintMul{\csname XINT_c_1_##2_inv_x\endcsname}{%
      \XINTinFloat[#1]{%
       \xintMul{\csname XINT_c_2_##3_inv_x\endcsname}{%
        \XINTinFloat[#1]{%
         \xintMul{\csname XINT_c_3_##4_inv_x\endcsname}{%
          \XINTinFloat[#1]{%
           \xintMul{\csname XINT_c_4_##5_inv_x\endcsname}{%
            \XINTinFloat[#1]{%
             \xintMul{\csname XINT_c_5_##6_inv_x\endcsname}{%
              \XINTinFloat[#1]{%
               \xintMul{\csname XINT_c_6_##7_inv_x\endcsname}
                       {##8[##9-##1]}%
               }}}}}}}}}%
     }%
     }\xint:
    }\xint:
}%
\def\XINT_logten_f_IorII_neg##1.##2##3##4##5##6##7\xint:##8[##9]%
{%
    {\the\numexpr##1##2##3##4##5##6##7[-6]}\xint:
    {\expandafter\XINT_LogTen_serII_a_ii
     \romannumeral0\XINTinfloat[#2]%
     {\xintAdd{-1[0]}%
     {\xintMul{\csname XINT_c_1_##2_x\endcsname}{%
      \XINTinFloat[#1]{%
       \xintMul{\csname XINT_c_2_##3_x\endcsname}{%
        \XINTinFloat[#1]{%
         \xintMul{\csname XINT_c_3_##4_x\endcsname}{%
          \XINTinFloat[#1]{%
           \xintMul{\csname XINT_c_4_##5_x\endcsname}{%
            \XINTinFloat[#1]{%
             \xintMul{\csname XINT_c_5_##6_x\endcsname}{%
              \XINTinFloat[#1]{%
               \xintMul{\csname XINT_c_6_##7_x\endcsname}
                       {##8[##9-##1]}%
               }}}}}}}}}%
     }%
```

```
      }\xint:
     }\xint:
}%
}\expandafter\XINT_tmpa
 \the\numexpr\XINTdigitsormax+10\expandafter.\the\numexpr\XINTdigitsormax+4.%
```

Initially all of this was done in a single big nested macro but the float-rounding of argument to less digits worked again each time from initial long input; the advantage on the other hand was that the 1/i constants were all pre-computed and rounded.

Pre-coding the successive rounding to six digits less at each stage could be done via a single loop which would then walk back up inserting coeffs like 1/#1 having no special optimizing tricks. Pre-computing the 1/#1 too is possible but then one would have to copy the full set of such constants (which would be pre-computed depending on P), and this will add grabbing overhead in the loop expansion. Or one defines macros to hold the pre-rounded constants.

Finally I do define macros, not only to hold the constants but to hold the whole build-up. Sacrificing brevity of code to benefit of expansion "speed".

Firts one prepares eta, with P+4 digits for mantissa, and then hands it over to the log series. This will proceed via first preparing eta\xint: eta\xint: .... eta\xint:, the leftmost ones being more and more reduced in number of digits. Finally one goes back up to the right, the hard-coded number of steps depending on value of P=\XINTdigits at time of reloading of package. This number of steps is hard-coded in the number of macros which get defined.

Descending (leftwards) chain: _a, Turning point: _b, Ascending: _c.

As it is very easy to make silly typing mistakes in the numerous macros I have refactored a number of times the set-up to make manual verification straightforward. Automatization is possible but the _b macros complicate things, each one is its own special case. In the end the set-up will define then redefine some _a and the (finally unique) _b macro, this allows easier to read code, with no nesting of conditionals or else branches.

Actually series III and series II differ by only a shift by and we could use always the slightly more costly series III in place of series II. But that would add one un-needed term and a bit overhead to the default P which is 16...

(1.4f: hesitation on 2021/05/09 after removal or case I log series should I not follow the simplifying logic and use always the slightly more costly III?)

14.11.1 Log series, case II

```
\def\XINT_tmpa#1.#2.{%
\def\XINT_LogTen_serII_a_ii##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b#1[#2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_
    \romannumeral0\xintadd{1}{\xintiiOpp\xintHalf{#10}[#2-1]}\xint:
}%
\def\XINT_LogTen_serII_c_##1\xint:##2\xint:
{%
    \XINTinFloat[#2]{\xintMul{##1}{##2}}%
}%
}%
\expandafter\XINT_tmpa
            \the\numexpr\XINTdigitsormax-2\expandafter.%
            \the\numexpr\XINTdigitsormax+4.%
```

```
\ifnum\XINTdigits>10
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_ii##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_iii
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_iii##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_i
    \romannumeral0\xintadd{#3}{##1/3[##2]}\xint:
}%
\def\XINT_LogTen_serII_c_i##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serII_c_
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-8\expandafter.%
  \the\numexpr\XINTdigitsormax-2.%
  {-5[-1]}.%
  {1[0]}.%
\fi
\ifnum\XINTdigits>16
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_iii##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_iv
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_iv##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_ii
    \romannumeral0\xintadd{#3}{\xintiiMul{-25}{##1}[##2-2]}\xint:
}%
\def\XINT_LogTen_serII_c_ii##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serII_c_i
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-14\expandafter.%
```

```
  \the\numexpr\XINTdigitsormax-8\expandafter.%
  \romannumeral0\XINTinfloat[\XINTdigitsormax-8]{1/3[0]}.%
  {-5[-1]}.%
\fi
\ifnum\XINTdigits>22
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_iv##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_v
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_v##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_iii
    \romannumeral0\xintadd{#3}{\xintDouble{##1}[##2-1]}\xint:
}%
\def\XINT_LogTen_serII_c_iii##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serII_c_ii
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-20\expandafter.%
  \the\numexpr\XINTdigitsormax-14\expandafter.\expanded{%
  {-25[-2]}.%
  \XINTinFloat[\XINTdigitsormax-8]{1/3[0]}.%
  }%
\fi
\ifnum\XINTdigits>28
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_v##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_vi
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_vi##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_iv
    \romannumeral0\xintadd{#3}{\xintiiOpp##1/6[##2]}\xint:
}%
\def\XINT_LogTen_serII_c_iv##1\xint:##2\xint:
{%
```

```
    \expandafter\XINT_LogTen_serII_c_iii
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-26\expandafter.%
  \the\numexpr\XINTdigitsormax-20.%
  {2[-1]}.%
  {-25[-2]}.%
\fi
\ifnum\XINTdigits>34
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_vi##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_vii
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_vii##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_v
    \romannumeral0\xintadd{#3}{##1/7[##2]}\xint:
}%
\def\XINT_LogTen_serII_c_v##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serII_c_iv
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-32\expandafter.%
  \the\numexpr\XINTdigitsormax-26\expandafter.%
  \romannumeral0\XINTinfloatS[\XINTdigitsormax-26]{-1/6[0]}.%
  {2[-1]}.%
\fi
\ifnum\XINTdigits>40
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_vii##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_viii
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_viii##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_vi
```

```
    \romannumeral0\xintadd{#3}{\xintiiMul{-125}{##1}[##2-3]}\xint:
}%
\def\XINT_LogTen_serII_c_vi##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serII_c_v
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-38\expandafter.%
  \the\numexpr\XINTdigitsormax-32\expandafter.\expanded{%
  \XINTinFloat[\XINTdigitsormax-32]{1/7[0]}.%
  \XINTinFloat[\XINTdigitsormax-26]{-1/6[0]}.%
  }%
\fi
\ifnum\XINTdigits>46
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_viii##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_ix
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_ix##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_vii
    \romannumeral0\xintadd{#3}{##1/9[##2]}\xint:
}%
\def\XINT_LogTen_serII_c_vii##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serII_c_vi
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-44\expandafter.%
  \the\numexpr\XINTdigitsormax-38\expandafter.\expanded{%
  {-125[-3]}.%
  \XINTinFloat[\XINTdigitsormax-32]{1/7[0]}.%
  }%
\fi
\ifnum\XINTdigits>52
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_ix##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_x
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_x##1\xint:
{%
```

```
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_viii
    \romannumeral0\xintadd{#3}{\xintiiOpp##1[##2-1]}\xint:
}%
\def\XINT_LogTen_serII_c_viii##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serII_c_vii
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-50\expandafter.%
  \the\numexpr\XINTdigitsormax-44\expandafter.%
  \romannumeral0\XINTinfloat[\XINTdigitsormax-44]{1/9[0]}.%
  {-125[-3]}.%
\fi
\ifnum\XINTdigits>58
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serII_a_x##1\xint:
{%
    \expandafter\XINT_LogTen_serII_a_xi
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_a_xi##1\xint:
{%
    \expandafter\XINT_LogTen_serII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serII_c_ix
    \romannumeral0\xintadd{#3}{##1/11[##2]}\xint:
}%
\def\XINT_LogTen_serII_c_ix##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serII_c_viii
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-56\expandafter.%
  \the\numexpr\XINTdigitsormax-50\expandafter.\expanded{%
  {-1[-1]}.%
  \XINTinFloat[\XINTdigitsormax-44]{1/9[0]}.%
  }%
\fi
```

14.11.2 Log series, case III

```
\def\XINT_tmpa#1.#2.{%
\def\XINT_LogTen_serIII_a_ii##1\xint:
```

```
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b#1[#2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_
    \romannumeral0\xintadd{1}{\xintiiOpp\xintHalf{#10}[#2-1]}\xint:
}%
\def\XINT_LogTen_serIII_c_##1\xint:##2\xint:
{%
    \XINTinFloat[#2]{\xintMul{##1}{##2}}%
}%
}%
\expandafter\XINT_tmpa
            \the\numexpr\XINTdigitsormax-1\expandafter.%
            \the\numexpr\XINTdigitsormax+4.%
\ifnum\XINTdigits>9
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serIII_a_ii##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_iii
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_a_iii##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_i
    \romannumeral0\xintadd{#3}{##1/3[##2]}\xint:
}%
\def\XINT_LogTen_serIII_c_i##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-7\expandafter.%
  \the\numexpr\XINTdigitsormax-1.%
  {-5[-1]}.%
  {1[0]}.%
\fi
\ifnum\XINTdigits>15
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serIII_a_iii##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_iv
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
```

```
\def\XINT_LogTen_serIII_a_iv##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_ii
    \romannumeral0\xintadd{#3}{\xintiiMul{-25}{##1}[##2-2]}\xint:
}%
\def\XINT_LogTen_serIII_c_ii##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_i
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-13\expandafter.%
  \the\numexpr\XINTdigitsormax-7\expandafter.%
  \romannumeral0\XINTinfloat[\XINTdigitsormax-7]{1/3[0]}.%
  {-5[-1]}.%
\fi
\ifnum\XINTdigits>21
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serIII_a_iv##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_v
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_a_v##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_iii
    \romannumeral0\xintadd{#3}{\xintDouble{##1}[##2-1]}\xint:
}%
\def\XINT_LogTen_serIII_c_iii##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_ii
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-19\expandafter.%
  \the\numexpr\XINTdigitsormax-13\expandafter.\expanded{%
  {-25[-2]}.%
  \XINTinFloat[\XINTdigitsormax-7]{1/3[0]}.%
  }%
\fi
\ifnum\XINTdigits>27
\def\XINT_tmpa#1.#2.#3.#4.{%
```

```
\def\XINT_LogTen_serIII_a_v##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_vi
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_a_vi##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_iv
    \romannumeral0\xintadd{#3}{\xintiiOpp##1/6[##2]}\xint:
}%
\def\XINT_LogTen_serIII_c_iv##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_iii
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-25\expandafter.%
  \the\numexpr\XINTdigitsormax-19.%
  {2[-1]}.%
  {-25[-2]}.%
\fi
\ifnum\XINTdigits>33
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serIII_a_vi##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_vii
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_a_vii##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_v
    \romannumeral0\xintadd{#3}{##1/7[##2]}\xint:
}%
\def\XINT_LogTen_serIII_c_v##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_iv
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-31\expandafter.%
  \the\numexpr\XINTdigitsormax-25\expandafter.%
  \romannumeral0\XINTinfloatS[\XINTdigitsormax-25]{-1/6[0]}.%
```

```
  {2[-1]}.%
\fi
\ifnum\XINTdigits>39
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serIII_a_vii##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_viii
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_a_viii##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_vi
    \romannumeral0\xintadd{#3}{\xintiiMul{-125}{##1}[##2-3]}\xint:
}%
\def\XINT_LogTen_serIII_c_vi##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_v
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-37\expandafter.%
  \the\numexpr\XINTdigitsormax-31\expandafter.\expanded{%
  \XINTinFloat[\XINTdigitsormax-31]{1/7[0]}.%
  \XINTinFloat[\XINTdigitsormax-25]{-1/6[0]}.%
  }%
\fi
\ifnum\XINTdigits>45
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serIII_a_viii##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_ix
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_a_ix##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_vii
    \romannumeral0\xintadd{#3}{##1/9[##2]}\xint:
}%
\def\XINT_LogTen_serIII_c_vii##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_vi
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
```

```
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-43\expandafter.%
  \the\numexpr\XINTdigitsormax-37\expandafter.\expanded{%
  {-125[-3]}.%
  \XINTinFloat[\XINTdigitsormax-31]{1/7[0]}.%
  }%
\fi
\ifnum\XINTdigits>51
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serIII_a_ix##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_x
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_a_x##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_viii
    \romannumeral0\xintadd{#3}{\xintiiOpp##1[##2-1]}\xint:
}%
\def\XINT_LogTen_serIII_c_viii##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_vii
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-49\expandafter.%
  \the\numexpr\XINTdigitsormax-43\expandafter.%
  \romannumeral0\XINTinfloat[\XINTdigitsormax-43]{1/9[0]}.%
  {-125[-3]}.%
\fi
\ifnum\XINTdigits>57
\def\XINT_tmpa#1.#2.#3.#4.{%
\def\XINT_LogTen_serIII_a_x##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_a_xi
    \romannumeral0\XINTinfloatS[#2]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_a_xi##1\xint:
{%
    \expandafter\XINT_LogTen_serIII_b
    \romannumeral0\XINTinfloatS[#1]{##1}\xint:##1\xint:
}%
\def\XINT_LogTen_serIII_b##1[##2]\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_ix
    \romannumeral0\xintadd{#3}{##1/11[##2]}\xint:
```

```
}%
\def\XINT_LogTen_serIII_c_ix##1\xint:##2\xint:
{%
    \expandafter\XINT_LogTen_serIII_c_viii
    \romannumeral0\xintadd{#4}{\XINTinFloat[#2]{\xintMul{##1}{##2}}}\xint:
}%
}\expandafter\XINT_tmpa
  \the\numexpr\XINTdigitsormax-55\expandafter.%
  \the\numexpr\XINTdigitsormax-49\expandafter.\expanded{%
  {-1[-1]}.%
  \XINTinFloat[\XINTdigitsormax-43]{1/9[0]}.%
  }%
\fi
\XINTlogendinput%
```

15 Cumulative line and macro count

module	lines	macros
xintkernel	649	(146)
xinttools	1625	(376)
xintcore	2115	(526)
xint	1623	(410)
xintbinhex	470	(91)
xintgcd	366	(63)
xintfrac	3685	(989)
xintseries	384	(66)
xintcfrac	1027	(257)
xintexpr	4548	(1369)
xinttrig	869	(68)
xintlog	1395	(123)

Total number of code lines: 18756. (but 4325 lines among them start either with {% or with }%). Each package starts with circa 50 lines dealing with catcodes, package identification and reloading management, also for Plain TeX.

Total number of def'ed (or let'ed) macros: 4484. This is an approximation as some macros are def'ed in a way escaping the automated detection, in particular this applies to xintexpr macros associated to infix operators and syntax elements, whose construction uses \csname-based definitions with a template and auxiliary macros. Their number has been evaluated manually at being at least about 452 (this is incorporated into the xintexpr count shown left, and the total above.)

Version 1.4m of 2022/06/10.