The luamplib package

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Abstract

Package to have METAPOST code typeset directly in a document with LuaTEX

Contents

1 Documentation

This package aims at providing a simple way to typeset directly METAPOST code in a document with LuaTEX. LuaTEX is built with the Lua mplib library, that runs METAPOST code. This package is basically a wrapper for the Lua mplib functions and some TEX functions to have the output of the mplib functions in the PDF.

Using this package is easy: in Plain, type your METAPOST code between the macros \mplibcode and \endmplibcode, and in LATEX in the mplibcode environment.

The resulting METAPOST figures are put in a TEX hbox with dimensions adjusted to the METAPOST code.

The code of luamplib is basically from the luatex-mplib.lua and luatex-mplib.tex files from ConTEXt. They have been adapted to LATEX and Plain by Elie Roux and Philipp Gesang and new functionalities have been added by Kim Dohyun. The most notable changes are:

- Possibility to use btex ... etex to typeset TEX code. textext ⟨*string*⟩ is a more versatile macro equivalent to TEX ⟨*string*⟩ from TEX.mp. TEX is also allowed and is a synonym of textext. The argument of mplib's primitive maketext will also be processed by the same routine.

- Possibility to use verbatimtex ... etex to run a TEX code. VerbatimTeX ⟨*string*⟩ is a more versatile macro corresponding to verbatimtex command. Of course the behavior cannot be the same as the stand-alone **mpost**, so that you cannot include \documentclass, \usepackage etc. When these TEX commands are found in verbatimtex ... etex, the entire code will be ignored.

  The treatment of verbatimtex command has changed a lot since v2.20: see below § 1.1.6.

- In the past, the package required PDF mode in order to have some output. Starting with v2.7 it works in DVI mode as well, though DVIPDFMx is the only DVI tool currently supported.

It seems to be convenient to divide the explanations of some more changes and cautions into three parts: TEX, METAPOST, and Lua interfaces.

1.1 TEX

1.1.1 \mplibforcehmode

When this macro is declared, every METAPOST figure box will be typeset in horizontal mode, so that \centering, \raggedleft etc. will have effects. \mplibnoforcehmode, being default for backward compatibility, reverts this setting.[1]

1.1.2 \everymplib{...}, \everyendmplib{...}

\everymplib and \everyendmplib redefine the Lua table entry containing METAPOST code which will be automatically inserted at the beginning and ending of each METAPOST code chunk.

```
\everymplib{ beginfig(0); }
\everyendmplib{ endfig; }
\begin{mplibcode}
  % beginfig/endfig not needed
  draw fullcircle scaled 1cm;
\end{mplibcode}
```

1.1.3 \mplibsetformat{plain|metafun}

There are (basically) two formats for METAPOST: *plain* and *metafun*. By default, the *plain* format is used, but you can set the format to be used by future figures at any time using \mplibsetformat {⟨*format name*⟩}.

N.B. As *metafun* is such a complicated format, we cannot support all the special effects provided by *metafun*. At least, however, transparency (actually opacity), shading (gradient colors) and transparency group are fully supported, and outlinetext is supported by our own alternative mpliboutlinetext (see below § 1.2.11). You can try other effects as well, though we did not fully tested their proper functioning.

[1] Actually these commands redefine \prependtomplibbox. So you can redefine this macro with anything suitable before a box. But see § 1.1.18 on Tagged PDF.

transparency (texdoc metafun § 8.2) Transparency is so simple that you can apply it to an object, with *plain* format as well as *metafun*, just by appending `withprescript "tr_transparency=⟨numeric⟩"` to the sentence. ($0 \leq \langle numeric \rangle \leq 1$)

From v2.36, `withtransparency` is available with *plain* format as well. See below § 1.2.4.

shading (texdoc metafun § 8.3) One thing worth mentioning about shading is: when a color expression is given in string type, it is regarded by **luamplib** as a color expression of TEX side. For instance, when `withshadecolors("orange", 2/3red)` is given, the first color `"orange"` will be interpreted as a **color**, **xcolor** or **l3color**'s expression.

From v2.36, shading is available with *plain* format as well with extended functionality. See below § 1.2.6.

transparency group (texdoc metafun § 8.8) As for transparency group, the current *metafun* document is not correct. The true syntax is:

```
draw <picture>|<path> asgroup <string>
```

where ⟨*string*⟩ should be `""` (empty), `"isolated"`, `"knockout"`, or `"isolated,knockout"`. Beware that currently many of the PDF rendering applications, except Adobe Acrobat and Foxit Editor, cannot properly render the isolated or knockout effect.

Transparency group is available with *plain* format as well with extended functionality. See below § 1.2.13.

1.1.4 `\mplibnumbersystem{scaled|double|decimal}`

Users can choose `numbersystem` option. The default value is `scaled`, which can be changed by declaring `\mplibnumbersystem{double}` or `\mplibnumbersystem{decimal}`.

1.1.5 `\mplibshowlog{enable|disable}`

Default: `disable`. When `\mplibshowlog{enable}`[2] is declared, log messages returned by the METAPOST process will be printed to the `.log` file. This is the TEX side interface for `luamplib.showlog`.

1.1.6 `\mpliblegacybehavior{enable|disable}`

Legacy behavior By default, `\mpliblegacybehavior{enable}` is already declared for backward compatibility, in which case TEX code in `verbatimtex ... etex` that comes just before `beginfig()` will be inserted before the following METAPOST figure box. In this way, each figure box can be freely moved horizontally or vertically. Also, a box number can be assigned to a figure box, allowing it to be reused later.[3]

```
\mplibcode
  verbatimtex \moveright 3cm etex; beginfig(0); ... endfig;
```

[2] As for user's setting, `enable`, `true` and `yes` are identical; all others are identical to `disable`.

[3] But the recommended way to reuse a figure is using `\mplibgroup` command. See below § 1.2.14.

```
  verbatimtex \leavevmode etex; beginfig(1); ... endfig;
  verbatimtex \leavevmode\lower 1ex etex; beginfig(2); ... endfig;
  verbatimtex \endgraf\moveright 1cm etex; beginfig(3); ... endfig;
\endmplibcode
```

N.B. `\endgraf` should be used instead of `\par` inside mplibcode environment.

On the other hand, TEX code in `verbatimtex ... etex` between `beginfig()` and `endfig` will be inserted after flushing out the METAPOST figure. An example:[4]

```
\mplibcode
  D := sqrt(2)**9;
  beginfig(0);
    draw fullcircle scaled D;
    VerbatimTeX("\gdef\Dia{" & decimal D & "}");
  endfig;
\endmplibcode
diameter: \Dia bp.
```

diameter: 22.62764bp.

New and recommended way By contrast, when `\mpliblegacybehavior{disable}` is declared, any `verbatimtex ... etex`, along with `btex ... etex`, will be run sequentially one by one. So, some TEX code in `verbatimtex ... etex` will have effect on `btex ... etex` codes thereafter.

```
\begin{mplibcode}
  beginfig(0);
    draw btex ABC etex;
    verbatimtex \bfseries etex;
    draw btex DEF etex shifted (1cm,0);    % bold face
    draw btex GHI etex shifted (2cm,0);    % bold face
  endfig;
\end{mplibcode}
```

ABC **DEF** **GHI**

1.1.7 `\mplibtextextlabel{enable|disable}`

Default: `disable`. `\mplibtextextlabel{enable}` enables the labels typeset via `textext` instead of `infont` operator. So, `label("my text", origin)` thereafter is exactly the same as `label(textext "my text", origin)`.

N.B. In the background, **luamplib** redefines `infont` operator so that the right side argument (the font part) is totally ignored. Therefore the left side arguemnt (the text part) will be typeset with the current TEX font.

From v2.35, however, the redefinition of `infont` operator has been revised: when the character code of the text argument is less than 32 (control characters), or is equal to 35 (#), 36 ($), 37 (%), 38 (&), 92 (\), 94 (^), 95 (_), 123 ({), 125 (}), 126 (~) or 127 (DEL), the original `infont` operator will be used instead of `textext` operator so that the font part will be honored. Despite the revision, please take care of `char` operator in the text argument, as this might bring unpermitted characters into TEX.

[4] But the recommended way to access METAPOST variables from TEX (or Lua) side is to use Lua code via `luamplib.instances`. For details see below § 1.3.2.

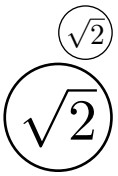
1.1.8 \mplibcodeinherit{enable|disable}

Default: disable. \mplibcodeinherit{enable} enables the inheritance of variables, constants, and macros defined by previous METAPOST code chunks. On the other hand, \mplibcodeinherit {disable} will make each code chunk being treated as an independent instance, never affected by previous code chunks.

1.1.9 \mplibglobaltextext{enable|disable}

Default: disable. Formerly, to inherit btex ... etex boxes as well as other METAPOST macros, variables and constants, it was necessary to declare \mplibglobaltextext{enable} in advance. But from v2.27, this is implicitly enabled when \mplibcodeinherit is enabled. The command still remains mostly for backward compatibility.

```
\mplibcodeinherit{enable}
%\mplibglobaltextext{enable}
\everymplib{ beginfig(0);} \everyendmplib{ endfig;}
\mplibcode
  label(btex $\sqrt{2}$ etex, origin);
  draw fullcircle scaled 20;
  picture pic; pic := currentpicture;
\endmplibcode
\mplibcode
  currentpicture := pic scaled 2;
\endmplibcode
```



1.1.10 Separate METAPOST instances

luamplib v2.22 has added the support for several named METAPOST instances in LaTeX environment mplibcode or Plain TeX commands \mplibcode ... \endmplibcode. The syntax for LaTeX is:

```
\begin{mplibcode}[instanceName]
  % some mp code
\end{mplibcode}
```

The behavior is as follows.

- All the variables and functions are shared only among all the environments belonging to the same instance.
- \mplibcodeinherit only affects the environments with no instance name set (since if a name is set, the code is intended to be reused at some point).
- btex ... etex boxes are also shared and do not require \mplibglobaltextext.
- When an instance names is set, respective \currentmpinstancename is set as well.

In parellel with this functionality, we support optional argument of instance name for \everymplib and \everyendmplib, affecting only those mplibcode environments of the same name.

Unnamed \everymplib affects not only those instances with no name, but also those with name but with no corresponding \everymplib. The syntax is:

```
\everymplib[instanceName]{...}
\everyendmplib[instanceName]{...}
```

1.1.11 \mplibverbatim{enable|disable}

Default: disable. Users can issue \mplibverbatim{enable}, after which the contents of mplibcode environment will be read verbatim. As a result, except for \mpdim and \mpcolor (see § 1.1.12 and § 1.1.13), all other TEX commands outside of the btex or verbatimtex ... etex are not expanded and will be fed literally to the **mplib** library.

1.1.12 \mpdim{...}

Besides other TEX commands, \mpdim is specially allowed in the mplibcode environment. This feature is inpired by **gmp** package authored by Enrico Gregorio. Please refer to the manual of **gmp** package for details.

```
draw origin--(.4\mpdim{\linewidth},0)
  withpen pencircle scaled 4 dashed evenly scaled 4
  withcolor \mpcolor{orange} ;
```


1.1.13 \mpcolor[...]{...}

With \mpcolor command, color names or expressions of **color**, **xcolor** and **l3color** module/packages can be used in the mplibcode environment (after withcolor command, in principle). See the example above at § 1.1.12. The optional [...] denotes the option of **xcolor**'s \color command. For spot colors, **l3color** module is well supported in PDF and DVI mode. Package **colorspace** is supported as well in PDF mode, but could conflict with **luamplib**'s special features such as shading when \DocumentMetadata, ie. PDF management code, is not loaded.

N.B. Formerly, only the first object would have been colored as intended among multiple graphical objects in a METAPOST image, because \mpcolor always produced withprescript command internally. Since v2.38.1, now that \mpcolor returns a METAPOST color expression if possible, users can issue the sentence as follows without worrying about the location of the color command:

```
draw image (drawarrow (left--right) scaled 5)
  scaled 8
  withcolor \mpcolor{red!50} ;
```

N.B. Be aware, however, that even after v2.38.1 \mpcolor still inserts withprescript command when the color specified is a spot color (or named color in DVI mode). Users therefore have to revise the code so that the color can have effect inside the image. For instance:

```
draw image (drawarrow (left--right) scaled 5)
  scaled 8
  withcolor \mpcolor{spotA}
  withoutcolor ;
```

or preferably,

```
draw image (drawarrow (left--right) scaled 5 withcolor \mpcolor{spotA})
  scaled 8 ;
```

1.1.14 \mpfig ... \endmpfig

Besides the mplibcode environment (for LaTeX) and \mplibcode ... \endmplibcode (for Plain), we also provide unexpandable TeX macros \mpfig ... \endmpfig and its starred version \mpfig* ... \endmpfig to save typing toil. The former is roughly the same as follows:

```
\begin{mplibcode}[@mpfig]
  beginfig(0)
    token list declared by \everymplib[@mpfig]
    ...
    token list declared by \everyendmplib[@mpfig]
  endfig;
\end{mplibcode}
```

and the starred version is roughly the same as follows:

```
\begin{mplibcode}[@mpfig]
  ...
\end{mplibcode}
```

In these macros \mpliblegacybehavior{disable} is forcibly declared. Again, as both share the same instance name, METAPOST codes are inherited among them. A simple example:

```
\everymplib[@mpfig]{ drawoptions(withcolor 1/3[red,white]); }
\mpfig* input boxes \endmpfig
\mpfig
  circleit.a(btex Box 1 etex); drawboxed(a);
\endmpfig
```

Users can change the instance name (default value: @mpfig) by redefining \mpfiginstancename, after which a new mplib instance will start and code inheritance too will begin anew. \let \mpfiginstancename\empty will prevent code inheritance if \mplibcodeinherit is not true.

1.1.15 About cache files

To support btex ... etex in external .mp files, luamplib inspects the content of each and every .mp file and makes caches if neceeccsary before returning their paths to the mplib library. This could waste the compilation time, as most .mp files do not contain btex ... etex commands. So luamplib provides macros as follows, so that users can give instructions about files that do not require this functionality.

- \mplibmakenocache{⟨*filename*⟩[,⟨*filename*⟩,...]}
- \mplibcancelnocache{⟨*filename*⟩[,⟨*filename*⟩,...]}

where ⟨*filename*⟩ is a filename without .mp extension. Note that .mp files under $TEXMFMAIN/metapost/base and $TEXMFMAIN/metapost/context/base are already registered by default.

N.B. \mplibmakenocache{*} will suppress making cache files. Use it at your own risk.

By default, cache files will be stored in $TEXMFVAR/luamplib_cache or, if it's not available (mostly not writable), in the directory where output files are saved: to be specific, $TEXMF_OUTPUT_DIRECTORY/luamplib_cache, ./luamplib_cache, $TEXMFOUTPUT/luamplib_cache, and ., in this order. $TEXMF_OUTPUT_DIRECTORY is normally the value of --output-directory command-line option.

Users can change this behavior by the command \mplibcachedir{⟨*directory path*⟩}, where tilde (~) is interpreted as the user's home directory (on a windows machine as well). As backslashes (\) should be escaped by users, it would be easier to use slashes (/) instead.

1.1.16 About figure box metric

Notice that, after each figure is processed, the macro \MPwidth stores the width value of the latest figure; \MPheight, the height value. Incidentally, also note that \MPllx, \MPlly, \MPurx, and \MPury store the bounding box information of the latest figure without the unit bp.

1.1.17 luamplib.cfg

At the end of package loading, **luamplib** searches luamplib.cfg and, if found, reads the file in automatically. Frequently used settings such as \everymplib, \mplibforcehmode or \mplibcodeinherit are suitable for going into this file.

1.1.18 Tagged PDF

When **tagpdf** package is loaded and activated, mplibcode environment accepts additional options for tagged PDF. The code related to this functionality is currently in experimental stage, not guaranteeing backward compatibility. Available optional keys are similar to those of the LaTeX's picture environment (texdoc latex-lab-graphic). The default tagging mode is the alt key with Figure structure.

alt=⟨*text*⟩ starts a Figure tag by default and sets an alternate text of the figure from the ⟨*text*⟩. BBox info will be added automatically to the PDF. This key is needed for ordinary METAPOST figures, for which, if no alt text is given, a default text will be used with a warning issued. You can change the alternate text within METAPOST code as well: VerbatimTeX "\mplibalttext{⟨*text*⟩}";

actualtext=⟨*text*⟩ starts a Span tag implicitly and sets a replacement text (a.k.a. actual text) from the ⟨*text*⟩. If in vertical mode, horizontal mode will be forced by \noindent command.[5] BBox info will not be added. This key is intended for figures which can be represented by a character or a small sequence of characters. You can change the actual text within METAPOST code as well: VerbatimTeX "\mplibactualtext{⟨*text*⟩}";

[5]It is not recommended to personally redefine \prependtomplibbox. Apart from using \mplibforcehmode or \mplibnoforcehmode, the redefinition might be incompatible with actualtext key. See § 1.1.1 on these commands.

artifact starts an `Artifact` MC (marked content). BBox info will not be added. This key is intended for decorative figures which have no semantic meaning.

text starts an `Artifact` MC but enables tagging on TEX-text boxes (such as `btex ... etex`, excluding pictures made by `infont` operator). If in vertical mode, horizontal mode will be forced by `\noindent` command.[6] BBox info will not be added. This key is intended for figures the meaning of which is the sequence of texts in the TEX-text boxes in the order they are drawn in the figure.

N.B. Within `text`-mode figures, reusing TEX-text boxes is strongly discouraged.

Note that the text in a TEX-text box which starts with `[taggingoff]` will not be tagged at all, and of course `[taggingoff]` and its trailing spaces will be gobbled by **luamplib**. For example, the first and the third boxes in the following figure will not be tagged, and still remain in the `Artifact` MC-chunks.

```
\begin{mplibcode}[text]
  beginfig(1)
    draw btex [taggingoff] $\sqrt 2$ etex ;
    draw textext "$\sqrt 3$" shifted 12down ;
    draw TEX "[taggingoff] $\sqrt 5$" shifted 24down ;
    draw maketext "$\sqrt 7$" shifted 36down ;
    draw mplibgraphictext "$\sqrt x$" shifted 48down ;
  endfig;
\end{mplibcode}
```

$\sqrt{2}$
$\sqrt{3}$
$\sqrt{5}$
$\sqrt{7}$
$\sqrt{x}$

off Given this key, nothing will be tagged by **luamplib**.

tag=⟨*name*⟩ You can choose a tag name, default value being `Figure`.[7] For instance, you can set `tag=Formula, alt=`⟨*text*⟩ to get a `Formula` element with its alternate text.[8]

adjust-BBox=⟨*dimens*⟩ You can correct the BBox attribute of the figure by space-separated four dimensional values, which will be added to the automatically calculated BBox values. To draw the bounding box for checking with half-transparent red color, you can add `debug=BBox` to the argument of `\DocumentMetadata` command.

tagging-setup=⟨*key-val list*⟩ This key accepts as its value the list of key-value options mentioned so far.

You can set these options anywhere in the document by declaring `\SetKeys[luamplib/tagging]` {⟨*key-val list*⟩}, which will affect **mplib** figures thereafter in the scope. And the options listed above are provided for `\mpfig` and `\usemplibgroup` (see below § 1.2.13) commands as well.

```
\begin{mplibcode}[myInstanceName, alt=drawing of a circle]
  ...
```

[6] The key `text` also shares the limitation mentioned in the previous footnote.
[7] The option `tag=false`, however, is a synonym of the `off` key.
[8] Beware that this bypasses LATEX's regular math formula tagging, for which the `text` key is needed.

```
\end{mplibcode}

\mpfig[alt=drawing of a square box]
  ...
\endmpfig

\usemplibgroup[alt=drawing of a triangle]{...}

\mppattern{...}          % see below
  \mpfig[off]            % do not tag this figure
    ...
  \endmpfig
\endmppattern
```

As for the instance name of `mplibcode` environment, `instance=`⟨*name*⟩ or `instancename=`⟨*name*⟩ is also allowed in addition to the raw instance name as shown above.

1.2 MetaPost

1.2.1 `mplibdimen ..., mplibcolor ...`

`mplibdimen` ⟨*string*⟩ and `mplibcolor` ⟨*string*⟩ are METAPOST interfaces for the TEX commands `\mpdim` and `\mpcolor` (see above § 1.1.12 and § 1.1.13). For example, `mplibdimen "\linewidth"` is basically the same as `\mpdim{\linewidth}`, and `mplibcolor "red!50"` is basically the same as `\mpcolor{red!50}`. The difference is that these METAPOST operators can also be used in external `.mp` files, which cannot have TEX commands outside of the `btex` or `verbatimtex ... etex`.

1.2.2 `mplibtexcolor ..., mplibrgbtexcolor ...`

`mplibtexcolor` ⟨*string*⟩ is a METAPOST operator that converts a TEX color expression to a METAPOST color expression, that can be used anywhere color expression is expected as well as after the `withcolor` command.[9] For instance:

```
color col;
col := mplibtexcolor "olive!50";
```

But the result may vary in its color model (gray/rgb/cmyk) according to the given TEX color. Therefore the example shown above would raise a METAPOST error: `cmykcolor col;` should have been declared. By contrast, `mplibrgbtexcolor` ⟨*string*⟩ always returns rgb-model expressions.

N.B. Spot colors are forced to cmyk or rgb model, so these operators are not recommended for spot colors.

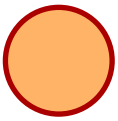
1.2.3 `withmplibcolors (..., ...)`

Unlike the `withcolor` command, users can specify one color for filling and another color for stroking using the macro `withmplibcolors` at the end of a sentence. The syntax is `withmplibcolors`

[9] Since v2.38.1, the operation of `mplibtexcolor` is the same as that of `mplibcolor` if the color specified is not a spot color or a named color in DVI mode.

(⟨*fill color expr*⟩, ⟨*stroke color expr*⟩). When the argument is in string type, it is regarded as the color expression of TEX side. A simple example (see also the example at § 1.2.10):

```
filldraw fullcircle scaled 40
  withpen pencircle scaled 2
  withmplibcolors ("orange!60", 2/3red) ;
```

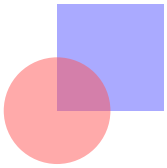


The PDF file size is much smaller than issueing two sentences with different colors, though the apparent effect is the same.

1.2.4 withtransparency (..., ...)

withtransparency(⟨*number*⟩ | ⟨*string*⟩, ⟨*numeric*⟩) is provided for *plain* format as well as *metafun*. The first argument accepts a number or a name among alternative transparency methods (see texdoc metafun § 8.2 Figure 8.1). The second argument accepts a numeric expression denoting opacity.

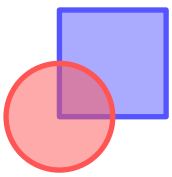
```
\mpfig
  fill unitsquare scaled 40
    withcolor 1/3[blue,white]
    withtransparency (1, 0.5)          % or ("normal", 0.5)
    ;
  fill fullcircle scaled 40
    withcolor 1/3[red,white]
    withtransparency (1, 0.5)
    ;
\endmpfig
```



1.2.5 withmplibopacities (..., ..., ...)

By analogy with the macro withmplibcolors (see above § 1.2.3), the macro withmplibopacities is also provided. The syntax is withmplibopacities (⟨*number*⟩ | ⟨*string*⟩, ⟨*numeric*⟩, ⟨*numeric*⟩). The first argument is the same as that of withtransparency command described above at § 1.2.4; the latter two arguments are numeric expressions denoting *fill opacity* and *stroke opacity* respectively. It is more efficient than issueing two sentences with different opacities.

```
\mpfig
  pickup pencircle scaled 2;
  filldraw unitsquare scaled 40
    withcolor 1/3[blue,white]
    withmplibopacities (1, 1/2, 1)      % or ("normal", 1/2, 1)
    ;
  filldraw fullcircle scaled 40
    withcolor 1/3[red,white]
    withmplibopacities (1, 1/2, 1)
    ;
\endmpfig
```



1.2.6 ... withshadingmethod ...

The syntax is exactly the same as *metafun*'s new shading method (texdoc metafun § 8.3.3), except that the 'shade' contained in each and every macro name has changed to 'shading' in luamplib: for instance, while withshademethod is a macro name which only works with *metafun* format, the equivalent provided by luamplib, withshadingmethod, works with *plain* as well. Other differences to the *metafun*'s and some cautions are:

- *Textual pictures* as well as paths can have shading effect. The term *textual picture* here means a picture generated by btex ... etex, textext, TEX, maketext, mplibgraphictext (see below § 1.2.8), or infont operator, though technically only the last one is a true textual picture. Note that the picture, including transparency group, in which the objects are filled *without* color can also be regarded as a textual picture (e.g., see below § 1.2.10, particularly the first example of tiling pattern at § 1.2.12; see also § 1.2.13 and § 1.2.14).

```
draw btex \bfseries\TeX etex rotated 15 scaled 6
  withshadingmethod "linear"
  withshadingvector (0,3)
  withshadingstep (
    withshadingfraction 1/2
    withshadingcolors (red,green)
  )
  withshadingstep (
    withshadingfraction 1
    withshadingcolors (green,blue)
  ) ;
```

- When shading a picture generated by 'infont' operator or that has multiple components, the effect of withshadingvector and that of withshadingdirection will be the same, as luamplib considers only the bounding box of the picture.
- Optional macro withshadingstroke is available (see below).

As shown, the syntax is ⟨*path*⟩ | ⟨*textual picture*⟩ withshadingmethod ⟨*string*⟩, where the latter shall be either "linear" or "circular". Other macros for optional values are:

withshadingvector ⟨***pair***⟩ Starting and ending points (as time value) on the path.

withshadingdirection ⟨***pair***⟩ Starting and ending points (as time value) on the bounding box. Default value: (0,2)

withshadingorigin ⟨***pair***⟩ The center of starting and ending circles. Default value: center p, where p is the operand of withshadingmethod.

withshadingradius ⟨***pair***⟩ Radii of starting and ending circles. This is no-op in linear mode. Default value: (0, abs(center p - urcorner p))

withshadingfactor ⟨***numeric***⟩ Multiplier of the radii. This is no-op in linear mode. Default value: 1.2

withshadingcenter ⟨***pair***⟩ Values for shifting starting center. For instance, `(0,0)` means that the center of starting circle is `center p`; `(1,1)` means `urcorner p`; `(-1,-1)` means `llcorner p`.

withshadingtransform ⟨***string***⟩ where ⟨*string*⟩ shall be `"yes"` (respect transform) or `"no"` (ignore transform). Default value: `"no"` for pictures made by `infont` operator or having multiple components; `"yes"` for all other cases.

withshadingdomain ⟨***pair***⟩ Limiting values of parametric variable that varies on the axis of color gradient. Default value is `(0,1)`. Of course the values can be negative or greater than 1.

withshadingstep (...) for combined shading of more than two colors.

withshadingfraction ⟨***numeric***⟩ Fractional number of each shading step. Only meaningful with `withshadingstep`.

withshadingcolors (⟨***color expr***⟩**,** ⟨***color expr***⟩**)** Starting and ending colors, default value being `(white, black)`. String-type argument is regarded as the color expression of TEX side.

withshadingstroke ⟨***string***⟩ where ⟨*string*⟩ shall be `"yes"` or `"no"`. Only meaningful when the shading object is a ⟨*path*⟩; if `"yes"`, we get the path stroked and *then* shaded. It is more efficient than issueing two sentences.

1.2.7 ... withfademethod ...

This is a METAPOST command which makes the color of an object gradiently transparent, a.k.a. *fading*. The syntax is ⟨*path*⟩ | ⟨*picture*⟩ `withfademethod` ⟨*string*⟩, the latter being either `"linear"` or `"circular"`. Though it is similar to the `withshademethod` from *metafun*, the differences are: (1) the object of fading can be a picture as well as a path; (2) you cannot make gradient colors, but can only make gradient opacity. Technically speaking, this command generates and applies a special kind of masking transparency group described below at § 1.2.15.

Related macros to control optional values are:

withfadeopacity (⟨***numeric***⟩**,** ⟨***numeric***⟩**)** sets the starting opacity and the ending opacity, default value being `(1,0)`. '`1`' denotes full color; '`0`' full transparency.

withfadevector (⟨***pair***⟩**,** ⟨***pair***⟩**)** sets the starting and ending points. Default value in the linear mode is `(llcorner p, lrcorner p)`, where `p` is the operand, meaning that fading starts from the left edge and ends at the right edge. Default value in the circular mode is `(center p, center p)`, which means centers of both starting and ending circles are the center of the bounding box.

withfadecenter is a synonym of `withfadevector`.

withfaderadius (⟨***numeric***⟩**,** ⟨***numeric***⟩**)** sets the radii of starting and ending circles. This is no-op in the linear mode. Default value is `(0, abs(center p - urcorner p))`, meaning that fading starts from the center and ends at the four corners of the bounding box.

withfadebbox (⟨*pair*⟩, ⟨*pair*⟩) sets the bounding box of the fading area, default value being `(llcorner p, urcorner p)`. Though this option is not needed in most cases, there could be cases when users want to explicitly control the bounding box. Particularly, see the description below at § 1.2.13 on the analogous macro `withgroupbbox`.

An example:

```
draw
  btex \includegraphics[width=100bp]{mill} etex
  withfademethod  "circular"
  withfaderadius  (20, 50)
  withfadeopacity (1, 0) ;
```

1.2.8 `mplibgraphictext ...`

`mplibgraphictext` ⟨*string*⟩ is a METAPOST operator, the effect of which is similar to that of ConTEXt's `graphictext` or our own `mpliboutlinetext` (see below § 1.2.11). However the syntax is somewhat different.

```
draw mplibgraphictext "$\sqrt{2+x}$"
  rotated 15 scaled 3
  fakebold 2.5                          % fontspec option
  fillcolor "red!50"                    % color expression
  drawcolor 2/3 red                     % or strokecolor 2/3 red
  ;
```

`fakebold`, `fillcolor` and `drawcolor` (or `strokecolor`) are optional; default values are `2`, `"white"` and `"black"` respectively.[10] When the color expression is given in string type, it is regarded as **color**, **xcolor** or **l3color**'s expression. All from `mplibgraphictext` to the end of sentence will compose an anonymous picture, which can be drawn or assigned to a variable. Incidentally, `withfillcolor` and `withdrawcolor` are synonyms of `fillcolor` and `drawcolor`, hopefully to be compatible with `graphictext`.

N.B. In some cases, especially when processing complicated TEX code, `mplibgraphictext` will produce better results than ConTEXt or even than our own `mpliboutlinetext`, not to mention the much smaller PDF file size. There are, however, some limitations such that you can't apply shading (gradient colors) to the text with *metafun*'s `withshademethod`.[11] Again, in DVI mode, **unicode-math** package is needed for math formulae, as we cannot embolden type1 fonts in DVI mode. But the most critical limitation is that, unlike `mpliboutlinetext`, you cannot manipulate the shape of outline paths, because the returned picture is basically a `btex ... etex` picture.

1.2.9 `mplibglyph ... of ...`

METAPOST operator `mplibglyph` ⟨*number*⟩ | ⟨*string*⟩ `of` ⟨*number*⟩ | ⟨*string*⟩ returns a METAPOST picture containing outline paths of a glyph in OpenType, TrueType or Type1 (`.pfb`) fonts. When a TFM font is specified, METAPOST primitive `glyph` will be called.

```
mplibglyph 50  of \fontid\font          % slot 50 of current font
```

[10] Users can use the `withmplibcolors` macro instead of `fillcolor` and `drawcolor` options. See § 1.2.3 on this macro.

[11] But this limitation is now lifted by the introduction of `withshadingmethod`. See above § 1.2.6.

```
mplibglyph "Q" of "TU/TeXGyrePagella(0)/m/n/10"      % font csname
mplibglyph "Q" of "texgyrepagella-regular.otf"       % raw filename
mplibglyph "R" of "utmr8a.pfb"                       % raw filename (type1 font)
mplibglyph "Q" of "Times.ttc(2)"                     % subfont number
mplibglyph "Q" of "SourceHanSansK-VF.otf[Regular]"   % instance name
mplibglyph "R" of "SourceHanSansK-VF.otf[wght=800]"  % axis names & values
```

Both arguments before and after 'of' can be either a number or a string. Number arguments are regarded as a glyph slot (GID) and a font id number, repectively. String argument at the left side is regarded as a glyph name in the font or a unicode character. String argument at the right side is regarded as a TEX font csname (without backslash) or the raw filename of a font. When it is a font filename, a number within parentheses after the filename denotes a subfont number (starting from zero) of a TTC font; a string within brackets denotes an instance name, or names and values for axis feature, of a variable font.

N.B. Regrettably we have some bug in processing not a few glyphs in cmr10.pfb and its family (or maybe other) Type1 fonts.[12] If that happens, consider using glyph operator instead of mplibglyph.

1.2.10 mplibdrawglyph ..., mplibstrokeglyph ..., mplibfillandstrokeglyph ...

As the structure of the picture returned by mplibglyph is quite similar to the result of glyph primitive, METAPOST's draw command will fill the inner path of the picture with the background color. In contrast, mplibdrawglyph ⟨*picture*⟩ command fills the paths according to the nonzero winding number rule. As a result, for instance, the area surrounded by inner path of "O" will remain transparent.

N.B. To apply the nonzero winding number rule to a picture containing paths, luamplib appends withpostscript "collect" to the paths except the last one in the picture. If you want the even-odd rule instead, you can additionally declare withpostscript "evenodd" to the last path.

N.B. By the way, when you want fill-and-stroke effect, issueing filldraw command to the last path will not always produce what you want: in such cases, you have to issue the command draw ⟨*the last path*⟩ withpostscript "both" (or "eoboth" to apply even-odd rule).[13]

As this could be somewhat annoying to users, luamplib v2.38.0 or later provides the following commands as well: mplibfillandstrokeglyph ⟨*picture*⟩, mplibstrokeglyph ⟨*picture*⟩, and mplibfillglyph ⟨*picture*⟩, the last one being a synonym of mplibdrawglyph command.

An example:

```
mplibfillandstrokeglyph
  mplibglyph "R" of \fontid\font scaled 1/12
  withpen pencircle scaled 1
  withmplibcolors ("orange", 2/3red) ;
```

[12] The bug seems to be fixed in font-cff.lmt contained in ConTEXt mkxl, but current luaotfload is based on font-cff.lua from ConTEXt mkiv. As you see, mplibglyph operator requires luaotfload package loaded, which however is done automatically by LATEX format.

[13] *metafun* provides macros nofill, eofill, fillup, eofillup etc. (see *metafun* manual § 2.11), which luamplib with *plain* format does not provide currently.

1.2.11 mpliboutlinetext (...)

As said before at § 1.1.3, luamplib provides the METAPOST operator mpliboutlinetext (⟨*string*⟩) which mimicks *metafun*'s outlinetext, but with some enhancements including the support for right-to-left writing direction. The syntax is the same as that of *metafun*: see the *metafun* documentation § 8.7 (texdoc metafun).

A simple example:

```
draw mpliboutlinetext.b ("$\sqrt{2+\alpha}$")
  (withcolor \mpcolor{red!50})
  (withpen pencircle scaled .25 withcolor 2/3red)
  scaled 3 ;
```

After the process, mpliboutlinepic[] and mpliboutlinenum will be preserved as global variables; mpliboutlinepic[1] ... mpliboutlinepic[mpliboutlinenum] will be an array of images, each of which containing outline paths of a glyph or a rule.

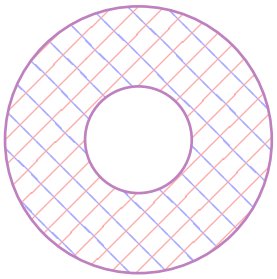
N.B. As Unicode grapheme cluster is not considered in the array, a unit that must be a single cluster might be separated apart.

1.2.12 \mppattern{...} ... \endmppattern, ... withmppattern ...

TEX macros \mppattern{⟨*name*⟩} ... \endmppattern define a tiling pattern cell associated with the ⟨*name*⟩. METAPOST command withmppattern, the syntax being ⟨*cyclic path*⟩ | ⟨*textual picture*⟩ withmppattern ⟨*string*⟩, will fill the given path or text with the tiling pattern cell of the ⟨*name*⟩ by replicating it horizontally and vertically.[14] As said before at § 1.2.6, the *textual picture* here means any text typeset by TEX, mostly the result of the btex command (and its derivatives) or the infont operator.

An example:

```
\mppattern{mypatt}              % or \begin{mppattern}{mypatt}
  [                             % options: see below
    xstep = 10,
    ystep = 7,
    matrix = "rotated 45",      % or "0.7 0.7 -0.7 0.7" or {0.7, 0.7, -0.7, 0.7}
  ]
  \mpfig                        % or any other TeX code
    draw (up--down) scaled 5
      withcolor 2/3[blue,white] ;
    draw (left--right) scaled 5
      withcolor 2/3[red,white] ;
  \endmpfig
\endmppattern                   % or \end{mppattern}

\mpfig
  mplibdrawglyph image(
```



[14] withpattern is an operator virtually the same as withmppattern, but the former forces a METAPOST picture. Therefore you cannot but use draw command with withpattern operator. On the other hand, ⟨*cyclic path*⟩ withmppattern ⟨*string*⟩ works as intended only with fill or filldraw command.

Table 1: options for \mppattern

Key	Value Type	Explanation
xstep	*number*	horizontal spacing between pattern cells
ystep	*number*	vertical spacing between pattern cells
xshift	*number*	horizontal shifting of pattern cells
yshift	*number*	vertical shifting of pattern cells
bbox	*table* or *string*	llx, lly, urx, ury values*
matrix	*table* or *string*	xx, yx, xy, yy values* or MP transform code
resources	*string*	PDF resources if needed
colored or coloured	*boolean*	false for uncolored pattern. default: true

* in string type, numbers are separated by spaces

```
    draw fullcircle scaled 100;
    draw reverse fullcircle scaled 40;
  )
  withmppattern "mypatt"
  withpen pencircle scaled 1
  withcolor \mpcolor{red!50!blue!50} ;
\endmpfig
```

The available options, actually elements of a Lua *table*, are listed in Table 1. For the sake of convenience, the width and height values of the tiling pattern cell will be written down into the log file (depth is always zero). Users can refer to them for option setting.

As for matrix option, METAPOST code such as "rotated 30 slanted .2" is allowed as well as the string or table of four numbers. You can also set xshift and yshift values by using 'shifted' operator. But when xshift or yshift option is explicitly given, they have precedence over the effect of 'shifted' operator.

When you use special effect such as transparency in a pattern cell, resources option is needed: for instance, resources="/ExtGState <</MyObj 5 0 R>>". However, as **luamplib** automatically includes the resources of the current page, this option is not needed in most cases.

Option colored=false (or coloured=false) will generate an uncolored pattern cell which shall have no color at all (i.e. withoutcolor command is needed for METAPOST code).[15] Uncolored pattern will be painted later by the color of a METAPOST object. An example:

```
\begin{mppattern}{pattnocolor}
  [
    colored = false,
    matrix = "slanted .3 rotated 30",
  ]
  \tiny\TeX
\end{mppattern}

\begin{mplibcode}
```

[15] When using DVI mode, -c option might be needed to the dvipdfmx command.

```
  beginfig(1)
    picture tex;
    tex = mpliboutlinetext ("\bfseries \TeX");
    for i=1 upto mpliboutlinenum:
      mplibfillandstrokeglyph mpliboutlinepic[i]
        scaled 8
        withmppattern "pattnocolor"
        withpen pencircle scaled 1/2
        withcolor (i/4)[red,blue]      % paints the pattern
        ;
    endfor
  endfig;
\end{mplibcode}
```

A much simpler and efficient way to obtain a similar result (but without colorful characters in this example) is to give a *textual picture* as the operand of `withmppattern`:

```
\begin{mplibcode}
  beginfig(2)
    draw mplibgraphictext "\bfseries\TeX"
      fakebold 1/2
      rotated 15 scaled 8
      withmppattern "pattnocolor"
      withmplibcolors (
        2/3[red,white],                % paints the pattern
        2/3 red
      ) ;
  endfig;
\end{mplibcode}
```

1.2.13 ... asgroup ...

As said before at § 1.1.3, transparency group is available with *plain* as well as *metafun*. It is called *Transparency Group* because the objects contained in the group are composited to produce a single object, so that outer transparency effect, if any, will be applied to the group as a whole, not to the individual objects cumulatively.

The syntax is basically the same as *metafun*'s: ⟨*picture*⟩ | ⟨*path*⟩ `asgroup` ⟨*string*⟩, the latter being `""` | `"isolated"` | `"knockout"` | `"isolated,knockout"` | `"off"`, which will return a METAPOST picture. The additional features provided by **luamplib** are:

- As shown, in addition to those arguments mimicking *metafun*'s, we allow another argument at the right-hand side: `asgroup "off"` will produce an ordinary *form XObject* rather than a transparency group XObject. On the contrary, `asgroup ""` (empty string) will produce a transparency group in which both of the PDF keys `/I` and `/K` are `false`.

- You can reuse the group as many times as you want in the TEX code or in other METAPOST code chunks, with infinitesimal increase in the size of PDF file. For this functionality we provide TEX and METAPOST macros as follows:

withgroupname ⟨***string***⟩ associates a transparency group with the given name. When this is not appended to the sentence with asgroup operator, the default group name '`lastmplibgroup`' will be used.

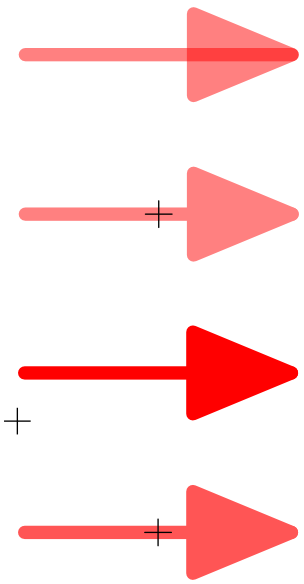
\usemplibgroup{⟨***name***⟩**}** is a TEX command to reuse a transparency group of the name once used. Note that the position of the group will be origin-based: in other words, lower-left corner of the bounding box will be shifted to the origin.

usemplibgroup ⟨***string***⟩ is a METAPOST command which will add a transparency group of the name to the currentpicture. Contrary to the TEX command just mentioned, the position of the group is the same as the original transparency group.

withgroupbbox (⟨***pair***⟩**,** ⟨***pair***⟩**)** sets the bounding box of the transparency group, default value being `(llcorner p, urcorner p)`. This option might be needed especially when you draw with a thick pen a path that touches the boundary; you would probably want to append to the sentence '`withgroupbbox (bot lft llcorner p, top rt urcorner p)`', supposing that the pen was selected by the `pickup` command.

An example showing the effect of transparency group and the difference between the TEX and METAPOST commands:

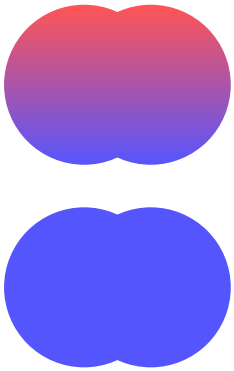
```
\mpfig
  picture pic;
  pic = image(drawarrow (left--right) scaled 5 withcolor red) scaled 10 ;
  draw pic
    asgroup "off"
    withtransparency (1, 1/2) ;
\endmpfig

\mpfig
  draw pic
    asgroup ""
    withgroupname "mygroup"
    withtransparency (1, 1/2) ;
  draw (left--right) scaled 5 ;
  draw (up--down) scaled 5 ;
\endmpfig

\noindent
\clap{\vrule width 10bp height .25bp depth .25bp}%
\clap{\vrule width .5bp height 5bp depth 5bp}%
\usemplibgroup{mygroup}

\mpfig
  usemplibgroup "mygroup"
    withtransparency (1, 2/3) ;
  draw (left--right) scaled 5 ;
  draw (up--down) scaled 5 ;
\endmpfig
```



Also note that normally the transparency groups are not affected by outer color commands. However, if you have made the original transparency group using `withoutcolor` command, colors will have effects on the uncolored objects in the group.

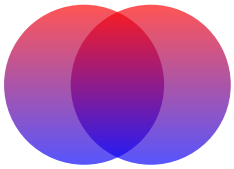
N.B. When you give shading effect upon a *textual picture* (ie. non-path object) inside or outside a transparency group, currently many of the PDF renderers, including Mac OS Preview and Foxit Editor, do not interprete PDF coordinates properly. If that happens, consider using other PDF viewer such as Adobe Acrobat. An example:

```
\mpfig*
  picture pic[];
  pic1 = image(
      fill fullcircle scaled 60 withoutcolor;
      fill fullcircle scaled 60 shifted 25right withoutcolor;
    ) ;
  pic2 = image(
    draw pic1
      withshadingmethod "linear"
      withshadingvector (2, 1)
      withshadingcolors (red, blue)
  ) ;
\endmpfig

\mpfig                              % shading inside group
  draw pic2
    asgroup ""
    withtransparency (1, 2/3) ;
\endmpfig

\mpfig                              % shading outside group
  draw pic1
    asgroup ""
    withshadingmethod "linear"
    withshadingvector (2, 1)
    withshadingcolors (red, blue)
    withtransparency (1, 2/3) ;
\endmpfig
```



After some experiment, however, it turned out that the best way to get picture shading with transparency group is to give shading effect within an ordinary form XObject and then wrap it in a transparency group XObject. Most PDF renderers do render it properly:

```
\mpfig                              % shading within ordinary xobject
  draw pic2
    asgroup "off"
    withgroupname "myshading"
    withtransparency (1, 2/3) ;
\endmpfig

\mpfig                              % wrap in a transparency group
```



```
  usemplibgroup "myshading"
    asgroup ""
    withtransparency (1, 2/3) ;
\endmpfig
```

or preferably (see next subsection § 1.2.14 on \mplibgroup):

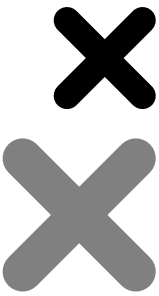
```
\mplibgroup{myshading}[asgroup="off"]           % or no option
  \mpfig
    draw pic2 ;
  \endmpfig
\endmplibgroup

\mpfig
  usemplibgroup "myshading"
    asgroup ""
    withtransparency (1, 2/3) ;
\endmpfig
```

1.2.14 \mplibgroup{...} ... \endmplibgroup

These TEX macros are described here in this subsection, as they are deeply related to the asgroup operator described just above at § 1.2.13. Users can define a transparency group or an ordinary *form XObject* with these macros from TEX side. The syntax is similar to the \mppattern command (see above § 1.2.12).

An example:

```
\mplibgroup{mygrx}                  % or \begin{mplibgroup}{mygrx}
  [                                 % options: see below
    asgroup="",
  ]
  \mpfig                            % or any other TeX code
    pickup pencircle scaled 10;
    draw (left--right) scaled 20 rotated 45 ;
    draw (left--right) scaled 20 rotated -45 ;
  \endmpfig
\endmplibgroup                      % or \end{mplibgroup}

\usemplibgroup{mygrx}

\mpfig
  usemplibgroup "mygrx" scaled 1.5
    withtransparency (1, 0.5) ;
\endmpfig
```



Availabe options, much fewer than those for \mppattern, are listed in Table 2. Again, the width/height/depth values of the mplibgroup will be written down into the log file.

When asgroup option is not given or is given as "off", an ordinary form XObject will be generated rather than a transparency group. Thus the individual objects, not the XObject as a

Table 2: options for `\mplibgroup`

Key	Value Type	Explanation
`asgroup`	*string*	`""`, `"isolated"`, `"knockout"`, `"isolated,knockout"`, `"masking"` or `"off"`
`bbox`	*table* or *string*	`llx`, `lly`, `urx`, `ury` values*
`matrix`	*table* or *string*	`xx`, `yx`, `xy`, `yy` values* or MP transform code
`resources`	*string*	PDF resources if needed

* in string type, numbers are separated by spaces

whole, will be affected by outer transparency command, just like the first figure in the example above at § 1.2.13.

As for the option `asgroup="masking"`, see the next subsection § 1.2.15.

As shown, you can reuse the mplibgroup using the TEX command `\usemplibgroup` or the METAPOST command `usemplibgroup`. The behavior of these commands is the same as that described above at § 1.2.13, excepting that the mplibgroup made by TEX code (not by METAPOST code) respects original height and depth.

1.2.15 ... withmaskinggroup ...

Using this command, the mplibgroup (see above § 1.2.14) generated by the option `asgroup="masking"` (see Table 2) can be utilized as a masking transparency group upon a picture or a path object. The syntax is ⟨*picture*⟩ | ⟨*path*⟩ `withmaskinggroup` ⟨*string*⟩, the latter being the name of a pre-defined masking group.

The masking group should be prepared in *grayscale* color model: the area painted with `1` (white) will preserve the full color of the object; the area painted with `0` (black) will force full transparency, making it invisible.[16]

By default, the background color of a masking group is `0` (black), which you can change by this macro:

withmaskingbgcolor ⟨***numeric***⟩ sets the background color of the masking group. `0` denotes full transparency (invisibility); `1`, full color.

An example:

```
\mpfig*
  picture pic;
  pic = image(
      fill fullcircle scaled 80 withcolor blue ;
      fill fullcircle scaled 80 shifted (25,0) withcolor green ;
      fill fullcircle scaled 80 shifted (50,0) withcolor red ;
    );
\endmpfig

\mplibgroup{mymask}[asgroup="masking"]
```

[16] In fact, colors in other color models are also allowed (such as `white`, `black`, `red`, `green`, `blue`). But they will be converted to grayscale model by the PDF renderer.

```
  \mpfig
    label(TEX "\sffamily\bfseries\scshape\Huge Meta" scaled 2, center pic)
      withcolor 1 ;
  \endmpfig
\endmplibgroup

\mpfig
  fill bbox pic
    withshadingmethod "linear"
    withshadingcolors (red, blue) ;
  draw pic
    withmaskinggroup "mymask"
    withmaskingbgcolor 1/10
    withtransparency (1, 0.8) ;
\endmpfig
```

1.2.16 mpliblength ..., mplibuclength ...

mpliblength ⟨*string*⟩ returns the number of unicode characters in the string. This is a unicode-aware version equivalent to the METAPOST primitive length, but accepts only a string-type argument. For instance, mpliblength "abçdéf" returns 6, not 8.

On the other hand, mplibuclength ⟨*string*⟩ returns the number of unicode grapheme clusters in the string. For instance, mplibuclength "Äpfel", where Ä is encoded using two codepoints (U+0041 and U+0308), returns 5, not 6 or 7. This operator requires lua-uni-algos package installed.

1.2.17 mplibsubstring ... of ..., mplibucsubstring ... of ...

mplibsubstring ⟨*pair*⟩ of ⟨*string*⟩ is a unicode-aware version equivalent to the METAPOST's substring ... of ... primitive. The syntax is the same as the latter, but the string is indexed by unicode characters. For instance, mplibsubstring (2,5) of "abçdéf" returns "çdé", and mplibsubstring (5,2) of "abçdéf" returns "édç".

On the other hand, mplibucsubstring ⟨*pair*⟩ of ⟨*string*⟩ returns the part of the string indexed by unicode grapheme clusters. For instance, mplibucsubstring (0,1) of "Äpfel", where Ä is encoded using two codepoints (U+0041 and U+0308), returns "Ä", not "A". This operator requires lua-uni-algos package installed.

1.3 Lua

1.3.1 runscript ...

A good many METAPOST macros described in this documentation have been implemented using the primitive runscript. With runscript ⟨*string*⟩, you can run a Lua code chunk from METAPOST side and get some METAPOST code returned by Lua if you want. As the functionality is provided by the mplib library itself, luamplib does not have much to say about it.

One thing is worth mentioning, however: if you return a Lua *table* to the METAPOST process, it is automatically converted to a relevant METAPOST data type such as pair, color, cmykcolor or

transform. So users can save some extra toil of converting a table to a string, though it's not a big deal. For instance, `runscript "return {1,0,0}"` will give you the METAPOST color expression `(1,0,0)` automatically.

1.3.2 Lua table `luamplib.instances`

Users can access the Lua table containing mplib instances, `luamplib.instances`, through which METAPOST variables are also easily accessible from Lua side, as documented in LuaTEX manual § 11.2.8.4 (`texdoc luatex`). The following example will print `false`, `3.0`, `MetaPost` and the knots and the cyclicity of the path `unitsquare`.

```
\begin{mplibcode}[myinstance]
  boolean b; b = 1 > 2;
  numeric n; n = 3;
  string s;  s = "MetaPost";
  path p;    p = unitsquare;
\end{mplibcode}

\directlua{
  local myinstance = luamplib.instances.myinstance
  print( myinstance:get_boolean "b" )
  print( myinstance:get_numeric "n" )
  print( myinstance:get_string  "s" )
  local t = myinstance:get_path "p"
  for k,v in pairs(t) do
    print(k, type(v)=='table' and table.concat(v,' ') or v)
  end
}
```

Of course, this sort of Lua code can also be run inside METAPOST code using `runscript` command. Again, of course you can access a METAPOST variable using your own TEX macro. For example:

```
\def\mpnumeric#1#2{\directlua{
  tex.sprint(tostring(luamplib.instances["#1"]:get_numeric"#2"))
}}
\mpnumeric{myinstance}{n}\relax                                    3.0
```

1.3.3 Lua function `luamplib.process_mplibcode`

Users can run a METAPOST code chunk from Lua side by using this function:

```
luamplib.process_mplibcode (<string> metapost code, <string> instance name)
```

The second argument cannot be absent, but can be an empty string (`""`) which means that it has no instance name.

Some other elements in the `luamplib` namespace, listed in Table 3, can affect the process of `process_mplibcode`.

Table 3: elements in luamplib table (partial)

Key	Type	Related TEX macro	Cf.
codeinherit	*boolean*	\mplibcodeinherit	§ 1.1.8
everyendmplib	*table*	\everyendmplib	§ 1.1.2
everymplib	*table*	\everymplib	§ 1.1.2
getcachedir	*function* (⟨*string*⟩)	\mplibcachedir	§ 1.1.15
globaltextext	*boolean*	\mplibglobaltextext	§ 1.1.9
legacyverbatimtex	*boolean*	\mpliblegacybehavior	§ 1.1.6
noneedtoreplace	*table*	\mplibmakenocache	§ 1.1.15
numbersystem	*string*	\mplibnumbersystem	§ 1.1.4
setformat	*function* (⟨*string*⟩)	\mplibsetformat	§ 1.1.3
showlog	*boolean*	\mplibshowlog	§ 1.1.5
textextlabel	*boolean*	\mplibtextextlabel	§ 1.1.7
verbatiminput	*boolean*	\mplibverbatim	§ 1.1.11

1.3.4 Lua function `luamplib.registerpattern`

This is the Lua interface for \mppattern ... \endmppattern described above at § 1.2.12.

```
luamplib.registerpattern (<number> box register, <string> pattern name, <table> options)
```

The first argument is the register of a box containing a pattern cell, which should be prepared in advance by the user. For instance, \setbox0=\hbox{\tiny\TeX}, or corresponding Lua code using tex.setbox function; then the argument should be 0.[17]

As for the third argument, see above Table 1. The argument cannot be absent, but can be an empty table, i.e. { }.

1.3.5 Lua function `luamplib.registergroup`

This is the Lua interface for \mplibgroup ... \endmplibgroup described above at § 1.2.14.

```
luamplib.registergroup (<number> box register, <string> group name, <table> options)
```

The first argument is the register of a box prepared in advance by the user. When the contents of the box have been generated from TEX (not METAPOST) code, please make sure that both of the TEX macros 'MPllx' and 'MPlly' are defined as '0' before invoking the Lua function.[18]

As for the third argument, see above Table 2. The argument cannot be absent, but can be an empty table, i.e. { }.

Reusing an mplibgroup, \usemplibgroup{⟨*name*⟩}, is basically the same as running the TEX macro 'luamplib.group.⟨*name*⟩'. If you need the boxresource index, inspect this macro using token.get_macro function.

[17] In DVI mode, TEX macro 'mplibpatternname' should be set as ⟨*pattern name*⟩ before preparing the box, if shading pattern (ie. shading on picture) is used in the pattern cell.

[18] In DVI mode, TEX macro 'mplibgroupname' also should be set as ⟨*group name*⟩ before preparing the box, if shading pattern (ie. shading on picture) is used in the mplibgroup.

2 Implementation

2.1 Lua module

```
1
2 luatexbase.provides_module {
3   name          = "luamplib",
4   version       = "2.40.8",
5   date          = "2026/04/16",
6   description   = "Lua package to typeset Metapost with LuaTeX's MPLib.",
7 }
8
```

Use the luamplib namespace, since mplib is for the METAPOST library itself. ConTEXt uses metapost.

```
9 luamplib          = luamplib or { }
10 local luamplib    = luamplib
11
12 local format, abs = string.format, math.abs
13
```

Use our own function for warn/info/err.

```
14 local function termorlog (target, text, kind)
15   if text then
16     local mod, write, append = "luamplib", texio.write_nl, texio.write
17     kind = kind
18         or target == "term" and "Warning (more info in the log)"
19         or target == "log" and "Info"
20         or target == "term and log" and "Warning"
21         or "Error"
22     target = kind == "Error" and "term and log" or target
23     local t = text:explode"\n+"
24     write(target, format("Module %s %s:", mod, kind))
25     if #t == 1 then
26       append(target, format(" %s", t[1]))
27     else
28       for _,line in ipairs(t) do
29         write(target, line)
30       end
31       write(target, format("(%s)     ", mod))
32     end
33     append(target, format(" on input line %s", tex.inputlineno))
34     write(target, "")
35     if kind == "Error" then error() end
36   end
37 end
38 local function warn (...) -- beware '%' symbol
39   termorlog("term and log", select("#",...) > 1 and format(...) or ...)
40 end
41 local function info (...)
```

```
  termorlog("log", select("#",...) > 1 and format(...) or ...)
end
local function err (...)
  termorlog("error", select("#",...) > 1 and format(...) or ...)
end

luamplib.showlog  = luamplib.showlog or false

```

Provide a few “shortcuts” expected by the code.

```
local tableconcat = table.concat
local tableinsert = table.insert
local tableunpack = table.unpack
local texsprint   = tex.sprint
local texgettoks  = tex.gettoks
local texgetbox   = tex.getbox
local texruntoks  = tex.runtoks
if not texruntoks then
  err("Your LuaTeX version is too old. Please upgrade it to the latest")
end
local is_defined  = token.is_defined
local get_macro   = token.get_macro
local mplib = require ('mplib')
local kpse  = require ('kpse')
local lfs   = require ('lfs')
local lfsattributes = lfs.attributes
local lfsisdir      = lfs.isdir
local lfsmkdir      = lfs.mkdir
local lfstouch      = lfs.touch
local ioopen        = io.open

```

Some helper functions, prepared for the case when `l-file` etc is not loaded.

```
local file = file or { }
local replacesuffix = file.replacesuffix or function(filename, suffix)
  return (filename:gsub("%.[%a%d]+$","")) .. "." .. suffix
end
local is_writable = file.is_writable or function(name)
  if lfsisdir(name) then
    name = name .. "/_luam_plib_temp_file_"
    local fh = ioopen(name,"w")
    if fh then
      fh:close(); os.remove(name)
      return true
    end
  end
end
local mk_full_path = lfs.mkdirp or lfs.mkdirs or function(path)
  local full = ""
  for sub in path:gmatch("(/*[^\\/]+)") do
```

```
    full = full .. sub
    lfsmkdir(full)
  end
end

```

btex ... etex in input .mp files will be replaced in finder. Because of the limitation of mplib regarding make_text, we might have to make cache files modified from input files.

First of all, determine the directory to store cache files.

```
local cachedir
local function outputdir ()
  if lfstouch then
    for i,v in ipairs{'TEXMFVAR','TEXMF_OUTPUT_DIRECTORY','.','TEXMFOUTPUT'} do
      local var = i == 3 and v or kpse.var_value(v)
      if var and var ~= "" then
        for _,vv in ipairs(var:explode(os.type == "unix" and ":" or ";")) do
          local dir = format("%s/%s",vv,"luamplib_cache")
          if not lfsisdir(dir) then
            mk_full_path(dir)
          end
          if is_writable(dir) then
            cachedir = dir; return cachedir
          end
        end
      end
    end
  end
  cachedir = "."; return cachedir
end
function luamplib.getcachedir(dir)
  dir = dir:gsub("##","#")
  dir = dir:gsub("^~",
    os.type == "windows" and os.getenv("UserProfile") or os.getenv("HOME"))
  if lfstouch and dir then
    if lfsisdir(dir) then
      if is_writable(dir) then
        cachedir = dir
      else
        warn("Directory '%s' is not writable!", dir)
      end
    else
      warn("Directory '%s' does not exist!", dir)
    end
  end
end
```

Some basic METAPOST files not necessary to make cache files.

```
local noneedtoreplace = {
  ["boxes.mp"] = true, --  ["format.mp"] = true,
  ["graph.mp"] = true, ["marith.mp"] = true, ["mfplain.mp"] = true,
```

```
  ["mpost.mp"] = true, ["plain.mp"] = true, ["rboxes.mp"] = true,
  ["sarith.mp"] = true, ["string.mp"] = true, -- ["TEX.mp"] = true,
  ["metafun.mp"] = true, ["metafun.mpiv"] = true, ["mp-abck.mpiv"] = true,
  ["mp-apos.mpiv"] = true, ["mp-asnc.mpiv"] = true, ["mp-bare.mpiv"] = true,
  ["mp-base.mpiv"] = true, ["mp-blob.mpiv"] = true, ["mp-butt.mpiv"] = true,
  ["mp-char.mpiv"] = true, ["mp-chem.mpiv"] = true, ["mp-core.mpiv"] = true,
  ["mp-crop.mpiv"] = true, ["mp-figs.mpiv"] = true, ["mp-form.mpiv"] = true,
  ["mp-func.mpiv"] = true, ["mp-grap.mpiv"] = true, ["mp-grid.mpiv"] = true,
  ["mp-grph.mpiv"] = true, ["mp-idea.mpiv"] = true, ["mp-luas.mpiv"] = true,
  ["mp-mlib.mpiv"] = true, ["mp-node.mpiv"] = true, ["mp-page.mpiv"] = true,
  ["mp-shap.mpiv"] = true, ["mp-step.mpiv"] = true, ["mp-text.mpiv"] = true,
  ["mp-tool.mpiv"] = true, ["mp-cont.mpiv"] = true,
}
luamplib.noneedtoreplace = noneedtoreplace

```

Pattern formats to replace btex and verbatimtex ... etex in input files, if needed.

```
local name_b = "%f[%a_]"
local name_e = "%f[^%a_]"
local btex_etex = name_b.."btex"..name_e.."%s*(.-)%s*"..name_b.."etex"..name_e
local verbatimtex_etex = name_b.."verbatimtex"..name_e.."%s*(.-)%s*"..name_b.."etex"..name_e

```

Function luamplib.finder

```
local currenttime = os.time()
do
  local luamplibtime = lfsattributes(kpse.find_file"luamplib.lua", "modification")
```

format.mp is much complicated, so specially treated.

```
  local function replaceformatmp(file,newfile,ofmodify)
    local fh = ioopen(file,"r")
    if not fh then return file end
    local data = fh:read("*all"); fh:close()
    fh = ioopen(newfile,"w")
    if not fh then return file end
    fh:write(
      "let normalinfont = infont;\n",
      "primarydef str infont name = rawtextext(str) enddef;\n",
      data,
      "vardef Fmant_(expr x) = rawtextext(decimal abs x) enddef;\n",
      "vardef Fexp_(expr x) = rawtextext(\"$^{\"&decimal x&\"}$\") enddef;\n",
      "let infont = normalinfont;\n"
    ); fh:close()
    lfstouch(newfile,currenttime,ofmodify)
    return newfile
  end
  local function replaceinputmpfile (name,file)
    local ofmodify = lfsattributes(file,"modification")
    if not ofmodify then return file end
    local newfile = name:gsub("%W","_")
    newfile = format("%s/luamplib_input_%s", cachedir or outputdir(), newfile)
```

```
    if newfile and luamplibtime then
      local nf = lfsattributes(newfile)
      if nf and nf.mode == "file" and
        ofmodify == nf.modification and luamplibtime < nf.access then
        return nf.size == 0 and file or newfile
      end
    end
    if name == "format.mp" then return replaceformatmp(file,newfile,ofmodify) end
    local fh = ioopen(file,"r")
    if not fh then return file end
    local data = fh:read("*all"); fh:close()
```

"etex" must be preceded by a space and followed by a space or semicolon as specified in LuaTEX manual, which is not the case of standalone METAPOST though.

```
    local count,cnt = 0,0
    data, cnt = data:gsub(btex_etex, "btex %1 etex ") -- space
    count = count + cnt
    data, cnt = data:gsub(verbatimtex_etex, "verbatimtex %1 etex;") -- semicolon
    count = count + cnt
    if count == 0 then
      noneedtoreplace[name] = true
      fh = ioopen(newfile,"w");
      if fh then
        fh:close()
        lfstouch(newfile,currenttime,ofmodify)
      end
      return file
    end
    fh = ioopen(newfile,"w")
    if not fh then return file end
    fh:write(data); fh:close()
    lfstouch(newfile,currenttime,ofmodify)
    return newfile
  end
```

As the finder function for mplib, use the kpse library and make it behave like as if METAPOST was used. And replace .mp files with cache files if needed. See also #74, #97.

```
  local mpkpse
  do
    local exe = 0
    while arg[exe-1] do
      exe = exe-1
    end
    mpkpse = kpse.new(arg[exe], "mpost")
  end
  local special_ftype = {
    pfb = "type1 fonts",
    enc = "enc files",
  }
  function luamplib.finder (name, mode, ftype)
```

```
    if mode == "w" then
      if name and name ~= "mpout.log" then
        kpse.record_output_file(name) -- recorder
      end
      return name
    else
      ftype = special_ftype[ftype] or ftype
      local file = mpkpse:find_file(name,ftype)
      if file then
        if lfstouch and ftype == "mp" and not noneedtoreplace[name] and not noneedtoreplace["*.mp"] then
          file = replaceinputmpfile(name,file)
        end
      else
        file = mpkpse:find_file(name, name:match("%a+$"))
      end
      if file then
        kpse.record_input_file(file) -- recorder
      end
      return file
    end
  end
end

```

For the main function: process

plain or *metafun*, though we cannot support *metafun* format fully.

```
local currentformat = "plain"
function luamplib.setformat (name)
  currentformat = name
end
```

v2.9 has introduced the concept of "code inherit"

```
luamplib.codeinherit = false
local mplibinstances = {}
luamplib.instances = mplibinstances
local has_instancename = false

local process
do
  local function reporterror (result, prevlog)
    if not result then
      err("no result object returned")
    else
      local t, e, l = result.term, result.error, result.log
```

log has more information than term, so log first (2021/08/02)

```
      local log = l or t or "no-term"
      log = log:gsub("%(Please type a command or say `end'%)",""):gsub("\n+","\n")
      if result.status > 0 then
        local first = log:match"(.-\n! .-)\n! "
        if first then
```

```
265           termorlog("term", first)
266           termorlog("log", log, "Warning")
267         else
268           warn(log)
269         end
270         if result.status > 1 then
271           err(e or "see above messages")
272         end
273       elseif prevlog then
274         log = prevlog..log
```

v2.6.1: now luamplib does not disregard `show` command, even when `luamplib.showlog` is false. Incidentally, it does not raise error nor prints an info, even if output has no figure.

```
275         local show = log:match"\n>>? .+"
276         if show then
277           termorlog("term", show, "Info (more info in the log)")
278           info(log)
279         elseif luamplib.showlog and log:find"%g" then
280           info(log)
281         end
282       end
283       return log
284     end
285   end
```

`lualibs-os.lua` installs a randomseed. When this file is not loaded, we should explicitly seed a unique integer to get random randomseed for each run.

```
286   if not math.initialseed then math.randomseed(currenttime) end
287   local function luamplibload (name)
288     local mpx = mplib.new {
289       ini_version = true,
290       find_file   = luamplib.finder,
```

Make use of `make_text` and `run_script`. And we provide `numbersystem` option since v2.4. See https://github.com/lualatex/luamplib/issues/21.

```
291       make_text   = luamplib.maketext,
292       run_script  = luamplib.runscript,
293       math_mode   = luamplib.numbersystem,
294       job_name    = tex.jobname,
295       random_seed = math.random(4095),
296       utf8_mode   = true,
297       extensions  = 1,
298     }
```

Append our own METAPOST preamble to the preamble loading plain/metafun format.

```
299     local preamble = tableconcat{
300       format(luamplib.preambles.preamble, replacesuffix(name,"mp")),
301       luamplib.preambles.mplibcode,
302       luamplib.legacyverbatimtex and luamplib.preambles.legacyverbatimtex or "",
303       luamplib.textextlabel and luamplib.preambles.textextlabel or "",
304     }
```

```
    local result, log
    if not mpx then
      result = { status = 99, error = "out of memory"}
    else
      result = mpx:execute(preamble)
    end
    log = reporterror(result)
    return mpx, result, log
  end
```

Here, excute each mplibcode data, ie \begin{mplibcode} ... \end{mplibcode}.

```
  function process (data, instancename)
    local currfmt
    if instancename and instancename ~= "" then
      currfmt = instancename
      has_instancename = true
    else
      currfmt = tableconcat{
        currentformat,
        luamplib.numbersystem or "scaled",
        tostring(luamplib.textextlabel),
        tostring(luamplib.legacyverbatimtex),
      }
      has_instancename = false
    end
    local mpx = mplibinstances[currfmt]
    local standalone = not (has_instancename or luamplib.codeinherit)
    if mpx and standalone then
      mpx:finish()
    end
    local log = ""
    if standalone or not mpx then
      mpx, _, log = luamplibload(currentformat)
      mplibinstances[currfmt] = mpx
    end
    local converted, result = false, {}
    if mpx and data then
      result = mpx:execute(data)
      local log = reporterror(result, log)
      if log then
        if result.fig then
          converted = luamplib.convert(result)
        end
      end
    else
      err"Mem file unloadable. Maybe generated with a different version of mplib?"
    end
    return converted, result
  end
end
```

```
353
```
dvipdfmx is supported, though nobody seems to use it.
```
354 local pdfmode = tex.outputmode > 0
355
```
make_text and some run_script uses LuaTEX's tex.runtoks.
```
356 local catlatex = luatexbase.registernumber("catcodetable@latex")
357 local catat11  = luatexbase.registernumber("catcodetable@atletter")
```
tex.scantoks sometimes fail to read catcode properly, especially \#, \&, or \%. After some experiment, we dropped using it. Instead, a function containing tex.sprint seems to work nicely.
```
358 local function run_tex_code (str, cat)
359   texruntoks(function() texsprint(cat or catlatex, str) end)
360 end
```
For conversion of sp to bp.
```
361 local factor = 65536*(7227/7200)
362
```
Prepare textext box number containers, locals and globals. localid can be any number. They are local anyway. The number will be reset at the start of a new code chunk. Global boxes will use \newbox command in tex.runtoks process. This is the same when codeinherit is true. Boxes in instances with name will also be global, so that their tex boxes can be shared among instances of the same name.
```
363 local texboxes = { globalid = 0, localid = 4096 }
364 local process_tex_text
365 do
366   local textext_fmt = 'image(addto currentpicture doublepath unitsquare \z
367     xscaled %f yscaled %f shifted (0,-%f) \z
368     withprescript "mplibtexboxid=%i:%f:%f")'
369   function process_tex_text (str, maketext)
370     if str then
371       if not maketext then str = str:gsub("\r.-$","") end
372       local global = (has_instancename or luamplib.globaltextext or luamplib.codeinherit)
373                      and "\\global" or ""
374       local tex_box_id
375       if global == "" then
376         tex_box_id = texboxes.localid + 1
377         texboxes.localid = tex_box_id
378       else
379         local boxid = texboxes.globalid + 1
380         texboxes.globalid = boxid
381         run_tex_code(format([[\expandafter\newbox\csname luamplib.box.%s\endcsname]], boxid))
382         tex_box_id = tex.getcount'allocationnumber'
383       end
384       if str:find"^%[taggingoff%]" then
385         str = str:gsub("^%[taggingoff%]%s*","")
386         run_tex_code(format("\\luamplibnotagtextboxset{%i}{%s\\setbox%i\\hbox{%s}}",
387                             tex_box_id, global, tex_box_id, str))
388       else
389         run_tex_code(format("\\luamplibtagtextboxset{%i}{%s\\setbox%i\\hbox{%s}}",
```

```
                            tex_box_id, global, tex_box_id, str))
      end
      local box = texgetbox(tex_box_id)
      local wd  = box.width  / factor
      local ht  = box.height / factor
      local dp  = box.depth  / factor
      return textext_fmt:format(wd, ht+dp, dp, tex_box_id, wd, ht+dp)
    end
    return ""
  end
end

```

Make color or xcolor's color expressions usable, with \mpcolor or mplibcolor. These commands should be used with graphical objects. Attempt to support l3color as well.

```
if is_defined'color_select:n' then
  run_tex_code{
    "\\newcatcodetable\\luamplibcctabexplat",
    "\\begingroup",
    "\\catcode`@=11 ",
    "\\catcode`_=11 ",
    "\\catcode`:=11 ",
    "\\savecatcodetable\\luamplibcctabexplat",
    "\\endgroup",
  }
end
local ccexplat = luatexbase.registernumber"luamplibcctabexplat"

local process_color, process_mplibcolor
```

A common function for color functions

```
local function colorsplit (res)
  local t, tt = { }, res:gsub("[%[%]]","",2):explode()
  local be = tt[1]:find"^%d" and 1 or 2
  for i=be, #tt do
    if not tonumber(tt[i]) then break end
    t[#t+1] = tt[i]
  end
  if #t == 0 then -- named color in DVI mode with no DocumentMetadata
    run_tex_code{"\\extractcolorspecs{", tt[3], "}\\mplibtmpa\\mplibtmpb"}
    t = get_macro"mplibtmpb":explode","
  end
  return t
end
do
  local colfmt = ccexplat and "l3color" or "xcolor"
  local mplibcolorfmt = {
    xcolor = tableconcat{
      [[\begingroup\let\XC@mcolor\relax]],
      [[\def\set@color{\global\mplibtmptoks\expandafter{\current@color}}]],
```

```
    [[\color%s\endgroup]],
  },
  l3color = tableconcat{
    [[\begingroup\def\__color_select:N#1{\expandafter\__color_select:nn#1}]],
    [[\def\__color_backend_select:nn#1#2{\global\mplibtmptoks{#1 #2}}]],
    [[\def\__kernel_backend_literal:e#1{\global\mplibtmptoks\expandafter{\expanded{#1}}}]],
    [[\color_select:n%s\endgroup]],
  },
}
function process_color (str)
  if str then
    if not str:find("%b{}") then
      str = format("{%s}",str)
    end
    local myfmt = mplibcolorfmt[colfmt]
    if colfmt == "l3color" and is_defined"color" then
      if str:find("%b[]") then
        myfmt = mplibcolorfmt.xcolor
      else
        for _,v in ipairs(str:match"{(.+)}":explode"!") do
          if not v:find("^%s*%d+%s*$") then
            local pp = get_macro(format("l__color_named_%s_prop",v))
            if not pp or pp == "" then
              myfmt = mplibcolorfmt.xcolor
              break
            end
          end
        end
      end
    end
    run_tex_code(myfmt:format(str), ccexplat or catat11)
    local t = texgettoks"mplibtmptoks"
    if not pdfmode then
      if t:find"^hsb" or not t:find"%d" then
        t = "color push " .. t
      elseif not t:find"^pdf" then
        t = t:gsub("%a+ (.+)","pdf:bc [%1]")
      end
    end
    return format('1 withprescript "mpliboverridecolor=%s"', t)
  end
  return ""
end
function process_mplibcolor(str)
  local res = process_color(str)
  if res:find" cs " or res:find"@pdf.obj" or res:find"color push" then return res end
  res = colorsplit(res:match'"mpliboverridecolor=(.+)"')
  return format("(%s)", tableconcat(res, ","))
end
```

```
end

```

for \mpdim or mplibdimen

```
local function process_dimen (str)
  if str then
    str = str:gsub("{(.+)}","%1")
    run_tex_code(format([[\mplibtmptoks\expandafter{\the\dimexpr %s\relax}]], str))
    return format("begingroup %s endgroup", texgettoks"mplibtmptoks")
  end
  return ""
end

```

Newly introduced method of processing verbatimtex ... etex. This function is used when \mpliblegacybehavior{false} is declared.

```
local function process_verbatimtex_text (str)
  if str then
    run_tex_code(str)
  end
  return ""
end

```

For legacy verbatimtex process. verbatimtex ... etex before beginfig() is inserted just before the mplib box. And TEX code inside beginfig() ... endfig is inserted after the mplib box.

```
local tex_code_pre_mplib = {}
luamplib.figid = 1
luamplib.in_the_fig = false
local function process_verbatimtex_prefig (str)
  if str then
    tex_code_pre_mplib[luamplib.figid] = str
  end
  return ""
end
local function process_verbatimtex_infig (str)
  if str then
    return format('special "postmplibverbtex=%s";', str)
  end
  return ""
end

```

For *metafun* format. see issue #79.

```
mp = mp or {}
local mp = mp
mp.mf_path_reset = mp.mf_path_reset or function() end
mp.mf_finish_saving_data = mp.mf_finish_saving_data or function() end
mp.report = mp.report or info
```

metafun 2021-03-09 changes crashes luamplib.

```
catcodes = catcodes or {}
```

```
local catcodes = catcodes
catcodes.numbers = catcodes.numbers or {}
catcodes.numbers.ctxcatcodes = catcodes.numbers.ctxcatcodes or catlatex
catcodes.numbers.texcatcodes = catcodes.numbers.texcatcodes or catlatex
catcodes.numbers.luacatcodes = catcodes.numbers.luacatcodes or catlatex
catcodes.numbers.notcatcodes = catcodes.numbers.notcatcodes or catlatex
catcodes.numbers.vrbcatcodes = catcodes.numbers.vrbcatcodes or catlatex
catcodes.numbers.prtcatcodes = catcodes.numbers.prtcatcodes or catlatex
catcodes.numbers.txtcatcodes = catcodes.numbers.txtcatcodes or catlatex

```

Now `luamplib.runscript`

```
do
  local runscript_funcs = {
    luamplibtext    = process_tex_text,
    luamplibcolor   = process_mplibcolor,
    luamplibdimen   = process_dimen,
    luamplibprefig  = process_verbatimtex_prefig,
    luamplibinfig   = process_verbatimtex_infig,
    luamplibverbtex = process_verbatimtex_text,
  }
```

A function from ConTEXt general.

```
  local function mpprint(buffer,...)
    for i=1,select("#",...) do
      local value = select(i,...)
      if value ~= nil then
        local t = type(value)
        if t == "number" then
          buffer[#buffer+1] = format("%.16f",value)
        elseif t == "string" then
          buffer[#buffer+1] = value
        elseif t == "table" then
          buffer[#buffer+1] = "(" .. tableconcat(value,",") .. ")"
        else -- boolean or whatever
          buffer[#buffer+1] = tostring(value)
        end
      end
    end
  end
  function luamplib.runscript (code)
    local id, str = code:match("(.-){(.*)}")
    if id and str then
      local f = runscript_funcs[id]
      if f then
        local t = f(str)
        if t then return t end
      end
    end
    local f = loadstring(code)
```

```
    if type(f) == "function" then
      local buffer = {}
      function mp.print(...)
        mpprint(buffer,...)
      end
      local res = {f()}
      buffer = tableconcat(buffer)
      if buffer and buffer ~= "" then
        return buffer
      end
      buffer = {}
      mpprint(buffer, tableunpack(res))
      return tableconcat(buffer)
    end
    return ""
  end
end
```

luamplib.maketext

```
luamplib.legacyverbatimtex = true
do
```

make_text must be one liner, so comment sign is not allowed.

```
  local function protecttexcontents (str)
    return str:gsub("\\%%", "\0PerCent\0")
              :gsub("%%.-\n", "")
              :gsub("%%.-$",  "")
              :gsub("%zPerCent%z", "\\%%")
              :gsub("\r.-$",  "")
              :gsub("%s+", " ")
  end
  function luamplib.maketext (str, what)
    if str and str ~= "" then
      str = protecttexcontents(str)
      if what == 1 then
        if not str:find("\\documentclass"..name_e) and
           not str:find("\\begin%s*{document}") and
           not str:find("\\documentstyle"..name_e) and
           not str:find("\\usepackage"..name_e) then
          if luamplib.legacyverbatimtex then
            if luamplib.in_the_fig then
              return process_verbatimtex_infig(str)
            else
              return process_verbatimtex_prefig(str)
            end
          else
            return process_verbatimtex_text(str)
          end
        end
```

```
      else
        return process_tex_text(str, true) -- bool is for 'char13'
      end
    end
    return ""
  end
end

```

luamplib's METAPOST color operators

```
luamplib.gettexcolor = function (str, rgb)
  local res = process_color(str):match'"mpliboverridecolor=(.+)"'
  if res:find" cs " or res:find"@pdf.obj" then
    if not rgb then
      warn("%s is a spot color. Forced to CMYK", str)
    end
    run_tex_code({
      "\\color_export:nnN{",
      str,
      "}{",
      rgb and "space-sep-rgb" or "space-sep-cmyk",
      "}\\mplib_@tempa",
    },ccexplat)
    return get_macro"mplib_@tempa":explode()
  end
  local t = colorsplit(res)
  if #t == 3 or not rgb then return t end
  if #t == 4 then
    return { 1 - math.min(1,t[1]+t[4]), 1 - math.min(1,t[2]+t[4]), 1 - math.min(1,t[3]+t[4]) }
  end
  return { t[1], t[1], t[1] }
end

luamplib.shadecolor = function (str)
  local res = process_color(str):match'"mpliboverridecolor=(.+)"'
  if res:find" cs " or res:find"@pdf.obj" then -- spot color shade: l3 only
```

An example of spot color shading:

```
\DocumentMetadata{ }
\documentclass{article}
\usepackage{luamplib}
\ExplSyntaxOn
\color_model_new:nnn { pantone3005 }
  { Separation }
  {
    name = PANTONE~3005~U ,
    alternative-model = cmyk ,
    alternative-values = {1, 0.56, 0, 0}
  }
  \color_set:nnn{spotA}{pantone3005}{1}
```

```
  \color_set:nnn{spotB}{pantone3005}{0.6}
\color_model_new:nnn { pantone1215 }
  { Separation }
  {
    name = PANTONE~1215~U ,
    alternative-model = cmyk ,
    alternative-values = {0, 0.15, 0.51, 0}
  }
  \color_set:nnn{spotC}{pantone1215}{1}
\color_model_new:nnn { pantone2040 }
  { Separation }
  {
    name = PANTONE~2040~U ,
    alternative-model = cmyk ,
    alternative-values = {0, 0.28, 0.21, 0.04}
  }
  \color_set:nnn{spotD}{pantone2040}{1}
\ExplSyntaxOff
\begin{document}
\begin{mplibcode}
beginfig(1)
  fill unitsquare xscaled \mpdim\textwidth yscaled 1cm
    withshadingmethod "linear"
    withshadingvector (0,1)
    withshadingstep (
      withshadingfraction .5
      withshadingcolors ("spotB","spotC")
    )
    withshadingstep (
      withshadingfraction 1
      withshadingcolors ("spotC","spotD")
    )
    ;
endfig;
\end{mplibcode}
\end{document}
```

another one: user-defined DeviceN colorspace

```
\DocumentMetadata{ }
\documentclass{article}
\usepackage{luamplib}
\ExplSyntaxOn
\color_model_new:nnn { pantone1215 }
  { Separation }
  {
    name = PANTONE~1215~U ,
    alternative-model = cmyk ,
    alternative-values = {0, 0.15, 0.51, 0}
  }
```

```
\color_model_new:nnn { pantone+black }
  { DeviceN }
  { names = {pantone1215,black} }
\color_set:nnn{purepantone}{pantone+black}{1,0}
\color_set:nnn{pureblack}  {pantone+black}{0,1}
\ExplSyntaxOff
\begin{document}
\mpfig
  fill unitsquare xscaled \mpdim{\textwidth} yscaled 30
    withshadingmethod "linear"
    withshadingcolors ("purepantone","pureblack")
    ;
\endmpfig
\end{document}
```

```
    run_tex_code({
      [[\color_export:nnN{]], str, [[}{backend}\mplib_@tempa]],
    },ccexplat)
    local name, value = get_macro'mplib_@tempa':match'{(.-)}{(.-)}'
    local t, obj = res:explode()
    if pdfmode then
      obj = format("%s 0 R", ltx.pdf.object_id( t[1]:sub(2,-1) ))
    else
      obj = t[2]
    end
    return format('(1) withprescript"mplib_spotcolor=%s:%s:%s"', value,obj,name)
  end
  return colorsplit(res)
end

```

luamplib.fillandstrokecolor

```
do
  local function graphictextcolor (col, filldraw)
    if col:find"^[%d%.:]+$" then
      col = col:explode":"
      for i=1,#col do
        col[i] = format("%.3f", col[i])
      end
      if pdfmode then
        local op = #col == 4 and "k" or #col == 3 and "rg" or "g"
        col[#col+1] = filldraw == "fill" and op or op:upper()
        return tableconcat(col," ")
      end
      return format("[%s]", tableconcat(col," "))
    end
    col = process_color(col):match'"mpliboverridecolor=(.+)"'
    if pdfmode then
      local t = col:explode()
      local b = filldraw == "fill" and 1 or #t/2+1
```

```
      local e = b == 1 and #t/2 or #t
      return tableconcat(t," ", b, e)
    end
    if col:find"@pdf.obj" then
      return col:gsub("pdf:bc%s*","",1)
    else
      return format("[%s]", tableconcat(colorsplit(col)," "))
    end
  end
  function luamplib.fillandstrokecolor (fill, stroke)
    fill   = graphictextcolor(fill, "fill")
    stroke = graphictextcolor(stroke, "stroke")
    local bc = pdfmode and "" or "pdf:bc "
    return format('withprescript "mpliboverridecolor=%s%s %s"', bc, fill, stroke)
  end
end

```

Remove trailing zeros for smaller PDF

```
local decimals = "%.%d+"
local function rmzeros(str) return str:gsub("%.?0+$","") end

```

common function for mplibgraphictext and mpliboutlinetext

```
local function getrulemetric (box, curr, bp)
  local running = -1073741824
  local wd,ht,dp = curr.width, curr.height, curr.depth
  wd = wd == running and box.width  or wd
  ht = ht == running and box.height or ht
  dp = dp == running and box.depth  or dp
  if bp then
    return wd/factor, ht/factor, dp/factor
  end
  return wd, ht, dp
end

```

luamplib's mplibgraphictext operator

```
do
  if not math.round then
    function math.round(x) return x < 0 and -math.floor(-x + 0.5) or math.floor(x + 0.5) end
  end
  local emboldenfonts = { }
  local function roundupwidth (f, fb)
    local wd = math.round(f.size * fb / factor * 10)
    if wd == 0 and fb ~= 0 then
      wd = 1
    end
    emboldenfonts.width = wd
    return wd
```

```
end
local function getemboldenwidth (curr, fakebold)
  local width = emboldenfonts.width
  if not width then
    local f
    local function getglyph(n)
      while n do
        if n.head then
          getglyph(n.head)
        elseif n.font and n.font > 0 then
          f = n.font; break
        end
        n = node.getnext(n)
      end
    end
    getglyph(curr)
    width = roundupwidth(font.getcopy(f or font.current()), fakebold)
  end
  return width
end
local function getrulewhatsit (line, wd, ht, dp)
  line, wd, ht, dp = line/1000, wd/factor, ht/factor, dp/factor
  line = line == 0 and "" or ("%f w"):format(line)
  local pl
  local fmt = "q %s %f %f %f %f re B Q"
  if pdfmode then
    pl = node.new("whatsit","pdf_literal")
    pl.mode = 0
  else
    fmt = "pdf:content "..fmt
    pl = node.new("whatsit","special")
  end
  pl.data = fmt:format(line, 0, -dp, wd, ht+dp) :gsub(decimals,rmzeros)
  local ss = node.new"glue"
  node.setglue(ss, 0, 65536, 65536, 2, 2)
  pl.next = ss
  return pl
end
```

copying attributes of rule/glue node to improve tagging of mplibgraphictext

```
local tag_update_attrs
if is_defined"ver@tagpdf.sty" then
  tag_update_attrs = function (n, curr)
    while n do
      n.attr = curr.attr
      if n.head then
        tag_update_attrs(n.head, curr)
      end
      n = node.getnext(n)
```

```
774       end
775     end
776   else
777     tag_update_attrs = function() end
778   end
779   local function embolden (box, curr, fakebold)
780     local head = curr
781     while curr do
782       if curr.head then
783         curr.head = embolden(curr, curr.head, fakebold)
784       elseif curr.replace then
785         curr.replace = embolden(box, curr.replace, fakebold)
786       elseif curr.leader then
787         if curr.leader.head then
788           curr.leader.head = embolden(curr.leader, curr.leader.head, fakebold)
789         elseif curr.leader.id == node.id"rule" then
790           local glue = node.effective_glue(curr, box)
791           local line = getemboldenwidth(curr, fakebold)
792           local wd,ht,dp = getrulemetric(box, curr.leader)
793           if box.id == node.id"hlist" then
794             wd = glue
795           else
796             ht, dp = 0, glue
797           end
798           local pl = getrulewhatsit(line, wd, ht, dp)
799           local pack = box.id == node.id"hlist" and node.hpack or node.vpack
800           local list = pack(pl, glue, "exactly")
801           tag_update_attrs(list,curr)
802           head = node.insert_after(head, curr, list)
803           head, curr = node.remove(head, curr)
804         end
805       elseif curr.id == node.id"rule" and curr.subtype == 0 then
806         local line = getemboldenwidth(curr, fakebold)
807         local wd,ht,dp = getrulemetric(box, curr)
808         if box.id == node.id"vlist" then
809           ht, dp = 0, ht+dp
810         end
811         local pl = getrulewhatsit(line, wd, ht, dp)
812         local list
813         if box.id == node.id"hlist" then
814           list = node.hpack(pl, wd, "exactly")
815         else
816           list = node.vpack(pl, ht+dp, "exactly")
817         end
818         tag_update_attrs(list,curr)
819         head = node.insert_after(head, curr, list)
820         head, curr = node.remove(head, curr)
821       elseif curr.id == node.id"glyph" and curr.font > 0 then
822         local f = curr.font
```

```
        local key = format("%s:%s",f,fakebold)
        local i = emboldenfonts[key]
        if not i then
          local ft = font.getfont(f) or font.getcopy(f)
          local width = roundupwidth(ft, fakebold)
          if ft.format == "opentype" or ft.format == "truetype" then
            local name = ft.name:gsub('"','''):gsub(';$','')
            local t = name:gsub("^file:",""):gsub("^name:",""):gsub("^kpse:",""):gsub("^my:","")
            name = format('%s%sembolden=%s;',name, t:find":" and ";" or ":", fakebold)
            _, i = fonts.constructors.readanddefine(name,ft.size)
          elseif pdfmode then
            local ft = table.copy(ft)
            ft.mode, ft.width = 2, width
            i = font.define(ft)
          else
            goto skip_type1
          end
          emboldenfonts[key] = i
        end
        curr.font = i
      end
      ::skip_type1::
      curr = node.getnext(curr)
    end
    return head
  end
  luamplib.graphictext = function (text, fakebold, fc, dc)
    local fmt = process_tex_text(text):sub(1,-2)
    local id = tonumber(fmt:match"mplibtexboxid=(%d+):")
    emboldenfonts.width = nil
    local box = texgetbox(id)
    box.head = embolden(box, box.head, fakebold)
    local colors = luamplib.fillandstrokecolor(fc, dc)
    return format('%s %s)', fmt, colors)
  end
end
```

luamplib's mplibglyph operator

```
do
  local function mperr (str)
    return format("hide(errmessage %q)", str)
  end
  local function getangle (a,b,c)
    local r = math.deg(math.atan(c.y-b.y, c.x-b.x) - math.atan(b.y-a.y, b.x-a.x))
    if r > 180 then
      r = r - 360
    elseif r < -180 then
      r = r + 360
```

```
870   end
871   return r
872 end
873 local function turning (t)
874   local r, n = 0, #t
875   for i=1,2 do
876     tableinsert(t, t[i])
877   end
878   for i=1,n do
879     r = r + getangle(t[i], t[i+1], t[i+2])
880   end
881   return r/360
882 end
883 local function glyphimage(t, fmt)
884   local q, p, r, towarn = {{},{}}
885   local function closepath(dots)
886     tableinsert(p, format("%scycle", dots or "--"))
887     tableinsert(q[ turning(r) > 0 and 1 or 2 ], tableconcat(p))
888   end
889   for i,v in ipairs(t) do
890     local cmd = v[#v]
891     local nt = t[i+1]
892     local final = not nt or nt[#nt] ~= "l" and nt[#nt] ~= "c"
893     if cmd == "m" then
894       if final then towarn = true end
895       p = {format('(%s,%s)',v[1],v[2])}
896       r = {{x=v[1],y=v[2]}}
897     else
898       if cmd == "l" then
899         local pt = t[i-1]
900         if (final or pt and pt[#pt] == "m") and r[1].x == v[1] and r[1].y == v[2] then
901         else
902           tableinsert(p, format('--(%s,%s)',v[1],v[2]))
903           tableinsert(r, {x=v[1],y=v[2]})
904         end
905         if final then closepath() end
906       elseif cmd == "c" then
907         tableinsert(p, format('..controls(%s,%s)and(%s,%s)',v[1],v[2],v[3],v[4]))
908         if final and r[1].x == v[5] and r[1].y == v[6] then
909           closepath ".."
910         else
911           tableinsert(p, format('..(%s,%s)',v[5],v[6]))
912           tableinsert(r, {x=v[5],y=v[6]})
913           if final then closepath() end
914         end
915       elseif cmd == "path" or cmd == "move" then
916       else
917         return mperr"unknown operator"
918       end
```

```
      end
    end
    r = { }
    if fmt == "opentype" then
      for _,v in ipairs(q[1]) do
        tableinsert(r, format('addto currentpicture contour %s;',v))
      end
      for _,v in ipairs(q[2]) do
        tableinsert(r, format('addto currentpicture contour %s withcolor background;',v))
      end
    else
      for _,v in ipairs(q[2]) do
        tableinsert(r, format('addto currentpicture contour %s;',v))
      end
      for _,v in ipairs(q[1]) do
        tableinsert(r, format('addto currentpicture contour %s withcolor background;',v))
      end
    end
    return format('image(%s)', tableconcat(r)), towarn
  end
  if not table.tofile then require"lualibs-lpeg"; require"lualibs-table"; end
  function luamplib.glyph (f, c)
    local filename, subfont, instance, kind, shapedata
    local fid = tonumber(f) or font.id(f)
    if fid > 0 then
      local fontdata = font.getfont(fid) or font.getcopy(fid)
      filename, subfont, kind = fontdata.filename, fontdata.subfont, fontdata.format
      instance = fontdata.specification and fontdata.specification.instance
        or fontdata.shared and fontdata.shared.features.axis
      filename = filename and filename:gsub("^harfloaded:","")
    else
      local name
      f = f:match"^%s*(.+)%s*$"
      name, subfont, instance = f:match"(.+)%((%d+)%)%[(.-)%]$"
      if not name then
        name, instance = f:match"(.+)%[(.-)%]$" -- SourceHanSansK-VF.otf[Heavy]
      end
      if not name then
        name, subfont = f:match"(.+)%((%d+)%)$" -- Times.ttc(2)
      end
      name = name or f
      subfont = (subfont or 0)+1
      instance = instance and instance:lower()
      for _,ftype in ipairs{"opentype", "truetype"} do
        filename = kpse.find_file(name, ftype.." fonts")
        if filename then
          kind = ftype; break
        end
      end
```

```
968     end
969     if kind ~= "opentype" and kind ~= "truetype" then
970       f = fid and fid > 0 and tex.fontname(fid) or f
971       if kpse.find_file(f, "tfm") then
972         return format("glyph %s of %q", tonumber(c) or format("%q",c), f)
973       else
974         filename = kpse.find_file(f, "type1 fonts")
975         if filename then
976           kind = "type1" -- there's bug in processing cmr family
977         else
978           return mperr"font not found"
979         end
980       end
981     end
982     local time = lfsattributes(filename,"modification")

  local k = format("shapes_%s(%s)[%s]%s", filename, subfont or "", instance or "",
                   luaotfload and luaotfload.version or "")

983     local k = format("shapes_%s(%s)[%s]", filename, subfont or "", instance or "")
984     local h = format(string.rep('%02x', 256/8), string.byte(sha2.digest256(k), 1, -1))
985     local newname = format("%s/%s.lua", cachedir or outputdir(), h)
986     local newtime = lfsattributes(newname,"modification") or 0
987     if time == newtime then
988       shapedata = require(newname)
989     end
990     if not shapedata then
991       if fonts then
992         local handler = kind == "type1" and fonts.handlers.afm or fonts.handlers.otf
993         shapedata = handler.readers.loadshapes(filename,subfont,instance)
994       end
995       if not shapedata then return mperr"loadshapes() failed. luaotfload not loaded?" end
996       table.tofile(newname, shapedata, "return")
997       lfstouch(newname, time, time)
998     end
999     local gid = tonumber(c)
1000    if not gid then
1001      local uni = utf8.codepoint(c)
1002      for i,v in pairs(shapedata.glyphs) do
1003        if c == v.name or uni == v.unicode then
1004          gid = i; break
1005        end
1006      end
1007    end
1008    if not gid then return mperr"cannot get GID (glyph id)" end
1009    local fac = 1000 / (shapedata.units or 1000)
1010    local t = shapedata.glyphs[gid]; t = t and t.segments
1011    if not t then return "image()" end
1012    for i,v in ipairs(t) do
```

```
      if type(v) == "table" then
        for ii,vv in ipairs(v) do
          if type(vv) == "number" then
            t[i][ii] = format("%.0f", vv * fac)
          end
        end
      end
    end
    local result, towarn = glyphimage(t, shapedata.format or kind)
    if towarn then
      warn("mplibglyph %s not working properly. Use glyph instead", f)
    end
    return result
  end
end
```

mpliboutlinetext : based on mkiv's font-mps.lua

```
do
  local rulefmt = "mpliboutlinepic[%i]:=image(addto currentpicture contour \z
    unitsquare shifted - center unitsquare;) xscaled %f yscaled %f shifted (%f,%f);"
  local outline_horz, outline_vert
  function outline_vert (res, box, curr, xshift, yshift)
    local b2u = box.dir == "LTL"
    local dy = (b2u and -box.depth or box.height)/factor
    local ody = dy
    while curr do
      if curr.id == node.id"rule" then
        local wd, ht, dp = getrulemetric(box, curr, true)
        local hd = ht + dp
        if hd ~= 0 then
          dy = dy + (b2u and dp or -ht)
          if wd ~= 0 and curr.subtype == 0 then
            res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+wd/2, yshift+dy+(ht-dp)/2)
          end
          dy = dy + (b2u and ht or -dp)
        end
      elseif curr.id == node.id"glue" then
        local vwidth = node.effective_glue(curr,box)/factor
        if curr.leader then
          local curr, kind = curr.leader, curr.subtype
          if curr.id == node.id"rule" then
            local wd = getrulemetric(box, curr, true)
            if wd ~= 0 then
              local hd = vwidth
              local dy = dy + (b2u and 0 or -hd)
              if hd ~= 0 and curr.subtype == 0 then
                res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+wd/2, yshift+dy+hd/2)
              end
```

```
1060            end
1061          elseif curr.head then
1062            local hd = (curr.height + curr.depth)/factor
1063            if hd <= vwidth then
1064              local dy, n, iy = dy, 0, 0
1065              if kind == 100 or kind == 103 then -- todo: gleaders
1066                local ady = abs(ody - dy)
1067                local ndy = math.ceil(ady / hd) * hd
1068                local diff = ndy - ady
1069                n = math.floor((vwidth-diff) / hd)
1070                dy = dy + (b2u and diff or -diff)
1071              else
1072                n = math.floor(vwidth / hd)
1073                if kind == 101 then
1074                  local side = vwidth % hd / 2
1075                  dy = dy + (b2u and side or -side)
1076                elseif kind == 102 then
1077                  iy = vwidth % hd / (n+1)
1078                  dy = dy + (b2u and iy or -iy)
1079                end
1080              end
1081              dy = dy + (b2u and curr.depth or -curr.height)/factor
1082              hd = b2u and hd or -hd
1083              iy = b2u and iy or -iy
1084              local func = curr.id == node.id"hlist" and outline_horz or outline_vert
1085              for i=1,n do
1086                res = func(res, curr, curr.head, xshift+curr.shift/factor, yshift+dy)
1087                dy = dy + hd + iy
1088              end
1089            end
1090          end
1091        end
1092        dy = dy + (b2u and vwidth or -vwidth)
1093      elseif curr.id == node.id"kern" then
1094        dy = dy + curr.kern/factor * (b2u and 1 or -1)
1095      elseif curr.id == node.id"vlist" then
1096        dy = dy + (b2u and curr.depth or -curr.height)/factor
1097        res = outline_vert(res, curr, curr.head, xshift+curr.shift/factor, yshift+dy)
1098        dy = dy + (b2u and curr.height or -curr.depth)/factor
1099      elseif curr.id == node.id"hlist" then
1100        dy = dy + (b2u and curr.depth or -curr.height)/factor
1101        res = outline_horz(res, curr, curr.head, xshift+curr.shift/factor, yshift+dy)
1102        dy = dy + (b2u and curr.height or -curr.depth)/factor
1103      end
1104      curr = node.getnext(curr)
1105    end
1106    return res
1107  end
1108  function outline_horz (res, box, curr, xshift, yshift, discwd)
```

```
  local r2l = box.dir == "TRT"
  local dx = r2l and (discwd or box.width/factor) or 0
  local dirs = { { dir = r2l, dx = dx } }
  while curr do
    if curr.id == node.id"dir" then
      local sign, dir = curr.dir:match"(.)(...)"
      local level, newdir = curr.level, r2l
      if sign == "+" then
        newdir = dir == "TRT"
        if r2l ~= newdir then
          local n = node.getnext(curr)
          while n do
            if n.id == node.id"dir" and n.level+1 == level then break end
            n = node.getnext(n)
          end
          n = n or node.tail(curr)
          dx = dx + node.rangedimensions(box, curr, n)/factor * (newdir and 1 or -1)
        end
        dirs[level] = { dir = r2l, dx = dx }
      else
        local level = level + 1
        newdir = dirs[level].dir
        if r2l ~= newdir then
          dx = dirs[level].dx
        end
      end
      r2l = newdir
    elseif curr.char and curr.font and curr.font > 0 then
      local ft = font.getfont(curr.font) or font.getcopy(curr.font)
      local gid = ft.characters[curr.char].index or curr.char
      local scale = ft.size / factor / 1000
      local slant   = (ft.slant or 0)/1000
      local extend  = (ft.extend or 1000)/1000
      local squeeze = (ft.squeeze or 1000)/1000
      local expand  = 1 + (curr.expansion_factor or 0)/1000000
      local xscale, yscale = scale * extend * expand, scale * squeeze
      dx = dx - (r2l and curr.width/factor*expand or 0)
      local xoff, yoff = (curr.xoffset or 0)/factor, (curr.yoffset or 0)/factor
      local xpos, ypos = dx + xshift + xoff, yshift + yoff
      local vertical = ""
      if ft.shared and (ft.shared.features.vert or ft.shared.features.vrt2) then
        if ft.shared.features.vertical then -- luatexko
          vertical = "rotated 90"
          local data = ft.characters[curr.char] or { }
          if ft.hb then
            local hoff, voff = (data.luatexko_hoff or 0)/factor, (data.luatexko_voff or 0)/factor
            local charraise = (ft.luatexko_charraise or 0)/factor
            xpos, ypos = xpos - voff + hoff - charraise, ypos + hoff + voff + charraise
          else
```

```
            local cmds = data.commands or { {0,0}, {0,0} }
            local voff, hoff = -cmds[1][2]/factor, cmds[2][2]/factor
            xpos, ypos = xpos + hoff, ypos + voff
          end
        elseif curr ~= box.head then -- luatexja
          vertical = "rotated 90"
          local en = ft.parameters.quad/factor/2
          xpos, ypos = xpos - xoff - yoff + en, ypos - yoff + xoff - en
        end
      end
      local image
      if ft.format == "opentype" or ft.format == "truetype" then
        image = luamplib.glyph(curr.font, gid)
      else
        local name, scale = ft.name, 1
        local vf = font.read_vf(name, ft.size)
        if vf and vf.characters[gid] then
          local cmds = vf.characters[gid].commands or {}
          for _,v in ipairs(cmds) do
            if v[1] == "char" then
              gid = v[2]
            elseif v[1] == "font" and vf.fonts[v[2]] then
              name  = vf.fonts[v[2]].name
              scale = vf.fonts[v[2]].size / ft.size
            end
          end
        end
        image = format("glyph %s of %q scaled %f", gid, name, scale)
      end
      res[#res+1] = format("mpliboutlinepic[%i]:=%s xscaled %f yscaled %f slanted %f %s shifted (%f,%f);",
                           #res+1, image, xscale, yscale, slant, vertical, xpos, ypos)
      dx = dx + (r2l and 0 or curr.width/factor*expand)
    elseif curr.replace then
      local width = node.dimensions(curr.replace)/factor
      dx = dx - (r2l and width or 0)
      res = outline_horz(res, box, curr.replace, xshift+dx, yshift, width)
      dx = dx + (r2l and 0 or width)
    elseif curr.id == node.id"rule" then
      local wd, ht, dp = getrulemetric(box, curr, true)
      if wd ~= 0 then
        local hd = ht + dp
        dx = dx - (r2l and wd or 0)
        if hd ~= 0 and curr.subtype == 0 then
          res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+dx+wd/2, yshift+(ht-dp)/2)
        end
        dx = dx + (r2l and 0 or wd)
      end
    elseif curr.id == node.id"glue" then
      local width = node.effective_glue(curr, box)/factor
```

```
      dx = dx - (r2l and width or 0)
      if curr.leader then
        local curr, kind = curr.leader, curr.subtype
        if curr.id == node.id"rule" then
          local wd, ht, dp = getrulemetric(box, curr, true)
          local hd = ht + dp
          if hd ~= 0 then
            wd = width
            if wd ~= 0 and curr.subtype == 0 then
              res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+dx+wd/2, yshift+(ht-dp)/2)
            end
          end
        elseif curr.head then
          local wd = curr.width/factor
          if wd <= width then
            local dx = r2l and dx+width or dx
            local n, ix = 0, 0
            if kind == 100 or kind == 103 then -- todo: gleaders
              local adx = abs(dx-dirs[1].dx)
              local ndx = math.ceil(adx / wd) * wd
              local diff = ndx - adx
              n = math.floor((width-diff) / wd)
              dx = dx + (r2l and -diff-wd or diff)
            else
              n = math.floor(width / wd)
              if kind == 101 then
                local side = width % wd /2
                dx = dx + (r2l and -side-wd or side)
              elseif kind == 102 then
                ix = width % wd / (n+1)
                dx = dx + (r2l and -ix-wd or ix)
              end
            end
            wd = r2l and -wd or wd
            ix = r2l and -ix or ix
            local func = curr.id == node.id"hlist" and outline_horz or outline_vert
            for i=1,n do
              res = func(res, curr, curr.head, xshift+dx, yshift-curr.shift/factor)
              dx = dx + wd + ix
            end
          end
        end
        dx = dx + (r2l and 0 or width)
      elseif curr.id == node.id"kern" then
        dx = dx + curr.kern/factor * (r2l and -1 or 1)
      elseif curr.id == node.id"math" then
        dx = dx + curr.surround/factor * (r2l and -1 or 1)
      elseif curr.id == node.id"vlist" then
```

```
      dx = dx - (r2l and curr.width/factor or 0)
      res = outline_vert(res, curr, curr.head, xshift+dx, yshift-curr.shift/factor)
      dx = dx + (r2l and 0 or curr.width/factor)
    elseif curr.id == node.id"hlist" then
      dx = dx - (r2l and curr.width/factor or 0)
      res = outline_horz(res, curr, curr.head, xshift+dx, yshift-curr.shift/factor)
      dx = dx + (r2l and 0 or curr.width/factor)
    end
    curr = node.getnext(curr)
  end
  return res
end
function luamplib.outlinetext (text)
  local fmt = process_tex_text(text)
  local id  = tonumber(fmt:match"mplibtexboxid=(%d+):")
  local box = texgetbox(id)
  local res = outline_horz({ }, box, box.head, 0, 0)
  if #res == 0 then res = { "mpliboutlinepic[1]:=image();" } end
  return tableconcat(res) .. format("mpliboutlinenum:=%i;", #res)
end
end
```

lua functions for mplib(uc)substring ... of ...

```
function luamplib.getunicodegraphemes (s)
  local t = { }
  local graphemes = require'lua-uni-graphemes'
  for _, _, c in graphemes.graphemes(s) do
    table.insert(t, c)
  end
  return t
end
function luamplib.unicodesubstring (s,b,e,grph)
  local tt, t, step = { }
  if grph then
    t = luamplib.getunicodegraphemes(s)
  else
    t = { }
    for _, c in utf8.codes(s) do
      table.insert(t, utf8.char(c))
    end
  end
  if b <= e then
    b, step = b+1, 1
  else
    e, step = e+1, -1
  end
  for i = b, e, step do
    table.insert(tt, t[i])
```

```
  end
  s = table.concat(tt):gsub('"','"&ditto&"')
  return string.format('"%s"', s)
end

```

METAPOST preambles

```
luamplib.preambles = {
  preamble = [[
boolean mplib ; mplib := true ;
let dump = endinput ;
let normalfontsize = fontsize;
input %s ;
]],
  mplibcode = [[
texscriptmode := 2;
def rawtextext primary t = runscript("luamplibtext{"&t&"}") enddef;
def mplibcolor primary t = runscript("luamplibcolor{"&t&"}") enddef;
def mplibdimen primary t = runscript("luamplibdimen{"&t&"}") enddef;
def VerbatimTeX primary t = runscript("luamplibverbtex{"&t&"}") enddef;
if known context_mlib:
  defaultfont := "cmtt10";
  let infont = normalinfont;
  let fontsize = normalfontsize;
  vardef thelabel@#(expr p,z) =
    if string p :
      thelabel@#(p infont defaultfont scaled defaultscale,z)
    else :
      p shifted (z + labeloffset*mfun_laboff@# -
        (mfun_labxf@#*lrcorner p + mfun_labyf@#*ulcorner p +
        (1-mfun_labxf@#-mfun_labyf@#)*llcorner p))
    fi
  enddef;
else:
  vardef textext@# primary t = rawtextext (t) enddef;
  def message expr t =
    if string t: runscript("mp.report[=["&t&"]=]") else: errmessage "Not a string" fi
  enddef;
  def withtransparency (expr a, t) =
    withprescript "tr_alternative=" & if numeric a: decimal fi a
    withprescript "tr_transparency=" & decimal t
  enddef;
  vardef ddecimal primary p =
    decimal xpart p & " " & decimal ypart p
  enddef;
  vardef boundingbox primary p =
    if (path p) or (picture p) :
      llcorner p -- lrcorner p -- urcorner p -- ulcorner p
    else :
```

```
      origin
    fi -- cycle
  enddef;
fi
def resolvedcolor(expr s) =
  runscript("return luamplib.shadecolor('"& s &"')")
enddef;
def colordecimals primary c =
  if cmykcolor c:
    decimal cyanpart c & ":" & decimal magentapart c & ":" &
    decimal yellowpart c & ":" & decimal blackpart c
  elseif rgbcolor c:
    decimal redpart c & ":" & decimal greenpart c & ":" & decimal bluepart c
  elseif string c:
    if known graphictextpic: c else: colordecimals resolvedcolor(c) fi
  else:
    decimal c
  fi
enddef;
def externalfigure primary filename =
  draw rawtextext("\includegraphics{"& filename &"}")
enddef;
def TEX = textext enddef;
def mplibtexcolor primary c =
  runscript("return luamplib.gettexcolor('"& c &"')")
enddef;
def mplibrgbtexcolor primary c =
  runscript("return luamplib.gettexcolor('"& c &"','rgb')")
enddef;
def mplibgraphictext primary t =
  begingroup;
  mplibgraphictext_ (t)
enddef;
def mplibgraphictext_ (expr t) text rest =
  save fakebold, scale, fillcolor, drawcolor, withfillcolor, withdrawcolor, strokecolor,
    fb, fc, dc, graphictextpic, alsoordoublepath;
  picture graphictextpic; graphictextpic := nullpicture;
  numeric fb; string fc, dc; fb:=2; fc:="white"; dc:="black";
  let scale = scaled;
  def fakebold  primary c = hide(fb:=c;) enddef;
  def fillcolor primary c = hide(fc:=colordecimals c;) enddef;
  def drawcolor primary c = hide(dc:=colordecimals c;) enddef;
  let withfillcolor = fillcolor; let withdrawcolor = drawcolor; let strokecolor = drawcolor;
  def alsoordoublepath expr p = if picture p: also else: doublepath fi p enddef;
  addto graphictextpic alsoordoublepath (origin--cycle) rest; graphictextpic:=nullpicture;
  def fakebold  primary c = enddef;
  let fillcolor = fakebold; let drawcolor = fakebold;
  let withfillcolor = fillcolor; let withdrawcolor = drawcolor; let strokecolor = drawcolor;
  image(draw runscript("return luamplib.graphictext([===["&t&"]===],"
```

```
    & decimal fb &"','"& fc &"','"& dc &"')") rest;)
  endgroup;
enddef;
def mplibglyph expr c of f =
  runscript (
    "return luamplib.glyph('"
    & if numeric f: decimal fi f
    & "','"
    & if numeric c: decimal fi c
    & "')"
  )
enddef;
numeric luamplib_tmp_num_; luamplib_tmp_num_ = 0;
def mplibdrawglyph expr g =
  luamplib_tmp_num_ := 0;
  for item within g:
    fill pathpart item
    if incr luamplib_tmp_num_ < length g: withpostscript "collect"; fi
  endfor
enddef;
let mplibfillglyph = mplibdrawglyph;
def mplibstrokeglyph expr g =
  luamplib_tmp_num_ := 0;
  for item within g:
    draw pathpart item
    if incr luamplib_tmp_num_ < length g: withpostscript "collect"; fi
  endfor
enddef;
def mplibfillandstrokeglyph expr g =
  luamplib_tmp_num_ := 0;
  for item within g:
    draw pathpart item withpostscript
    if incr luamplib_tmp_num_ < length g: "collect"; else: "both" fi
  endfor
enddef;
def withmplibcolors (expr f, s) =
  runscript("return luamplib.fillandstrokecolor('" &
    if not string f: colordecimals fi f & "','" &
    if not string s: colordecimals fi s & "')")
enddef;
def withmplibopacities (expr a, f, s) =
  withprescript "tr_alternative=" & if numeric a: decimal fi a
  withprescript "tr_transparency=" & decimal f & ":" & decimal s
enddef;
def mplib_do_outline_text_set_b (text f) (text d) text r =
  def mplib_do_outline_options_f = f enddef;
  def mplib_do_outline_options_d = d enddef;
  def mplib_do_outline_options_r = r enddef;
enddef;
```

```
def mplib_do_outline_text_set_f (text f) text r =
  def mplib_do_outline_options_f = f enddef;
  def mplib_do_outline_options_r = r enddef;
enddef;
def mplib_do_outline_text_set_u (text f) text r =
  def mplib_do_outline_options_f = f enddef;
enddef;
def mplib_do_outline_text_set_d (text d) text r =
  def mplib_do_outline_options_d = d enddef;
  def mplib_do_outline_options_r = r enddef;
enddef;
def mplib_do_outline_text_set_r (text d) (text f) text r =
  def mplib_do_outline_options_d = d enddef;
  def mplib_do_outline_options_f = f enddef;
  def mplib_do_outline_options_r = r enddef;
enddef;
def mplib_do_outline_text_set_n text r =
  def mplib_do_outline_options_r = r enddef;
enddef;
def mplib_do_outline_text_set_p = enddef;
def mplib_fill_outline_text =
  for n=1 upto mpliboutlinenum:
    i:=0;
    for item within mpliboutlinepic[n]:
      i:=i+1;
      fill pathpart item mplib_do_outline_options_f withpen pencircle scaled 0
      if (n<mpliboutlinenum) or (i<length mpliboutlinepic[n]): withpostscript "collect"; fi
    endfor
  endfor
enddef;
def mplib_draw_outline_text =
  for n=1 upto mpliboutlinenum:
    for item within mpliboutlinepic[n]:
      draw pathpart item mplib_do_outline_options_d;
    endfor
  endfor
enddef;
def mplib_filldraw_outline_text =
  for n=1 upto mpliboutlinenum:
    i:=0;
    for item within mpliboutlinepic[n]:
      i:=i+1;
      if (n<mpliboutlinenum) or (i<length mpliboutlinepic[n]):
        fill pathpart item mplib_do_outline_options_f withpostscript "collect";
      else:
        draw pathpart item mplib_do_outline_options_f withpostscript "both";
      fi
    endfor
  endfor
```

```
enddef;
vardef mpliboutlinetext@# (expr t) text rest =
  save kind; string kind; kind := str @#;
  save i; numeric i;
  picture mpliboutlinepic[]; numeric mpliboutlinenum;
  def mplib_do_outline_options_d = enddef;
  def mplib_do_outline_options_f = enddef;
  def mplib_do_outline_options_r = enddef;
  runscript("return luamplib.outlinetext[===["&t&"]===]");
  image ( addto currentpicture also image (
    if kind = "f":
      mplib_do_outline_text_set_f rest;
      mplib_fill_outline_text;
    elseif kind = "d":
      mplib_do_outline_text_set_d rest;
      mplib_draw_outline_text;
    elseif kind = "b":
      mplib_do_outline_text_set_b rest;
      mplib_fill_outline_text;
      mplib_draw_outline_text;
    elseif kind = "u":
      mplib_do_outline_text_set_u rest;
      mplib_filldraw_outline_text;
    elseif kind = "r":
      mplib_do_outline_text_set_r rest;
      mplib_draw_outline_text;
      mplib_fill_outline_text;
    elseif kind = "p":
      mplib_do_outline_text_set_p;
      mplib_draw_outline_text;
    else:
      mplib_do_outline_text_set_n rest;
      mplib_fill_outline_text;
    fi;
  ) mplib_do_outline_options_r; )
enddef ;
def withmppattern primary p =
  withprescript "mplibpattern=" & if numeric p: decimal fi p
enddef;
primarydef t withpattern p =
  image(
    if cycle t:
      fill
    else:
      draw
    fi
    t withprescript "mplibpattern=" & if numeric p: decimal fi p; )
enddef;
vardef mplibtransformmatrix (text e) =
```

```
  save t; transform t;
  t = identity e;
  runscript("luamplib.transformmatrix = {"
  & decimal xxpart t & ","
  & decimal yxpart t & ","
  & decimal xypart t & ","
  & decimal yypart t & ","
  & decimal xpart  t & ","
  & decimal ypart  t & ","
  & "}");
enddef;
primarydef p withmaskinggroup s =
  if picture p:
    image(
      draw p;
      draw center p withprescript "mplibfadestate=stop";
    )
  else:
    p withprescript "mplibfadestate=stop"
  fi
  withprescript "mplibfadetype=masking"
  withprescript "mplibmaskname=" & s
enddef;
def withmaskingbgcolor expr c =
  withprescript "mplibmaskingbgcolor=" & decimal c
enddef;
primarydef p withfademethod s =
  if picture p:
    image(
      draw p;
      draw center p withprescript "mplibfadestate=stop";
    )
  else:
    p withprescript "mplibfadestate=stop"
  fi
    withprescript "mplibfadetype=" & s
    withprescript "mplibfadebbox=" &
      decimal (xpart llcorner p -1/4) & ":" &
      decimal (ypart llcorner p -1/4) & ":" &
      decimal (xpart urcorner p +1/4) & ":" &
      decimal (ypart urcorner p +1/4)
enddef;
def withfadeopacity (expr a,b) =
  withprescript "mplibfadeopacity=" &
    decimal a & ":" &
    decimal b
enddef;
def withfadevector (expr a,b) =
  withprescript "mplibfadevector=" &
```

```
    decimal xpart a & ":" &
    decimal ypart a & ":" &
    decimal xpart b & ":" &
    decimal ypart b
enddef;
let withfadecenter = withfadevector;
def withfaderadius (expr a,b) =
  withprescript "mplibfaderadius=" &
    decimal a & ":" &
    decimal b
enddef;
def withfadebbox (expr a,b) =
  withprescript "mplibfadebbox=" &
    decimal xpart a & ":" &
    decimal ypart a & ":" &
    decimal xpart b & ":" &
    decimal ypart b
enddef;
primarydef p asgroup s =
  image(
    draw center p
      withprescript "mplibgroupbbox=" &
        decimal (xpart llcorner p -1/4) & ":" &
        decimal (ypart llcorner p -1/4) & ":" &
        decimal (xpart urcorner p +1/4) & ":" &
        decimal (ypart urcorner p +1/4)
      withprescript "gr_state=start"
      withprescript "gr_type=" & s;
    draw p withprescript "sh_in_xobj=yes";
    draw center p withprescript "gr_state=stop";
  )
enddef;
def withgroupbbox (expr a,b) =
  withprescript "mplibgroupbbox=" &
    decimal xpart a & ":" &
    decimal ypart a & ":" &
    decimal xpart b & ":" &
    decimal ypart b
enddef;
def withgroupname expr s =
  withprescript "mplibgroupname=" & s
enddef;
def usemplibgroup primary s =
  draw maketext("\luamplibtagasgroupput{"& s &"}{\csname luamplib.group."& s &"\endcsname}")
    shifted runscript("return luamplib.trgroupshifts['" & s & "']")
enddef;
path    mplib_shade_path ;
numeric mplib_shade_step ; mplib_shade_step := 0 ;
numeric mplib_shade_fx, mplib_shade_fy ;
```

```
numeric mplib_shade_lx, mplib_shade_ly ;
numeric mplib_shade_nx, mplib_shade_ny ;
numeric mplib_shade_dx, mplib_shade_dy ;
numeric mplib_shade_tx, mplib_shade_ty ;
primarydef p withshadingmethod m =
  p
  if picture p :
    withprescript "sh_operand_type=picture"
    if textual p or (length p > 1):
      withprescript "sh_transform=no"
      mplib_with_shade_method (boundingbox p, m)
    else:
      withprescript "sh_transform=yes"
      mplib_with_shade_method (pathpart p, m)
    fi
  else :
    withprescript "sh_transform=yes"
    mplib_with_shade_method (p, m)
  fi
enddef;
def mplib_with_shade_method (expr p, m) =
  hide(mplib_with_shade_method_analyze(p))
  withprescript "sh_domain=0 1"
  withprescript "sh_color=into"
  withprescript "sh_color_a=" & colordecimals white
  withprescript "sh_color_b=" & colordecimals black
  withprescript "sh_first=" & ddecimal point 0 of p
  withprescript "sh_set_x=" & ddecimal (mplib_shade_nx,mplib_shade_lx)
  withprescript "sh_set_y=" & ddecimal (mplib_shade_ny,mplib_shade_ly)
  if m = "linear" :
    withprescript "sh_type=linear"
    withprescript "sh_factor=1"
    withprescript "sh_center_a=" & ddecimal llcorner p
    withprescript "sh_center_b=" & ddecimal urcorner p
  else :
    withprescript "sh_type=circular"
    withprescript "sh_factor=1.2"
    withprescript "sh_center_a=" & ddecimal center p
    withprescript "sh_center_b=" & ddecimal center p
    withprescript "sh_radius_a=" & decimal 0
    withprescript "sh_radius_b=" & decimal mplib_max_radius(p)
  fi
enddef;
def mplib_with_shade_method_analyze(expr p) =
  mplib_shade_path := p ;
  mplib_shade_step := 1 ;
  mplib_shade_fx   := xpart point 0 of p ;
  mplib_shade_fy   := ypart point 0 of p ;
  mplib_shade_lx   := mplib_shade_fx ;
```

```
  mplib_shade_ly   := mplib_shade_fy ;
  mplib_shade_nx   := 0 ;
  mplib_shade_ny   := 0 ;
  mplib_shade_dx   := abs(mplib_shade_fx - mplib_shade_lx) ;
  mplib_shade_dy   := abs(mplib_shade_fy - mplib_shade_ly) ;
  for i=1 upto length(p) :
    mplib_shade_tx := abs(mplib_shade_fx - xpart point i of p) ;
    mplib_shade_ty := abs(mplib_shade_fy - ypart point i of p) ;
    if mplib_shade_tx > mplib_shade_dx :
      mplib_shade_nx := i + 1 ;
      mplib_shade_lx := xpart point i of p ;
      mplib_shade_dx := mplib_shade_tx ;
    fi ;
    if mplib_shade_ty > mplib_shade_dy :
      mplib_shade_ny := i + 1 ;
      mplib_shade_ly := ypart point i of p ;
      mplib_shade_dy := mplib_shade_ty ;
    fi ;
  endfor ;
enddef;
vardef mplib_max_radius(expr p) =
  max (
    (xpart center   p - xpart llcorner p) ++ (ypart center   p - ypart llcorner p),
    (xpart center   p - xpart ulcorner p) ++ (ypart ulcorner p - ypart center   p),
    (xpart lrcorner p - xpart center   p) ++ (ypart center   p - ypart lrcorner p),
    (xpart urcorner p - xpart center   p) ++ (ypart urcorner p - ypart center   p)
  )
enddef;
def withshadingstep (text t) =
  hide(mplib_shade_step := mplib_shade_step + 1 ;)
  withprescript "sh_step=" & decimal mplib_shade_step
  t
enddef;
def withshadingradius expr a =
  withprescript "sh_radius_a=" & decimal (xpart a)
  withprescript "sh_radius_b=" & decimal (ypart a)
enddef;
def withshadingorigin expr a =
  withprescript "sh_center_a=" & ddecimal a
  withprescript "sh_center_b=" & ddecimal a
enddef;
def withshadingvector expr a =
  withprescript "sh_center_a=" & ddecimal (point xpart a of mplib_shade_path)
  withprescript "sh_center_b=" & ddecimal (point ypart a of mplib_shade_path)
enddef;
def withshadingdirection expr a =
  withprescript "sh_center_a=" & ddecimal (point xpart a of boundingbox(mplib_shade_path))
  withprescript "sh_center_b=" & ddecimal (point ypart a of boundingbox(mplib_shade_path))
enddef;
```

```
def withshadingtransform expr a =
  withprescript "sh_transform=" & a
enddef;
def withshadingcenter expr a =
  withprescript "sh_center_a=" & ddecimal (
    center mplib_shade_path shifted (
      xpart a * xpart (lrcorner mplib_shade_path - llcorner mplib_shade_path)/2,
      ypart a * ypart (urcorner mplib_shade_path - lrcorner mplib_shade_path)/2
    )
  )
enddef;
def withshadingdomain expr d =
  withprescript "sh_domain=" & ddecimal d
enddef;
def withshadingfactor expr f =
  withprescript "sh_factor=" & decimal f
enddef;
def withshadingfraction expr a =
  if mplib_shade_step > 0 :
    withprescript "sh_fraction_" & decimal mplib_shade_step & "=" & decimal a
  fi
enddef;
def withshadingcolors (expr a, b) =
  if mplib_shade_step > 0 :
    withprescript "sh_color=into"
    withprescript "sh_color_a_" & decimal mplib_shade_step & "=" & colordecimals a
    withprescript "sh_color_b_" & decimal mplib_shade_step & "=" & colordecimals b
  else :
    withprescript "sh_color=into"
    withprescript "sh_color_a=" & colordecimals a
    withprescript "sh_color_b=" & colordecimals b
  fi
enddef;
def withshadingstroke expr a =
  withprescript "sh_stroking=" & a
enddef;
def mpliblength primary t =
  runscript("return utf8.len[===[" & t & "]===]")
enddef;
def mplibsubstring expr p of t =
  runscript("return luamplib.unicodesubstring([===[" & t & "]===],"
    & decimal xpart p & ","
    & decimal ypart p & ")")
enddef;
def mplibuclength primary t =
  runscript("return #luamplib.getunicodegraphemes[===[" & t & "]===]")
enddef;
def mplibucsubstring expr p of t =
  runscript("return luamplib.unicodesubstring([===[" & t & "]===],"
```

```
    & decimal xpart p & ","
    & decimal ypart p & ",true)")
enddef;
]],
  legacyverbatimtex = [[
def specialVerbatimTeX (text t) = runscript("luamplibprefig{"&t&"}") enddef;
def normalVerbatimTeX  (text t) = runscript("luamplibinfig{"&t&"}") enddef;
let VerbatimTeX = specialVerbatimTeX;
extra_beginfig := extra_beginfig & " let VerbatimTeX = normalVerbatimTeX;"&
  "runscript(" &ditto& "luamplib.in_the_fig=true" &ditto& ");";
extra_endfig := extra_endfig & " let VerbatimTeX = specialVerbatimTeX;"&
  "runscript(" &ditto&
  "if luamplib.in_the_fig then luamplib.figid=luamplib.figid+1 end "&
  "luamplib.in_the_fig=false" &ditto& ");";
]],
  textextlabel = [[
let luampliboriginalinfont = infont;
primarydef s infont f =
  if   (s < char 32)
    or (s = char 35) % #
    or (s = char 36) % $
    or (s = char 37) % %
    or (s = char 38) % &
    or (s = char 92) % \
    or (s = char 94) % ^
    or (s = char 95) % _
    or (s = char 123) % {
    or (s = char 125) % }
    or (s = char 126) % ~
    or (s = char 127) :
    s luampliboriginalinfont f
  else :
    rawtextext(s)
  fi
enddef;
def fontsize expr f =
  begingroup
  save size; numeric size;
  size := mplibdimen("1em");
  if size = 0: 10pt else: size fi
  endgroup
enddef;
]],
}
```

process_mplibcode

When \mplibverbatim is enabled, do not expand mplibcode data.

```
luamplib.verbatiminput = false
```

```
luamplib.everymplib    = setmetatable({ [""] = "" },{ __index = function(t) return t[""] end })
luamplib.everyendmplib = setmetatable({ [""] = "" },{ __index = function(t) return t[""] end })
function luamplib.process_mplibcode (data, instancename)
  texboxes.localid = 4096
```

This is needed for legacy behavior

```
  if luamplib.legacyverbatimtex then
    luamplib.figid, tex_code_pre_mplib = 1, {}
  end
  local everymplib    = luamplib.everymplib[instancename]
  local everyendmplib = luamplib.everyendmplib[instancename]
  data = format("\n%s\n%s\n%s\n",everymplib, data, everyendmplib)
  :gsub("\r","\n")
```

These five lines are needed for `mplibverbatim` mode.

```
  if luamplib.verbatiminput then
    data = data:gsub("\\mpcolor%s+(.-%b{})","mplibcolor(\"%1\")")
    :gsub("\\mpdim%s+(%b{})", "mplibdimen(\"%1\")")
    :gsub("\\mpdim%s+(\\%a+)","mplibdimen(\"%1\")")
    :gsub(btex_etex, "btex %1 etex ")
    :gsub(verbatimtex_etex, "verbatimtex %1 etex;")
  else
```

If not `mplibverbatim`, expand `mplibcode` data, so that users can use TEX codes in it. It has turned out that no comment sign is allowed. However, we do not expand `btex ... etex`, `verbatimtex ... etex`, and string expressions.

```
    local t = { } -- to store btex, verbatimtex, string
    data = data:gsub(btex_etex, function(str)
      t[#t+1] = str
      return format("btex \\unexpanded{!l!u!a!%s!m!p!l!} etex ",  #t) -- space
    end)
    :gsub(verbatimtex_etex, function(str)
      t[#t+1] = str
      return format("verbatimtex \\unexpanded{!l!u!a!%s!m!p!l!} etex;", #t) -- semicolon
    end)
    :gsub('"(.-)"', function(str)
      t[#t+1] = str
      return format('"\\unexpanded{!l!u!a!%s!m!p!l!}"', #t)
    end)
    :gsub("\\%%", "\0PerCent\0")
    :gsub("%%.-\n","\n")
    :gsub("%zPerCent%z", "\\%%")
    run_tex_code(format("\\mplibtmptoks\\expandafter{\\expanded{%s}}",data))
    data = texgettoks"mplibtmptoks"
```

Next line to address issue #55

```
    :gsub("##", "#")
    :gsub("!l!u!a!(%d+)!m!p!l!", function(str) return t[tonumber(str)] or str end)
  end
  process(data, instancename)
```

```
end

```

pdfliterals will be stored in `figcontents` table, and written to pdf in one go at the end of the flushing figure. Subtable `post` is for the legacy behavior.

```
local figcontents = { post = { } }
local function put2output(a,...)
  figcontents[#figcontents+1] = type(a) == "string" and format(a,...) or a
end
local function pdf_startfigure(n,llx,lly,urx,ury)
  put2output("\\mplibstarttoPDF{%f}{%f}{%f}{%f}",llx,lly,urx,ury)
end
local function pdf_stopfigure()
  put2output("\\mplibstoptoPDF")
end
```

`tex.sprint` with catcode regime -2, as sometimes # gets doubled in the argument of pdfliteral.

```
local function pdf_literalcode (...)
  put2output{ -2, (format(...) :gsub(decimals,rmzeros)) }
end
local start_pdf_code = pdfmode
  and function() pdf_literalcode"q" end
  or  function() put2output"\\special{pdf:bcontent}" end
local stop_pdf_code = pdfmode
  and function() pdf_literalcode"Q" end
  or  function() put2output"\\special{pdf:econtent}" end

```

Now we process hboxes created from `btex ... etex` or `textext(...)` or `TEX(...)` etc.

```
local function put_tex_boxes (object,prescript)
  local box = prescript.mplibtexboxid:explode":"
  local n,tw,th = box[1],tonumber(box[2]),tonumber(box[3])
  if n and tw and th then
    local op = object.path
    local first, second, fourth = op[1], op[2], op[4]
    local tx, ty = first.x_coord, first.y_coord
    local sx, rx, ry, sy = 1, 0, 0, 1
    if tw ~= 0 then
      sx = (second.x_coord - tx)/tw
      rx = (second.y_coord - ty)/tw
      if sx == 0 then sx = 0.00001 end
    end
    if th ~= 0 then
      sy = (fourth.y_coord - ty)/th
      ry = (fourth.x_coord - tx)/th
      if sy == 0 then sy = 0.00001 end
    end
    start_pdf_code()
    pdf_literalcode("%f %f %f %f %f %f cm",sx,rx,ry,sy,tx,ty)
    put2output("\\mplibputtextbox{%i}",n)
```

```
    stop_pdf_code()
  end
end
```

Colors

```
local do_preobj_CR
do
  local prev_override_color
  function do_preobj_CR(object,prescript)
    if object.postscript == "collect" then return end
    local override = prescript and prescript.mpliboverridecolor
    if override then
      if pdfmode then
        pdf_literalcode(override)
        override = nil
      else
        put2output("\\special{%s}",override)
        prev_override_color = override
      end
    else
      local cs = object.color
      if cs and #cs > 0 then
        pdf_literalcode(luamplib.colorconverter(cs))
        prev_override_color = nil
      elseif not pdfmode then
        override = prev_override_color
        if override then
          put2output("\\special{%s}",override)
        end
      end
    end
    return override
  end
end
```

For transparency, shading, fading, and pattern

```
local pdfmanagement = is_defined'pdfmanagement_add:nnn'
local pdfobjs, pdfetcs = {}, {}
pdfetcs.pgfextgs = "pgf@sys@addpdfresource@extgs@plain"
pdfetcs.pgfpattern = "pgf@sys@addpdfresource@patterns@plain"
pdfetcs.pgfcolorspace = "pgf@sys@addpdfresource@colorspaces@plain"
local function update_pdfobjs (os, stream)
  local key = os
  if stream then key = key..stream end
  local on = key and pdfobjs[key]
  if on then
    return on,false
  end
```

```
  if pdfmode then
    if stream then
      on = pdf.immediateobj("stream",stream,os)
    elseif os then
      on = pdf.immediateobj(os)
    else
      on = pdf.reserveobj()
    end
  else
    on = pdfetcs.cnt or 1
    if stream then
      texsprint(format("\\special{pdf:stream @mplibpdfobj%s (%s) <<%s>>}",on,stream,os))
    elseif os then
      texsprint(format("\\special{pdf:obj @mplibpdfobj%s %s}",on,os))
    else
      texsprint(format("\\special{pdf:obj @mplibpdfobj%s <<>>}",on))
    end
    pdfetcs.cnt = on + 1
  end
  if key then
    pdfobjs[key] = on
  end
  return on,true
end
pdfetcs.resfmt = pdfmode and "%s 0 R" or "@mplibpdfobj%s"
if pdfmode then
  pdfetcs.getpageres = pdf.getpageresources or function() return pdf.pageresources end
  local getpageres = pdfetcs.getpageres
  local setpageres = pdf.setpageresources or function(s) pdf.pageresources = s end
  local initialize_resources = function (name)
    local tabname = format("%s_res",name)
    pdfetcs[tabname] = { }
    if luatexbase.callbacktypes.finish_pdffile then -- ltluatex
      local obj = pdf.reserveobj()
      setpageres(format("%s/%s %i 0 R", getpageres() or "", name, obj))
      luatexbase.add_to_callback("finish_pdffile", function()
        pdf.immediateobj(obj, format("<<%s>>", tableconcat(pdfetcs[tabname])))
      end,
      format("luamplib.%s.finish_pdffile",name))
    end
  end
  pdfetcs.fallback_update_resources = function (name, res)
    local tabname = format("%s_res",name)
    if not pdfetcs[tabname] then
      initialize_resources(name)
    end
    if luatexbase.callbacktypes.finish_pdffile then
      local t = pdfetcs[tabname]
      t[#t+1] = res
```

```
    else
      local tpr, n = getpageres() or "", 0
      tpr, n = tpr:gsub(format("/%s<<",name), "%1"..res)
      if n == 0 then
        tpr = format("%s/%s<<%s>>", tpr, name, res)
      end
      setpageres(tpr)
    end
  end
else
  texsprint {
    "\\luamplibatfirstshipout{",
    "\\special{pdf:obj @MPlibTr<<>>}",
    "\\special{pdf:obj @MPlibSh<<>>}",
    "\\special{pdf:obj @MPlibCS<<>>}",
    "\\special{pdf:obj @MPlibPt<<>>}}",
  }
  pdfetcs.fallback_update_resources = function (name,res,obj)
    texsprint{"\\special{pdf:put ", obj, " <<", res, ">>}"}
    local tabname = format("%s_res",name)
    if not pdfetcs[tabname] then
      texsprint{"\\luamplibateveryshipout{\\special{pdf:put @resources <</", name, " ", obj, ">>}}"}
      pdfetcs[tabname] = { }
    end
    tableinsert(pdfetcs[tabname], res)
  end
end

```

Transparency

```
local function add_extgs_resources (on, new)
  local key = format("MPlibTr%s", on)
  if new then
    local val = format(pdfetcs.resfmt, on)
    if pdfmanagement then
      texsprint {
        "\\csname pdfmanagement_add:nnn\\endcsname{Page/Resources/ExtGState}{", key, "}{", val, "}"
      }
    else
      local tr = format("/%s %s", key, val)
      if is_defined(pdfetcs.pgfextgs) then
        texsprint { "\\csname ", pdfetcs.pgfextgs, "\\endcsname{", tr, "}" }
      elseif is_defined"TRP@list" then
        texsprint(catat11,{
          [[\if@filesw\immediate\write\@auxout{]],
          [[\string\g@addto@macro\string\TRP@list{]],
          tr,
          [[}}\fi]],
        })
```

```
      if not get_macro"TRP@list":find(tr) then
        texsprint(catat11,[[\global\TRP@reruntrue]])
      end
    else
      pdfetcs.fallback_update_resources("ExtGState",tr,"@MPlibTr")
    end
  end
end
return key
end

local do_preobj_TR
do
  local transparancy_modes = {
    [0] = "Normal",
    "Normal",       "Multiply",     "Screen",       "Overlay",
    "SoftLight",    "HardLight",    "ColorDodge",   "ColorBurn",
    "Darken",       "Lighten",      "Difference",   "Exclusion",
    "Hue",          "Saturation",   "Color",        "Luminosity",
    "Compatible",
    normal     = "Normal",     multiply   = "Multiply",   screen    = "Screen",
    overlay    = "Overlay",    softlight  = "SoftLight",  hardlight = "HardLight",
    colordodge = "ColorDodge", colorburn  = "ColorBurn",  darken    = "Darken",
    lighten    = "Lighten",    difference = "Difference", exclusion = "Exclusion",
    hue        = "Hue",        saturation = "Saturation", color     = "Color",
    luminosity = "Luminosity", compatible = "Compatible",
  }
  function do_preobj_TR(object,prescript)
    if object.postscript == "collect" then return end
    local opaq = prescript and prescript.tr_transparency
    if not opaq then return end

    local key, on, os, new
    local mode = prescript.tr_alternative or 1
    mode = transparancy_modes[tonumber(mode) or mode:lower()]
    if not mode then
      mode = prescript.tr_alternative
      warn("unsupported blend mode: '%s'", mode)
    end
    opaq = opaq:explode":"
    for i,v in ipairs(opaq) do
      opaq[i] = format("%.3f", v) :gsub(decimals,rmzeros)
    end
    for i,v in ipairs{ {mode,opaq[1],opaq[2] or opaq[1]},{"Normal",1,1} } do
      os = format("<</BM/%s/ca %s/CA %s/AIS false>>",v[1],v[2],v[3])
      on, new = update_pdfobjs(os)
      key = add_extgs_resources(on,new)
      if i == 1 then
        pdf_literalcode("/%s gs",key)
```

```
      else
        return format("/%s gs",key)
      end
    end
  end
end

```

Shading with *metafun* format.

```
local function sh_pdfpageresources(shtype,domain,colorspace,ca,cb,coordinates,steps,fractions)
  for _,v in ipairs{ca,cb} do
    for i,vv in ipairs(v) do
      for ii,vvv in ipairs(vv) do
        v[i][ii] = tonumber(vvv) and format("%.3f",vvv) or vvv
      end
    end
  end
  local fun2fmt,os = "<</FunctionType 2/Domain[%s]/C0[%s]/C1[%s]/N 1>>"
  if steps > 1 then
    local list,bounds,encode = { },{ },{ }
    for i=1,steps do
      if i < steps then
        bounds[i] = format("%.3f", fractions[i] or 1)
      end
      encode[2*i-1] = 0
      encode[2*i]   = 1
      os = fun2fmt:format(domain,tableconcat(ca[i],' '),tableconcat(cb[i],' '))
        :gsub(decimals,rmzeros)
      list[i] = format(pdfetcs.resfmt, update_pdfobjs(os))
    end
    os = tableconcat {
      "<</FunctionType 3",
      format("/Bounds[%s]",    tableconcat(bounds,' ')),
      format("/Encode[%s]",    tableconcat(encode,' ')),
      format("/Functions[%s]", tableconcat(list,  ' ')),
      format("/Domain[%s]>>",  domain),
    } :gsub(decimals,rmzeros)
  else
    os = fun2fmt:format(domain,tableconcat(ca[1],' '),tableconcat(cb[1],' '))
      :gsub(decimals,rmzeros)
  end
  local objref = format(pdfetcs.resfmt, update_pdfobjs(os))
  os = tableconcat {
    format("<</ShadingType %i", shtype),
    format("/ColorSpace %s",    colorspace),
    format("/Function %s",      objref),
    format("/Coords[%s]",       coordinates),
    "/Extend[true true]/AntiAlias true>>",
  } :gsub(decimals,rmzeros)
```

```
  local on, new = update_pdfobjs(os)
  if new then
    local key, val = format("MPlibSh%s", on), format(pdfetcs.resfmt, on)
    if pdfmanagement then
      texsprint {
        "\\csname pdfmanagement_add:nnn\\endcsname{Page/Resources/Shading}{", key, "}{", val, "}"
      }
    else
      local res = format("/%s %s", key, val)
      pdfetcs.fallback_update_resources("Shading",res,"@MPlibSh")
    end
  end
  return on
end

local do_preobj_SH
do
  pdfetcs.clrspcs = setmetatable({ }, { __index = function(t,names)
    run_tex_code({
      [[\color_model_new:nnn]],
      format("{mplibcolorspace_%s}", names:gsub(",","_")),
      format("{DeviceN}{names={%s}}", names),
      [[\edef\mplib_@tempa{\pdf_object_ref_last:}]],
    }, ccexplat)
    local colorspace = get_macro'mplib_@tempa'
    t[names] = colorspace
    return colorspace
  end })
  local function color_normalize(ca,cb)
    if #cb == 1 then
      if #ca == 4 then
        cb[1], cb[2], cb[3], cb[4] = 0, 0, 0, 1-cb[1]
      else -- #ca = 3
        cb[1], cb[2], cb[3] = cb[1], cb[1], cb[1]
      end
    elseif #cb == 3 then -- #ca == 4
      cb[1], cb[2], cb[3], cb[4] = 1-cb[1], 1-cb[2], 1-cb[3], 0
    end
  end
  function do_preobj_SH(object, prescript)
    local shade_no
    local sh_type = prescript and prescript.sh_type
    if not sh_type then return end

    local domain  = prescript.sh_domain or "0 1"
    local centera = (prescript.sh_center_a or "0 0"):explode()
    local centerb = (prescript.sh_center_b or "0 0"):explode()
    local transform = prescript.sh_transform == "yes"
    local sx,sy,sr,dx,dy = 1,1,1,0,0
```

```
  if transform then
    local first = (prescript.sh_first or "0 0"):explode()
    local setx  = (prescript.sh_set_x or "0 0"):explode()
    local sety  = (prescript.sh_set_y or "0 0"):explode()
    local x,y = tonumber(setx[1]) or 0, tonumber(sety[1]) or 0
    if x ~= 0 and y ~= 0 then
      local path = object.path
      local path1x = path[1].x_coord
      local path1y = path[1].y_coord
      local path2x = path[x].x_coord
      local path2y = path[y].y_coord
      local dxa = path2x - path1x
      local dya = path2y - path1y
      local dxb = setx[2] - first[1]
      local dyb = sety[2] - first[2]
      if dxa ~= 0 and dya ~= 0 and dxb ~= 0 and dyb ~= 0 then
        sx = dxa / dxb ; if sx < 0 then sx = - sx end
        sy = dya / dyb ; if sy < 0 then sy = - sy end
        sr = math.sqrt(sx^2 + sy^2)
        dx = path1x - sx*first[1]
        dy = path1y - sy*first[2]
      end
    end
  end
  local ca, cb, colorspace, steps, fractions
  ca = { (prescript.sh_color_a_1 or prescript.sh_color_a or "0"):explode":" }
  cb = { (prescript.sh_color_b_1 or prescript.sh_color_b or "1"):explode":" }
  steps = tonumber(prescript.sh_step) or 1
  if steps > 1 then
    fractions = { prescript.sh_fraction_1 or 0 }
    for i=2,steps do
      fractions[i] = prescript[format("sh_fraction_%i",i)] or (i/steps)
      ca[i] = (prescript[format("sh_color_a_%i",i)] or "0"):explode":"
      cb[i] = (prescript[format("sh_color_b_%i",i)] or "1"):explode":"
    end
  end
  if prescript.mplib_spotcolor then
    ca, cb = { }, { }
    local names, pos, objref = { }, -1, ""
    local script = object.prescript:explode"\13+"
    for i=#script,1,-1 do
      if script[i]:find"mplib_spotcolor" then
        local t, name, value = script[i]:explode"="[2]:explode":"
        value, objref, name = t[1], t[2], t[3]
        if not names[name] then
          pos = pos+1
          names[name] = pos
          names[#names+1] = name
        end
```

```
        t = { }
        for j=1,names[name] do t[#t+1] = 0 end
        t[#t+1] = value
        tableinsert(#ca == #cb and ca or cb, t)
      end
    end
    for _,t in ipairs{ca,cb} do
      for _,tt in ipairs(t) do
        for i=1,#names-#tt do tt[#tt+1] = 0 end
      end
    end
    if #names == 1 then
      colorspace = objref
    else
      colorspace = pdfetcs.clrspcs[ tableconcat(names,",") ]
    end
  else
    local model = 0
    for _,t in ipairs{ca,cb} do
      for _,tt in ipairs(t) do
        model = model > #tt and model or #tt
      end
    end
    for _,t in ipairs{ca,cb} do
      for _,tt in ipairs(t) do
        if #tt < model then
          color_normalize(model == 4 and {1,1,1,1} or {1,1,1},tt)
        end
      end
    end
    colorspace = model == 4 and "/DeviceCMYK"
              or model == 3 and "/DeviceRGB"
              or model == 1 and "/DeviceGray"
              or err"unknown color model"
  end
  if sh_type == "linear" then
    local coordinates = format("%f %f %f %f",
      dx + sx*centera[1], dy + sy*centera[2],
      dx + sx*centerb[1], dy + sy*centerb[2])
    shade_no = sh_pdfpageresources(2,domain,colorspace,ca,cb,coordinates,steps,fractions)
  elseif sh_type == "circular" then
    local factor = prescript.sh_factor or 1
    local radiusa = factor * prescript.sh_radius_a
    local radiusb = factor * prescript.sh_radius_b
    local coordinates = format("%f %f %f %f %f %f",
      dx + sx*centera[1], dy + sy*centera[2], sr*radiusa,
      dx + sx*centerb[1], dy + sy*centerb[2], sr*radiusb)
    shade_no = sh_pdfpageresources(3,domain,colorspace,ca,cb,coordinates,steps,fractions)
  else
```

```
      err"unknown shading type"
    end
    return shade_no, prescript.sh_stroking == "yes"
  end
end
```

Shading Patterns: we can apply shading to textual pictures as well as paths.

```
local function add_pattern_resources (key, val)
  if pdfmanagement then
    texsprint {
      "\\csname pdfmanagement_add:nnn\\endcsname{Page/Resources/Pattern}{", key, "}{", val, "}"
    }
  else
    local res = format("/%s %s", key, val)
    if is_defined(pdfetcs.pgfpattern) then
      texsprint { "\\csname ", pdfetcs.pgfpattern, "\\endcsname{", res, "}" }
    else
      pdfetcs.fallback_update_resources("Pattern",res,"@MPlibPt")
    end
  end
end
if not pdfmode then
  pdfetcs.shadingpatterns = { }
  pdfetcs.shadingpatterninit_r, pdfetcs.shadingpatterninit_w = true, true
end
function luamplib.dolatelua (on, os, xobj)
  local h, v = pdf.getpos()
  h = format("%f", h/factor) :gsub(decimals,rmzeros)
  v = format("%f", v/factor) :gsub(decimals,rmzeros)
  if pdfmode then
    pdf.obj(on, format("<<%s/Matrix[1 0 0 1 %s %s]>>", os, h, v))
    pdf.refobj(on)
  else
    local t = pdfetcs.shadingpatterns[on] or { }
    local shift = os == "group" and pdfetcs.tr_group.shifts[xobj]
                or os == "pattern" and pdfetcs.patterns[xobj].shifts
    if shift then
      h, v = -shift[1], -shift[2] -- engine bug in dvi mode?
    end
    if tonumber(h) ~= tonumber(t[1]) or tonumber(v) ~= tonumber(t[2]) then
      warn"Rerun to get correct shading pattern"
    end
    local name = format("%s/%s_shadingpatterns.aux", cachedir or outputdir(), tex.jobname)
    local init = pdfetcs.shadingpatterninit_w
    if init then pdfetcs.shadingpatterninit_w = nil end
    local f = ioopen(name, init and "w" or "a")
    if f then
      f:write(("%s %s %s\n"):format(on, h, v))
```

```
      f:close()
    else
      err"cannot write a file. check the cache dir path"
    end
  end
end
local function do_preobj_shading (object, prescript)
  if not prescript or not prescript.sh_operand_type then return end
  local on = do_preobj_SH(object, prescript)
  local os = format("/PatternType 2/Shading %s", format(pdfetcs.resfmt, on))
  if prescript.sh_in_xobj == "yes" then
    on = update_pdfobjs(("<<%s>>"):format(os))
    goto skip_latelua
  end
  on = update_pdfobjs()
  if pdfmode then
    put2output(tableconcat{ "\\latelua{ luamplib.dolatelua(",on,",[[",os,"]]) }" })
  else
    local xobj = is_defined"mplibgroupname" and {"group", get_macro"mplibgroupname"}
              or is_defined"mplibpatternname" and {"pattern", get_macro"mplibpatternname"}
    if xobj or not is_defined"RecordProperties" then -- in xobject or plain
      local init = pdfetcs.shadingpatterninit_r
      if init then
        pdfetcs.shadingpatterninit_r = nil
        local name = format("%s/%s_shadingpatterns.aux", cachedir or outputdir(), tex.jobname)
        local f = ioopen(name)
        if f then
          for line in f:lines() do
            local t = line:explode()
            pdfetcs.shadingpatterns[ tonumber(t[1]) ] = { t[2], t[3] }
          end
          f:close()
        end
      end
      local t = pdfetcs.shadingpatterns[on] or { 0, 0 }
      texsprint{ "\\special{pdf:put ", format(pdfetcs.resfmt, on),
                format(" <<%s/Matrix[1 0 0 1 %s %s]>>}", os, t[1], t[2]) }
      put2output("\\latelua{ luamplib.dolatelua(%s,%s) }", on,
                xobj and ("'%s',[[%s]]"):format(xobj[1], xobj[2]))
    else
```

Why @xpos @ypos do not work properly???
Anyway, this seems to be needed for proper functioning:

```
\pagewidth=\paperwidth
\pageheight=\paperheight
\special{papersize=\the\paperwidth,\the\paperheight}
```

```
      put2output(tableconcat{
        "\\csname tex_savepos:D\\endcsname\\RecordProperties{luamplib/getpos/",on,"}{xpos,ypos}\z
```

```
        \\special{pdf:put ",format(pdfetcs.resfmt, on)," <<",os,"/Matrix[1 0 0 1 \z
        \\csname dim_to_decimal_in_bp:n\\endcsname{\\RefProperty{luamplib/getpos/",on,"}{xpos}sp} \z
        \\csname dim_to_decimal_in_bp:n\\endcsname{\\RefProperty{luamplib/getpos/",on,"}{ypos}sp}\z
        ]>>}"
      })
    end
  end
  ::skip_latelua::
  local key, val = format("MPlibPt%s", on), format(pdfetcs.resfmt, on)
  add_pattern_resources(key,val)
  pdf_literalcode("/Pattern cs/%s scn", key)
```

To avoid possible double execution, once by Pattern gs, once by Sh operator.

```
  prescript.sh_type = nil
end
```

Tiling Patterns

```
pdfetcs.patterns = { }
local function gather_resources (optres, ispattern)
  local t = { }
  if pdfmanagement then
    for _,v in ipairs {"ExtGState","ColorSpace","Pattern","Shading"} do
      local mytoks
      run_tex_code ({
        "\\mplibtmptoks\\expanded{{",
        "\\pdfdict_if_empty:nF{g__pdf_Core/Page/Resources/",v,"}",
        "{\\pdfdict_use:n{g__pdf_Core/Page/Resources/",v,"}}", "}}",
      },ccexplat)
      mytoks = texgettoks"mplibtmptoks"
      if not pdfmode then
        mytoks = mytoks:gsub("\\str_convert_pdfname:n%s*{(.-)}","%1") -- why not expanded?
      end
      mytoks = mytoks and mytoks:gsub("^%s*(.-)%s*$", "%1")
      if mytoks and mytoks ~= "" then
        t[#t+1] = ("/%s<<%s>>"):format(v, mytoks)
      end
    end
  elseif is_defined(pdfetcs.pgfextgs) then
    run_tex_code"\\relax" -- flush tex.sprint queue
    if pdfmode then
      for k,v in pairs { ExtGState  = "pgf@sys@pgf@resource@list@extgs",
                         ColorSpace = "pgf@sys@pgf@resource@list@colorspaces",
                         Pattern    = "pgf@sys@pgf@resource@list@patterns", } do
        local res = (get_macro(v) or ""):gsub("^%s*(.-)%s*$","%1")
        if res ~= "" then
          t[#t+1] = ("/%s<<%s>>"):format(k, res )
        end
      end
    else
```

```
    local abc = get_macro"pgfutil@abc" or ""
    for k,v in pairs { ExtGState  = "@pgfextgs",
                       ColorSpace = "@pgfcolorspaces",
                       Pattern    = "@pgfpatterns", } do
      local tt = { }
      for vv in abc:gmatch( v .. "%s*(%b<>)" ) do
        tt[#tt+1] = vv:match("^<<%s*(.-)%s*>>$")
      end
      if #tt > 0 then
        t[#t+1] = ("/%s<<%s>>"):format(k, tableconcat(tt) )
      end
    end
  end
```

We still have to deal with Shading resources.

```
  if luatexbase.callbacktypes.finish_pdffile then
    if pdfetcs.Shading_res then
      t[#t+1] = ("/Shading<<%s>>"):format( tableconcat(pdfetcs.Shading_res) )
    end
  else
    local res = pdfetcs.getpageres()
    res = res and res:match"/Shading%s*%b<>"
    if res then
      t[#t+1] = res
    end
  end
else
  if ispattern and is_defined"TRP@list" then
```

We do not gather transparent package's `\TRP@list` as Acrobat glitches on tiling pattern plus masking group, so warn users and recommend `\DocumentMetadata`

```
    warn"transparent package is not fully functional without pdfmanagement code."
  end
  if luatexbase.callbacktypes.finish_pdffile then
    for _,v in ipairs {"ExtGState","ColorSpace","Pattern","Shading"} do
      local tt = pdfetcs[v.."_res"]
      if tt then
        t[#t+1] = ("/%s<<%s>>"):format(v, tableconcat(tt))
      end
    end
  else
    local res = pdfetcs.getpageres()
    if res then
      t[#t+1] = res
    end
  end
end
local result = tableconcat(t)
if optres ~= "" then
  for _,v in ipairs {"ExtGState","ColorSpace","Pattern","Shading"} do
```

```
      local res = optres:match("/"..v.."%s*%b<>")
      if res then
        if result:find("/"..v) then
          res = res:match("<<(.+)>>$")
          result = result:gsub("/"..v.."%s*<<", "%1"..res, 1)
        else
          result = result .. res
        end
      end
    end
  end
  return result
end
function luamplib.registerpattern ( boxid, name, opts )
  local box = texgetbox(boxid)
  local wd = format("%.3f",box.width/factor)
  local hd = format("%.3f",(box.height+box.depth)/factor)
  info("w/h/d of pattern '%s': %s 0", name, format("%s %s",wd, hd):gsub(decimals,rmzeros))
  if opts.xstep == 0 then opts.xstep = nil end
  if opts.ystep == 0 then opts.ystep = nil end
  if opts.colored == nil then
    opts.colored = opts.coloured
    if opts.colored == nil then
      opts.colored = true
    end
  end
  if type(opts.matrix) == "table" then opts.matrix = tableconcat(opts.matrix," ") end
  if type(opts.bbox) == "table" then opts.bbox = tableconcat(opts.bbox," ") end
  if opts.matrix and opts.matrix:find"%a" then
    local data = format("mplibtransformmatrix(%s);",opts.matrix)
    process(data,"@mplibtransformmatrix")
    local t = luamplib.transformmatrix
    opts.matrix = format("%f %f %f %f", t[1], t[2], t[3], t[4])
    opts.xshift = opts.xshift or format("%f",t[5])
    opts.yshift = opts.yshift or format("%f",t[6])
  end
  local attr = {
    "/Type/Pattern",
    "/PatternType 1",
    format("/PaintType %i", opts.colored and 1 or 2),
    "/TilingType 2",
    format("/XStep %s", opts.xstep or wd),
    format("/YStep %s", opts.ystep or hd),
    format("/Matrix[%s %s %s]", opts.matrix or "1 0 0 1", opts.xshift or 0, opts.yshift or 0),
  }
  local optres = opts.resources or ""
  optres = gather_resources(optres, true) -- tiling pattern plus masking glitches with acrobat
  local patterns = pdfetcs.patterns
  if pdfmode then
```

```
    if opts.bbox then
      attr[#attr+1] = format("/BBox[%s]", opts.bbox)
    end
    attr = tableconcat(attr) :gsub(decimals,rmzeros)
    local index = tex.saveboxresource(boxid, attr, optres, true, opts.bbox and 4 or 1)
    patterns[name] = { id = index, colored = opts.colored }
  else
    local cnt = #patterns + 1
    local objname = "@mplibpattern" .. cnt
    local metric = format("bbox %s", opts.bbox or format("0 0 %s %s",wd,hd))
    texsprint {
      "\\expandafter\\newbox\\csname luamplib.patternbox.", cnt, "\\endcsname",
      "\\global\\setbox\\csname luamplib.patternbox.", cnt, "\\endcsname",
      "\\hbox{\\unhbox ", boxid, "}\\luamplibatnextshipout{",
      "\\special{pdf:bcontent}",
      "\\special{pdf:bxobj ", objname, " ", metric, "}",
      "\\raise\\dp\\csname luamplib.patternbox.", cnt, "\\endcsname",
      "\\box\\csname luamplib.patternbox.", cnt, "\\endcsname",
      "\\special{pdf:put @resources <<", optres, ">>}",
      "\\special{pdf:exobj <<", tableconcat(attr), ">>}",
      "\\special{pdf:econtent}}",
    }
    patterns[cnt] = objname
    patterns[name] = { id = cnt, colored = opts.colored }
    patterns[name].shifts = { get_macro"MPllx", get_macro"MPlly" } -- for shading patterns above
  end
end

local do_preobj_PAT
do
  local function pattern_colorspace (cs)
    local on, new = update_pdfobjs(format("[/Pattern %s]", cs))
    if new then
      local key, val = format("MPlibCS%i",on), format(pdfetcs.resfmt,on)
      if pdfmanagement then
        texsprint {
          "\\csname pdfmanagement_add:nnn\\endcsname{Page/Resources/ColorSpace}{", key, "}{", val, "}"
        }
      else
        local res = format("/%s %s", key, val)
        if is_defined(pdfetcs.pgfcolorspace) then
          texsprint { "\\csname ", pdfetcs.pgfcolorspace, "\\endcsname{", res, "}" }
        else
          pdfetcs.fallback_update_resources("ColorSpace",res,"@MPlibCS")
        end
      end
    end
    return on
  end
```

```
function do_preobj_PAT(object, prescript)
  local name = prescript and prescript.mplibpattern
  if not name then return end
  local patterns = pdfetcs.patterns
  local patt = patterns[name]
  local index = patt and patt.id or err("cannot get pattern object '%s'", name)
  local key = format("MPlibPt%s",index)
  if patt.colored then
    pdf_literalcode("/Pattern cs /%s scn", key)
  else
    local color = prescript.mpliboverridecolor
    if not color then
      local t = object.color
      color = t and #t>0 and luamplib.colorconverter(t)
    end
    if not color then return end
    local cs
    if color:find" cs " or color:find"@pdf.obj" then
      local t = color:explode()
      if pdfmode then
        cs = format("%s 0 R", ltx.pdf.object_id( t[1]:sub(2,-1) ))
        color = t[3]
      else
        cs = t[2]
        color = t[3]:match"%[(.+)%]"
      end
    else
      local t = colorsplit(color)
      cs = #t == 4 and "/DeviceCMYK" or #t == 3 and "/DeviceRGB" or "/DeviceGray"
      color = tableconcat(t," ")
    end
    pdf_literalcode("/MPlibCS%i cs %s /%s scn", pattern_colorspace(cs), color, key)
  end
  if not patt.done then
    local val = pdfmode and format("%s 0 R",index) or patterns[index]
    add_pattern_resources(key,val)
  end
  patt.done = true
end
end
```

Fading

```
pdfetcs.fading = { }
local function do_preobj_FADE (object, prescript)
  local fd_type = prescript and prescript.mplibfadetype
  local fd_stop = prescript and prescript.mplibfadestate
  if not fd_type then
    return fd_stop -- returns "stop" (if picture) or nil
```

```
2630  end
2631  local on, os, new
2632  if fd_type == "masking" then
2633    local mac = get_macro("luamplib.group."..prescript.mplibmaskname)
2634    on = mac:match(pdfmode and "%d+" or "{pdf:uxobj (.-)}")
2635    local bc = prescript.mplibmaskingbgcolor
2636    bc = bc and ("/BC[%f]"):format(bc):gsub(decimals,rmzeros) or ""
2637    os = format("<</SMask<</S/Luminosity/G %s%s>>>>",
2638                pdfmode and format(pdfetcs.resfmt, on) or on, bc)
2639  else
2640    local bbox = prescript.mplibfadebbox:explode":"
2641    local dx, dy = -bbox[1], -bbox[2]
2642    local vec = prescript.mplibfadevector; vec = vec and vec:explode":"
2643    if not vec then
2644      if fd_type == "linear" then
2645        vec = {bbox[1], bbox[2], bbox[3], bbox[2]} -- left to right
2646      else
2647        local centerx, centery = (bbox[1]+bbox[3])/2, (bbox[2]+bbox[4])/2
2648        vec = {centerx, centery, centerx, centery} -- center for both circles
2649      end
2650    end
2651    local coords = { vec[1]+dx, vec[2]+dy, vec[3]+dx, vec[4]+dy }
2652    if fd_type == "linear" then
2653      coords = format("%f %f %f %f", tableunpack(coords))
2654    elseif fd_type == "circular" then
2655      local width, height = bbox[3]-bbox[1], bbox[4]-bbox[2]
2656      local radius = (prescript.mplibfaderadius or "0:"..math.sqrt(width^2+height^2)/2):explode":"
2657      tableinsert(coords, 3, radius[1])
2658      tableinsert(coords, radius[2])
2659      coords = format("%f %f %f %f %f %f", tableunpack(coords))
2660    else
2661      err("unknown fading method '%s'", fd_type)
2662    end
2663    fd_type = fd_type == "linear" and 2 or 3
2664    local opaq = (prescript.mplibfadeopacity or "1:0"):explode":"
2665    on = sh_pdfpageresources(fd_type, "0 1", "/DeviceGray", {{opaq[1]}}, {{opaq[2]}}, coords, 1)
2666    os = format("<</PatternType 2/Shading %s>>", format(pdfetcs.resfmt, on))
2667    on = update_pdfobjs(os)
2668    bbox = format("0 0 %f %f", bbox[3]+dx, bbox[4]+dy)
2669    local streamtext = format("q /Pattern cs/MPlibFd%s scn %s re f Q", on, bbox)
2670      :gsub(decimals,rmzeros)
2671    os = format("<</Pattern<</MPlibFd%s %s>>>>", on, format(pdfetcs.resfmt, on))
2672    on = update_pdfobjs(os)
2673    local resources = format(pdfetcs.resfmt, on)
2674    on = update_pdfobjs"<</S/Transparency/CS/DeviceGray>>"
2675    local attr = tableconcat{
2676      "/Subtype/Form",
2677      "/BBox[", bbox, "]",
2678      "/Matrix[1 0 0 1 ", format("%f %f", -dx,-dy), "]",
```

```
      "/Resources ", resources,
      "/Group ", format(pdfetcs.resfmt, on),
    } :gsub(decimals,rmzeros)
    on = update_pdfobjs(attr, streamtext)
    os = format("<</SMask<</S/Luminosity/G %s>>>>", format(pdfetcs.resfmt, on))
  end
  on, new = update_pdfobjs(os)
  local key = add_extgs_resources(on,new)
  start_pdf_code()
  pdf_literalcode("/%s gs", key)
  if fd_stop then return "standalone" end
  return "start"
end

```

Transparency Group

```
pdfetcs.tr_group = { shifts = { } }
luamplib.trgroupshifts = pdfetcs.tr_group.shifts
local function do_preobj_GRP (object, prescript)
  local grstate = prescript and prescript.gr_state
  if not grstate then return end
  local trgroup = pdfetcs.tr_group
  if grstate == "start" then
    trgroup.name = prescript.mplibgroupname or "lastmplibgroup"
    trgroup.isolated, trgroup.knockout, trgroup.off = false, false, false
    for _,v in ipairs(prescript.gr_type:explode",+") do
      trgroup[v] = true
    end
    trgroup.bbox = prescript.mplibgroupbbox:explode":"
    put2output[[\begingroup\setbox\mplibscratchbox\hbox\bgroup\luamplibtagasgroupset]]
  elseif grstate == "stop" then
    local llx,lly,urx,ury = tableunpack(trgroup.bbox)
    put2output(tableconcat{
      "\\egroup",
      format("\\wd\\mplibscratchbox %fbp", urx-llx),
      format("\\ht\\mplibscratchbox %fbp", ury-lly),
      "\\dp\\mplibscratchbox 0pt",
    })
    local grattr
    if trgroup.off then
      grattr = ""
    else
      local on = update_pdfobjs(format("<</S/Transparency/I %s/K %s>>",
                                       trgroup.isolated, trgroup.knockout))
      grattr = format("/Group %s", pdfetcs.resfmt:format(on))
    end
    local res = gather_resources("")
    local bbox = format("%f %f %f %f", llx,lly,urx,ury) :gsub(decimals,rmzeros)
    if pdfmode then
```

```
      put2output(tableconcat{
        "\\saveboxresource type 2 attr{/Type/XObject/Subtype/Form/FormType 1",
        "/BBox[", bbox, "]", grattr, "} resources{", res, "}\\mplibscratchbox",
        "\\luamplibtagasgroupput{",trgroup.name,"}{",
        [[\setbox\mplibscratchbox\hbox{\useboxresource\lastsavedboxresourceindex}]],
        [[\wd\mplibscratchbox 0pt\ht\mplibscratchbox 0pt\dp\mplibscratchbox 0pt]],
        [[\box\mplibscratchbox]],
        "}\\endgroup",
        "\\expandafter\\xdef\\csname luamplib.group.", trgroup.name, "\\endcsname{",
        "\\setbox\\mplibscratchbox\\hbox{\\hskip",-llx,"bp\\raise",-lly,"bp\\hbox{",
        "\\useboxresource \\the\\lastsavedboxresourceindex",
        "}}\\wd\\mplibscratchbox",urx-llx,"bp\\ht\\mplibscratchbox",ury-lly,"bp",
        "\\box\\mplibscratchbox}",
      })
    else
      trgroup.cnt = (trgroup.cnt or 0) + 1
      local objname = format("@mplibtrgr%s", trgroup.cnt)
      put2output(tableconcat{
        "\\special{pdf:bxobj ", objname, " bbox ", bbox, "}",
        "\\unhbox\\mplibscratchbox",
        "\\special{pdf:put @resources <<", res, ">>}",
        "\\special{pdf:exobj <<", grattr, ">>}",
        "\\luamplibtagasgroupput{",trgroup.name,"}{",
        "\\special{pdf:uxobj ", objname, "}",
        "}\\endgroup",
      })
      token.set_macro("luamplib.group."..trgroup.name, tableconcat{
        "\\setbox\\mplibscratchbox\\hbox{\\hskip",-llx,"bp\\raise",-lly,"bp\\hbox{",
        "\\special{pdf:uxobj ", objname, "}",
        "}}\\wd\\mplibscratchbox",urx-llx,"bp\\ht\\mplibscratchbox",ury-lly,"bp",
        "\\box\\mplibscratchbox",
      }, "global")
    end
    trgroup.shifts[trgroup.name] = { llx, lly }
  end
  return grstate
end
function luamplib.registergroup (boxid, name, opts)
  local box = texgetbox(boxid)
  local wd, ht, dp = node.getwhd(box)
  local is_mask = opts.asgroup and opts.asgroup:find"masking"
  local res = opts.resources or ""
  res = gather_resources(res)
  local attr = { "/Type/XObject/Subtype/Form/FormType 1" }
  if type(opts.matrix) == "table" then opts.matrix = tableconcat(opts.matrix," ") end
  if type(opts.bbox) == "table" then opts.bbox = tableconcat(opts.bbox," ") end
  if opts.matrix and opts.matrix:find"%a" then
    local data = format("mplibtransformmatrix(%s);",opts.matrix)
    process(data,"@mplibtransformmatrix")
```

```
2775    opts.matrix = format("%f %f %f %f %f %f",tableunpack(luamplib.transformmatrix))
2776  end
2777  local grtype = 3
2778  if opts.bbox then
2779    attr[#attr+1] = format("/BBox[%s]", opts.bbox)
2780    grtype = 2
2781  end
2782  local mpllx, mplly = get_macro'MPllx', get_macro'MPlly'
2783  if is_mask then
2784    local t = opts.matrix and opts.matrix:explode() or {1, 0, 0, 1, 0, 0}
2785    t[5], t[6] = t[5]+mpllx, t[6]+mplly
2786    opts.matrix = format("%f %f %f %f %f %f",tableunpack(t))
2787    mpllx, mplly = 0, 0
2788  end
2789  if opts.matrix then
2790    attr[#attr+1] = format("/Matrix[%s]", opts.matrix)
2791    grtype = opts.bbox and 4 or 1
2792  end
2793  if opts.asgroup and not opts.asgroup:find"off" then
2794    local t = { isolated = false, knockout = false, masking = false }
2795    for _,v in ipairs(opts.asgroup:explode",+") do t[v] = true end
2796    local on
2797    if t.masking then
2798      on = update_pdfobjs"<</S/Transparency/CS/DeviceGray>>"
2799    else
2800      on = update_pdfobjs(format("<</S/Transparency/I %s/K %s>>", t.isolated, t.knockout))
2801    end
2802    attr[#attr+1] = format("/Group %s", pdfetcs.resfmt:format(on))
2803  end
2804  local trgroup = pdfetcs.tr_group
2805  trgroup.shifts[name] = { mpllx, mplly }
2806  local whd
2807  if pdfmode then
2808    attr = tableconcat(attr) :gsub(decimals,rmzeros)
2809    local index = tex.saveboxresource(boxid, attr, res, true, grtype)
2810    token.set_macro("luamplib.group."..name, tableconcat{
2811      "\\useboxresource ", index,
2812    }, "global")
2813    whd = format("%.3f %.3f 0", wd/factor, (ht+dp)/factor) :gsub(decimals,rmzeros)
2814  else
2815    trgroup.cnt = (trgroup.cnt or 0) + 1
2816    local objname = format("@mplibtrgr%s", trgroup.cnt)
2817    texsprint {
2818      "\\expandafter\\newbox\\csname luamplib.groupbox.", trgroup.cnt, "\\endcsname",
2819      "\\global\\setbox\\csname luamplib.groupbox.", trgroup.cnt, "\\endcsname",
2820      "\\hbox{\\unhbox ", boxid, "}\\luamplibatnextshipout{",
2821      "\\special{pdf:bcontent}",
2822      "\\special{pdf:bxobj ", objname, " width ", wd, "sp height ", ht, "sp depth ", dp, "sp}",
2823      "\\unhbox\\csname luamplib.groupbox.", trgroup.cnt, "\\endcsname",
```

```
    "\\special{pdf:put @resources <<", res, ">>}",
    "\\special{pdf:exobj <<", tableconcat(attr), ">>}",
    "\\special{pdf:econtent}}",
  }
  token.set_macro("luamplib.group."..name, tableconcat{
    "\\setbox\\mplibscratchbox\\hbox{\\special{pdf:uxobj ", objname, "}}",
    "\\wd\\mplibscratchbox ", wd, "sp",
    "\\ht\\mplibscratchbox ", ht, "sp",
    "\\dp\\mplibscratchbox ", dp, "sp",
    "\\box\\mplibscratchbox",
  }, "global")
  whd = format("%.3f %.3f %.3f", wd/factor, ht/factor, dp/factor) :gsub(decimals,rmzeros)
 end
 info("w/h/d of group '%s': %s", name, whd)
end

```

luamplib.convert: flushing figures

```
do
 local function stop_special_effects(fade,opaq,over)
  if fade then -- fading
   stop_pdf_code()
  end
  if opaq then -- opacity
   pdf_literalcode(opaq)
  end
  if over then -- color
   if over:find"pdf:bc" then
    put2output"\\special{pdf:ec}"
   else
    put2output"\\special{color pop}"
   end
  end
 end

```

For parsing prescript materials.

```
 local function script2table(s)
  local t = {}
  for _,i in ipairs(s:explode("\13+")) do
   local k,v = i:match("(.-)=(.*)") -- v may contain = or empty.
   if k and v and k ~= "" and not t[k] then
    t[k] = v
   end
  end
  return t
 end

```

Codes below to insert PDF lieterals are mostly from ConTEXt general, with small changes when

needed.

```
local function pdf_textfigure(font,size,text,width,height,depth)
  text = text:gsub(".",function(c)
    return format("\\hbox{\\char%i}",string.byte(c)) -- kerning happens in metapost : false
  end)
  put2output("\\mplibtextext{%s}{%f}{%s}{%s}{%s}",font,size,text,0,0)
end

local bend_tolerance = 131/65536

local rx, sx, sy, ry, tx, ty, divider = 1, 0, 0, 1, 0, 0, 1

local function pen_characteristics(object)
  local t = mplib.pen_info(object)
  rx, ry, sx, sy, tx, ty = t.rx, t.ry, t.sx, t.sy, t.tx, t.ty
  divider = sx*sy - rx*ry
  return not (sx==1 and rx==0 and ry==0 and sy==1 and tx==0 and ty==0), t.width
end

local function concat(px, py) -- no tx, ty here
  return (sy*px-ry*py)/divider,(sx*py-rx*px)/divider
end

local function curved(ith,pth)
  local d = pth.left_x - ith.right_x
  if abs(ith.right_x - ith.x_coord - d) <= bend_tolerance and
     abs(pth.x_coord - pth.left_x - d) <= bend_tolerance then
    d = pth.left_y - ith.right_y
    if abs(ith.right_y - ith.y_coord - d) <= bend_tolerance and
       abs(pth.y_coord - pth.left_y - d) <= bend_tolerance then
      return false
    end
  end
  return true
end

local function flushnormalpath(path,open)
  local pth, ith
  for i=1,#path do
    pth = path[i]
    if not ith then
      pdf_literalcode("%f %f m",pth.x_coord,pth.y_coord)
    elseif curved(ith,pth) then
      pdf_literalcode("%f %f %f %f %f %f c",
        ith.right_x,ith.right_y,pth.left_x,pth.left_y,pth.x_coord,pth.y_coord)
    else
      pdf_literalcode("%f %f l",pth.x_coord,pth.y_coord)
    end
    ith = pth
```

```
    end
    if not open then
      local one = path[1]
      if curved(pth,one) then
        pdf_literalcode("%f %f %f %f %f %f c",
          pth.right_x,pth.right_y,one.left_x,one.left_y,one.x_coord,one.y_coord )
      else
        pdf_literalcode("%f %f l",one.x_coord,one.y_coord)
      end
    elseif #path == 1 then -- special case .. draw point
      local one = path[1]
      pdf_literalcode("%f %f l",one.x_coord,one.y_coord)
    end
  end

  local function flushconcatpath(path,open)
    pdf_literalcode("%f %f %f %f %f %f cm", sx, rx, ry, sy, tx ,ty)
    local pth, ith
    for i=1,#path do
      pth = path[i]
      if not ith then
        pdf_literalcode("%f %f m",concat(pth.x_coord,pth.y_coord))
      elseif curved(ith,pth) then
        local a, b = concat(ith.right_x,ith.right_y)
        local c, d = concat(pth.left_x,pth.left_y)
        pdf_literalcode("%f %f %f %f %f %f c",a,b,c,d,concat(pth.x_coord, pth.y_coord))
      else
        pdf_literalcode("%f %f l",concat(pth.x_coord, pth.y_coord))
      end
      ith = pth
    end
    if not open then
      local one = path[1]
      if curved(pth,one) then
        local a, b = concat(pth.right_x,pth.right_y)
        local c, d = concat(one.left_x,one.left_y)
        pdf_literalcode("%f %f %f %f %f %f c",a,b,c,d,concat(one.x_coord, one.y_coord))
      else
        pdf_literalcode("%f %f l",concat(one.x_coord,one.y_coord))
      end
    elseif #path == 1 then -- special case .. draw point
      local one = path[1]
      pdf_literalcode("%f %f l",concat(one.x_coord,one.y_coord))
    end
  end

```

Finally, flush figures by inserting PDF literals.

```
  local function flush (result,flusher)
```

```
    if result then
      local figures = result.fig
      if figures then
        for f=1, #figures do
          info("flushing figure %s",f)
          local figure = figures[f]
          local objects = figure:objects()
          local fignum = tonumber(figure:filename():match("([%d]+)$") or figure:charcode() or 0)
          local miterlimit, linecap, linejoin, dashed = -1, -1, -1, false
          local bbox = figure:boundingbox()
          local llx, lly, urx, ury = bbox[1], bbox[2], bbox[3], bbox[4] -- faster than unpack
          if urx < llx then
```

luamplib silently ignores this invalid figure for those that do not contain beginfig ... endfig. (issue #70) Original code of ConTEXt general was:

```
-- invalid
pdf_startfigure(fignum,0,0,0,0)
pdf_stopfigure()
```

```
          else
```

For legacy behavior, insert 'pre-fig' TEX code here.

```
            if tex_code_pre_mplib[f] then
              put2output(tex_code_pre_mplib[f])
            end
            pdf_startfigure(fignum,llx,lly,urx,ury)
            start_pdf_code()
            if objects then
              local savedpath = nil
              local savedhtap = nil
              for o=1,#objects do
                local object       = objects[o]
                local objecttype   = object.type
```

The following 10 lines are part of btex...etex patch. Again, colors are processed at this stage.

```
                local prescript    = object.prescript
                prescript = prescript and script2table(prescript) -- prescript is now a table
                local cr_over = do_preobj_CR(object,prescript) -- color
                local tr_opaq = do_preobj_TR(object,prescript) -- opacity
                local fading_ = do_preobj_FADE(object,prescript) -- fading
                local pattern_ = do_preobj_PAT(object,prescript) -- tiling pattern
                local shading_ = do_preobj_shading(object,prescript) -- shading pattern
                local trgroup = do_preobj_GRP(object,prescript) -- transparency group
                if prescript and prescript.mplibtexboxid then
                  put_tex_boxes(object,prescript)
                elseif objecttype == "start_bounds" or objecttype == "stop_bounds" then --skip
                elseif objecttype == "start_clip" then
                  local evenodd = not object.istext and object.postscript == "evenodd"
                  start_pdf_code()
                  flushnormalpath(object.path,false)
```

```
3002                pdf_literalcode(evenodd and "W* n" or "W n")
3003              elseif objecttype == "stop_clip" then
3004                stop_pdf_code()
3005                miterlimit, linecap, linejoin, dashed = -1, -1, -1, false
3006              elseif objecttype == "special" then
```

Collect TEX codes that will be executed after flushing. Legacy behavior.

```
3007                if prescript and prescript.postmplibverbtex then
3008                  figcontents.post[#figcontents.post+1] = prescript.postmplibverbtex
3009                end
3010              elseif objecttype == "text" then
3011                local ot = object.transform -- 3,4,5,6,1,2
3012                start_pdf_code()
3013                pdf_literalcode("%f %f %f %f %f %f cm",ot[3],ot[4],ot[5],ot[6],ot[1],ot[2])
3014                pdf_textfigure(object.font,object.dsize,object.text,object.width,object.height,object.depth)
3015                stop_pdf_code()
3016              elseif not trgroup and fading_ ~= "stop" then
3017                local evenodd, collect, both = false, false, false
3018                local postscript = object.postscript
3019                if not object.istext then
3020                  if postscript == "evenodd" then
3021                    evenodd = true
3022                  elseif postscript == "collect" then
3023                    collect = true
3024                  elseif postscript == "both" then
3025                    both = true
3026                  elseif postscript == "eoboth" then
3027                    evenodd = true
3028                    both    = true
3029                  end
3030                end
3031                if collect then
3032                  if not savedpath then
3033                    savedpath = { object.path or false }
3034                    savedhtap = { object.htap or false }
3035                  else
3036                    savedpath[#savedpath+1] = object.path or false
3037                    savedhtap[#savedhtap+1] = object.htap or false
3038                  end
3039                else
```

Removed from ConTEXt general: color stuff.

```
3040                  local ml = object.miterlimit
3041                  if ml and ml ~= miterlimit then
3042                    miterlimit = ml
3043                    pdf_literalcode("%f M",ml)
3044                  end
3045                  local lj = object.linejoin
3046                  if lj and lj ~= linejoin then
3047                    linejoin = lj
```

```
    pdf_literalcode("%i j",lj)
  end
  local lc = object.linecap
  if lc and lc ~= linecap then
    linecap = lc
    pdf_literalcode("%i J",lc)
  end
  local dl = object.dash
  if dl then
    local d = format("[%s] %f d",tableconcat(dl.dashes or {}," "),dl.offset)
    if d ~= dashed then
      dashed = d
      pdf_literalcode(dashed)
    end
  elseif dashed then
    pdf_literalcode("[] 0 d")
    dashed = false
  end
  local path = object.path
  local transformed, penwidth = false, 1
  local open = path and path[1].left_type and path[#path].right_type
  local pen = object.pen
  if pen then
    if pen.type == 'elliptical' then
      transformed, penwidth = pen_characteristics(object) -- boolean, value
      pdf_literalcode("%f w",penwidth)
      if objecttype == 'fill' then
        objecttype = 'both'
      end
    else -- calculated by mplib itself
      objecttype = 'fill'
    end
  end
```

Added : shading

```
  local shade_no, shade_stroking = do_preobj_SH(object,prescript) -- shading
  if shade_no then
    pdf_literalcode"q /Pattern cs"
    objecttype = false
  end
  if transformed then
    start_pdf_code()
  end
  if path then
    if savedpath then
      for i=1,#savedpath do
        local path = savedpath[i]
        if transformed then
          flushconcatpath(path,open)
```

```
      else
        flushnormalpath(path,open)
      end
    end
    savedpath = nil
  end
  if transformed then
    flushconcatpath(path,open)
  else
    flushnormalpath(path,open)
  end
  if objecttype == "fill" then
    pdf_literalcode(evenodd and "h f*" or "h f")
  elseif objecttype == "outline" then
    if both then
      pdf_literalcode(evenodd and "h B*" or "h B")
    else
      pdf_literalcode(open and "S" or "h S")
    end
  elseif objecttype == "both" then
    pdf_literalcode(evenodd and "h B*" or "h B")
  end
end
if transformed then
  stop_pdf_code()
end
local path = object.htap
```

How can we generate an htap object? Please let us know if you have succeeded.

```
if path then
  if transformed then
    start_pdf_code()
  end
  if savedhtap then
    for i=1,#savedhtap do
      local path = savedhtap[i]
      if transformed then
        flushconcatpath(path,open)
      else
        flushnormalpath(path,open)
      end
    end
    savedhtap = nil
    evenodd   = true
  end
  if transformed then
    flushconcatpath(path,open)
  else
    flushnormalpath(path,open)
```

```
      end
      if objecttype == "fill" then
        pdf_literalcode(evenodd and "h f*" or "h f")
      elseif objecttype == "outline" then
        pdf_literalcode(open and "S" or "h S")
      elseif objecttype == "both" then
        pdf_literalcode(evenodd and "h B*" or "h B")
      end
      if transformed then
        stop_pdf_code()
      end
    end
```

Added to ConTEXt general: post-object colors and shading stuff. Beware `q ... Q` scope.

```
      if shade_no then -- shading
        pdf_literalcode("W%s %s /MPlibSh%s sh Q",
          evenodd and "*" or "", shade_stroking and "s" or "n", shade_no)
      end
    end
  end
  if fading_ == "start" then
    pdfetcs.fading.specialeffects = {fading_, tr_opaq, cr_over}
  elseif trgroup == "start" then
    pdfetcs.tr_group.specialeffects = {fading_, tr_opaq, cr_over}
  elseif fading_ == "stop" then
    local se = pdfetcs.fading.specialeffects
    if se then stop_special_effects(se[1], se[2], se[3]) end
  elseif trgroup == "stop" then
    local se = pdfetcs.tr_group.specialeffects
    if se then stop_special_effects(se[1], se[2], se[3]) end
  else
    stop_special_effects(fading_, tr_opaq, cr_over)
  end
  if fading_ or trgroup then -- extgs resetted
    miterlimit, linecap, linejoin, dashed = -1, -1, -1, false
  end
 end
end
stop_pdf_code()
pdf_stopfigure()
```

output collected materials to PDF, plus legacy verbatimtex code.

```
for _,v in ipairs(figcontents) do
  if type(v) == "table" then
    texsprint"\\mplibtoPDF{"; texsprint(v[1], v[2]); texsprint"}"
  else
    texsprint(v)
  end
end
if #figcontents.post > 0 then texsprint(figcontents.post) end
```

```
            figcontents = { post = { } }
          end
        end
      end
    end
  end

  function luamplib.convert (result, flusher)
    flush(result, flusher)
    return true -- done
  end
end

function luamplib.colorconverter (cr)
  local n = #cr
  if n == 4 then
    local c, m, y, k = cr[1], cr[2], cr[3], cr[4]
    return format("%.3f %.3f %.3f %.3f k %.3f %.3f %.3f %.3f K",c,m,y,k,c,m,y,k), "0 g 0 G"
  elseif n == 3 then
    local r, g, b = cr[1], cr[2], cr[3]
    return format("%.3f %.3f %.3f rg %.3f %.3f %.3f RG",r,g,b,r,g,b), "0 g 0 G"
  else
    local s = cr[1]
    return format("%.3f g %.3f G",s,s), "0 g 0 G"
  end
end
```

2.2 TEX package

First we need to load some packages.

```
\ifcsname ProvidesPackage\endcsname
```

We need LATEX 2024-06-01 as we use `ltx.pdf.object_id` when pdfmanagement is loaded. But as fp package does not accept an option, we do not append the date option.

```
  \NeedsTeXFormat{LaTeX2e}
  \ProvidesPackage{luamplib}
    [2026/04/16 v2.40.8 mplib package for LuaTeX]
\fi
\ifdefined\newluafunction\else
  \input ltluatex
\fi
```

In DVI mode, a new XObject (mppattern, mplibgroup) must be encapsulated in an `\hbox`. But this should not affect typesetting. So we use Hook mechanism provided by LATEX kernel. In Plain, atbegshi.sty is loaded.

```
\ifnum\outputmode=0
  \ifdefined\AddToHookNext
    \def\luamplibatnextshipout{\AddToHookNext{shipout/background}}
    \def\luamplibatfirstshipout{\AddToHook{shipout/firstpage}}
```

```
    \def\luamplibateveryshipout{\AddToHook{shipout/background}}
  \else
    \input atbegshi.sty
    \def\luamplibatnextshipout#1{\AtBeginShipoutNext{\AtBeginShipoutAddToBox{#1}}}
    \let\luamplibatfirstshipout\AtBeginShipoutFirst
    \def\luamplibateveryshipout#1{\AtBeginShipout{\AtBeginShipoutAddToBox{#1}}}
  \fi
\fi
```

Loading of lua code.

```
\directlua{require("luamplib")}
```

legacy commands. Seems we don't need it, but no harm.

```
\ifx\pdfoutput\undefined
  \let\pdfoutput\outputmode
\fi
\ifx\pdfliteral\undefined
  \protected\def\pdfliteral{\pdfextension literal}
\fi
```

Set the format for METAPOST.

```
\def\mplibsetformat#1{\directlua{luamplib.setformat("#1")}}
```

luamplib works in both PDF and DVI mode, but only DVIPDFMx is supported currently among a number of DVI tools. So we output a info.

```
\ifnum\pdfoutput>0
  \let\mplibtoPDF\pdfliteral
\else
  \def\mplibtoPDF#1{\special{pdf:literal direct #1}}
  \ifcsname PackageInfo\endcsname
    \PackageInfo{luamplib}{only dvipdfmx is supported currently}
  \else
    \immediate\write-1{luamplib Info: only dvipdfmx is supported currently}
  \fi
\fi
```

To make `mplibcode` typeset always in horizontal mode.

```
\def\mplibforcehmode{\let\prependtomplibbox\leavevmode}
\def\mplibnoforcehmode{\let\prependtomplibbox\relax}
\mplibnoforcehmode
```

Catcode. We want to allow comment sign in `mplibcode`.

```
\def\mplibsetupcatcodes{%
  %catcode`\{=12 %catcode`\}=12
  \catcode`\#=12 \catcode`\^=12 \catcode`\~=12 \catcode`\_=12
  \catcode`\&=12 \catcode`\$=12 \catcode`\%=12 \catcode`\^^M=12
}
```

Make `btex...etex` box zero-metric.

```
\def\mplibputtextbox#1{\vbox to 0pt{\vss\hbox to 0pt{\raise\dp#1\copy#1\hss}}}
```

use Transparency Group

```
\protected\def\usemplibgroup#1#{\usemplibgroupmain}
\def\usemplibgroupmain#1{%
  \prependtomplibbox\hbox dir TLT\bgroup
  \csname luamplib.group.#1\endcsname
  \egroup
}
\protected\def\mplibgroup#1{%
  \begingroup
  \def\MPllx{0}\def\MPlly{0}%
  \def\mplibgroupname{#1}%
  \mplibgroupgetnexttok
}
\def\mplibgroupgetnexttok{\futurelet\nexttok\mplibgroupbranch}
\def\mplibgroupskipspace{\afterassignment\mplibgroupgetnexttok\let\nexttok= }
\def\mplibgroupbranch{%
  \ifx [\nexttok
    \expandafter\mplibgroupopts
  \else
    \ifx\mplibsptoken\nexttok
      \expandafter\expandafter\expandafter\mplibgroupskipspace
    \else
      \let\mplibgroupoptions\empty
      \expandafter\expandafter\expandafter\mplibgroupmain
    \fi
  \fi
}
\def\mplibgroupopts[#1]{\def\mplibgroupoptions{#1}\mplibgroupmain}
\def\mplibgroupmain{\setbox\mplibscratchbox\hbox\bgroup\ignorespaces}
\protected\def\endmplibgroup{\egroup
  \directlua{ luamplib.registergroup(
    \the\mplibscratchbox, '\mplibgroupname', {\mplibgroupoptions}
  )}%
  \endgroup
}
```

Patterns

```
{\def\:{\global\let\mplibsptoken= } \: }
\protected\def\mppattern#1{%
  \begingroup
  \def\MPllx{0}\def\MPlly{0}%
  \def\mplibpatternname{#1}%
  \mplibpatterngetnexttok
}
\def\mplibpatterngetnexttok{\futurelet\nexttok\mplibpatternbranch}
\def\mplibpatternskipspace{\afterassignment\mplibpatterngetnexttok\let\nexttok= }
\def\mplibpatternbranch{%
  \ifx [\nexttok
    \expandafter\mplibpatternopts
```

```
  \else
    \ifx\mplibsptoken\nexttok
      \expandafter\expandafter\expandafter\mplibpatternskipspace
    \else
      \let\mplibpatternoptions\empty
      \expandafter\expandafter\expandafter\mplibpatternmain
    \fi
  \fi
}
\def\mplibpatternopts[#1]{%
  \def\mplibpatternoptions{#1}%
  \mplibpatternmain
}
\def\mplibpatternmain{%
  \setbox\mplibscratchbox\hbox\bgroup\ignorespaces
}
\protected\def\endmppattern{%
  \egroup
  \directlua{ luamplib.registerpattern(
    \the\mplibscratchbox, '\mplibpatternname', {\mplibpatternoptions}
  )}%
  \endgroup
}
```

simple way to use mplib: `\mpfig draw fullcircle scaled 10; \endmpfig`

```
\def\mpfiginstancename{@mpfig}
\protected\def\mpfig{%
  \begingroup
  \futurelet\nexttok\mplibmpfigbranch
}
\def\mplibmpfigbranch{%
  \ifx *\nexttok
    \expandafter\mplibprempfig
  \else
    \ifx [\nexttok
      \expandafter\expandafter\expandafter\mplibgobbleoptsmpfig
    \else
      \expandafter\expandafter\expandafter\mplibmainmpfig
    \fi
  \fi
}
\def\mplibgobbleoptsmpfig[#1]{\mplibmainmpfig}
\def\mplibmainmpfig{%
  \begingroup
  \mplibsetupcatcodes
  \mplibdomainmpfig
}
\long\def\mplibdomainmpfig#1\endmpfig{%
  \endgroup
```

```
  \directlua{
    local legacy = luamplib.legacyverbatimtex
    local everympfig = luamplib.everymplib["\mpfiginstancename"] or ""
    local everyendmpfig = luamplib.everyendmplib["\mpfiginstancename"] or ""
    luamplib.legacyverbatimtex = false
    luamplib.everymplib["\mpfiginstancename"] = ""
    luamplib.everyendmplib["\mpfiginstancename"] = ""
    luamplib.process_mplibcode(
    "beginfig(0) "..everympfig.." "..[===[\unexpanded{#1}]===].." "..everyendmpfig.." endfig;",
    "\mpfiginstancename")
    luamplib.legacyverbatimtex = legacy
    luamplib.everymplib["\mpfiginstancename"] = everympfig
    luamplib.everyendmplib["\mpfiginstancename"] = everyendmpfig
  }%
  \endgroup
}
\def\mplibprempfig#1{%
  \begingroup
  \mplibsetupcatcodes
  \mplibdoprempfig
}
\long\def\mplibdoprempfig#1\endmpfig{%
  \endgroup
  \directlua{
    local legacy = luamplib.legacyverbatimtex
    local everympfig = luamplib.everymplib["\mpfiginstancename"]
    local everyendmpfig = luamplib.everyendmplib["\mpfiginstancename"]
    luamplib.legacyverbatimtex = false
    luamplib.everymplib["\mpfiginstancename"] = ""
    luamplib.everyendmplib["\mpfiginstancename"] = ""
    luamplib.process_mplibcode([===[\unexpanded{#1}]===],"\mpfiginstancename")
    luamplib.legacyverbatimtex = legacy
    luamplib.everymplib["\mpfiginstancename"] = everympfig
    luamplib.everyendmplib["\mpfiginstancename"] = everyendmpfig
  }%
  \endgroup
}
\protected\def\endmpfig{endmpfig}
```

The Plain-specific stuff.

```
\unless\ifcsname ver@luamplib.sty\endcsname
  \def\mplibcodegetinstancename[#1]{\xdef\currentmpinstancename{#1}\mplibcodeindeed}
  \protected\def\mplibcode{%
    \begingroup
    \futurelet\nexttok\mplibcodebranch
  }
  \def\mplibcodebranch{%
    \ifx [\nexttok
      \expandafter\mplibcodegetinstancename
```

```
    \else
      \global\let\currentmpinstancename\empty
      \expandafter\mplibcodeindeed
    \fi
  }
  \def\mplibcodeindeed{%
    \begingroup
    \mplibsetupcatcodes
    \mplibdocode
  }
  \long\def\mplibdocode#1\endmplibcode{%
    \endgroup
    \directlua{luamplib.process_mplibcode([===[\unexpanded{#1}]===],"\currentmpinstancename")}%
    \endgroup
  }
  \protected\def\endmplibcode{endmplibcode}
\else
```

The LaTeX-specific part: a new environment.

```
  \newenvironment{mplibcode}[1][]{%
    \xdef\currentmpinstancename{#1}%
    \mplibtmptoks{}\ltxdomplibcode
  }{}
  \def\ltxdomplibcode{%
    \begingroup
    \mplibsetupcatcodes
    \ltxdomplibcodeindeed
  }
  \def\mplib@mplibcode{mplibcode}
  \long\def\ltxdomplibcodeindeed#1\end#2{%
    \endgroup
    \mplibtmptoks\expandafter{\the\mplibtmptoks#1}%
    \def\mplibtemp@a{#2}%
    \ifx\mplib@mplibcode\mplibtemp@a
      \directlua{luamplib.process_mplibcode([===[\the\mplibtmptoks]===],"\currentmpinstancename")}%
      \end{mplibcode}%
    \else
      \mplibtmptoks\expandafter{\the\mplibtmptoks\end{#2}}%
      \expandafter\ltxdomplibcode
    \fi
  }
\fi
```

User settings.

```
\def\mplibshowlog#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.showlog = true
    else
      luamplib.showlog = false
```

```
    end
}}
\def\mpliblegacybehavior#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.legacyverbatimtex = true
    else
      luamplib.legacyverbatimtex = false
    end
}}
\def\mplibverbatim#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.verbatiminput = true
    else
      luamplib.verbatiminput = false
    end
}}
\newtoks\mplibtmptoks
```

\everymplib & \everyendmplib: macros resetting luamplib.every(end)mplib tables

```
\ifcsname ver@luamplib.sty\endcsname
  \protected\def\everymplib{%
    \begingroup
    \mplibsetupcatcodes
    \mplibdoeverymplib
  }
  \protected\def\everyendmplib{%
    \begingroup
    \mplibsetupcatcodes
    \mplibdoeveryendmplib
  }
  \newcommand\mplibdoeverymplib[2][]{%
    \endgroup
    \directlua{
      luamplib.everymplib["#1"] = [===[\unexpanded{#2}]===]
    }%
  }
  \newcommand\mplibdoeveryendmplib[2][]{%
    \endgroup
    \directlua{
      luamplib.everyendmplib["#1"] = [===[\unexpanded{#2}]===]
    }%
  }
\else
  \def\mplibgetinstancename[#1]{\def\currentmpinstancename{#1}}
  \protected\def\everymplib#1#{%
    \ifx\empty#1\empty \mplibgetinstancename[]\else \mplibgetinstancename#1\fi
    \begingroup
```

```
    \mplibsetupcatcodes
    \mplibdoeverymplib
  }
  \long\def\mplibdoeverymplib#1{%
    \endgroup
    \directlua{
      luamplib.everymplib["\currentmpinstancename"] = [===[\unexpanded{#1}]===]
    }%
  }
  \protected\def\everyendmplib#1#{%
    \ifx\empty#1\empty \mplibgetinstancename[]\else \mplibgetinstancename#1\fi
    \begingroup
    \mplibsetupcatcodes
    \mplibdoeveryendmplib
  }
  \long\def\mplibdoeveryendmplib#1{%
    \endgroup
    \directlua{
      luamplib.everyendmplib["\currentmpinstancename"] = [===[\unexpanded{#1}]===]
    }%
  }
\fi
```

TEX macros for dimen/color

```
\def\mpdim#1{ runscript("luamplibdimen{#1}") }
\def\mpcolor#1#{\domplibcolor{#1}}
\def\domplibcolor#1#2{ runscript("luamplibcolor{#1{#2}}") }
```

mplib's number system. Now binary has gone away.

```
\def\mplibnumbersystem#1{\directlua{
  local t = "#1"
  if t == "binary" then t = "decimal" end
  luamplib.numbersystem = t
}}
```

Settings for .mp cache files.

```
\def\mplibmakenocache#1{\mplibdomakenocache #1,\stop,}
\def\mplibdomakenocache#1,{%
  \ifx\empty#1\empty
    \expandafter\mplibdomakenocache
  \else
    \ifx\stop#1\else
      \directlua{luamplib.noneedtoreplace["#1.mp"]=true}%
      \expandafter\expandafter\expandafter\mplibdomakenocache
    \fi
  \fi
}
\def\mplibcancelnocache#1{\mplibdocancelnocache #1,\stop,}
\def\mplibdocancelnocache#1,{%
  \ifx\empty#1\empty
```

```
    \expandafter\mplibdocancelnocache
  \else
    \ifx\stop#1\else
      \directlua{luamplib.noneedtoreplace["#1.mp"]=false}%
      \expandafter\expandafter\expandafter\mplibdocancelnocache
    \fi
  \fi
}
\def\mplibcachedir#1{\directlua{luamplib.getcachedir("\unexpanded{#1}")}}
```

More user settings.

```
\def\mplibtextextlabel#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.textextlabel = true
    else
      luamplib.textextlabel = false
    end
}}
\def\mplibcodeinherit#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.codeinherit = true
    else
      luamplib.codeinherit = false
    end
}}
\def\mplibglobaltextext#1{\directlua{
    local s = string.lower("#1")
    if s == "enable" or s == "true" or s == "yes" then
      luamplib.globaltextext = true
    else
      luamplib.globaltextext = false
    end
}}
```

The followings are from ConTEXt general, mostly.

We use a dedicated scratchbox.

```
\ifx\mplibscratchbox\undefined \newbox\mplibscratchbox \fi
```

We encapsulate the literals.

```
\def\mplibstarttoPDF#1#2#3#4{%
  \prependtomplibbox
  \hbox dir TLT\bgroup
  \xdef\MPllx{#1}\xdef\MPlly{#2}%
  \xdef\MPurx{#3}\xdef\MPury{#4}%
  \xdef\MPwidth{\the\dimexpr#3bp-#1bp\relax}%
  \xdef\MPheight{\the\dimexpr#4bp-#2bp\relax}%
  \parskip0pt%
  \leftskip0pt%
```

```
  \parindent0pt%
  \everypar{}%
  \setbox\mplibscratchbox\vbox\bgroup
  \noindent
}
\def\mplibstoptoPDF{%
  \par
  \egroup %
  \setbox\mplibscratchbox\hbox %
    {\hskip-\MPllx bp%
     \raise-\MPlly bp%
     \box\mplibscratchbox}%
  \setbox\mplibscratchbox\vbox to \MPheight
    {\vfill
     \hsize\MPwidth
     \wd\mplibscratchbox0pt%
     \ht\mplibscratchbox0pt%
     \dp\mplibscratchbox0pt%
     \box\mplibscratchbox}%
  \wd\mplibscratchbox\MPwidth
  \ht\mplibscratchbox\MPheight
  \box\mplibscratchbox
  \egroup
}
```

Text items have a special handler.

```
\def\mplibtextext#1#2#3#4#5{%
  \begingroup
  \setbox\mplibscratchbox\hbox
    {\font\temp=#1 at #2bp%
     \temp
     #3}%
  \setbox\mplibscratchbox\hbox
    {\hskip#4 bp%
     \raise#5 bp%
     \box\mplibscratchbox}%
  \wd\mplibscratchbox0pt%
  \ht\mplibscratchbox0pt%
  \dp\mplibscratchbox0pt%
  \box\mplibscratchbox
  \endgroup
}
```

Input `luamplib.cfg` when it exists.

```
\openin0=luamplib.cfg
\ifeof0 \else
  \closein0
  \input luamplib.cfg
\fi
```

Code for tagpdf

```
\def\luamplibtagtextboxset#1#2{#2}
\let\luamplibnotagtextboxset\luamplibtagtextboxset
\let\luamplibtagasgroupset\relax
\let\luamplibtagasgroupput\luamplibtagtextboxset
\ifcsname SuspendTagging\endcsname\else\endinput\fi
\ifcsname ver@tagpdf.sty\endcsname \else
  \ExplSyntaxOn
  \keys_define:nn{luamplib/tagging}
    {
      ,alt          .code:n = { }
      ,actualtext   .code:n = { }
      ,artifact     .code:n = { }
      ,text         .code:n = { }
      ,off          .code:n = { }
      ,tag          .code:n = { }
      ,adjust-BBox  .code:n = { }
      ,tagging-setup .code:n = { }
      ,instance     .code:n = { \tl_gset:Nn \currentmpinstancename {#1} }
      ,instancename .meta:n = { instance = {#1} }
      ,unknown      .code:n = { \tl_gset:NV \currentmpinstancename \l_keys_key_str }
    }
  \RenewDocumentCommand\mplibcode{O{}}
    {
      \tl_gclear:N \currentmpinstancename
      \keys_set:ne{luamplib/tagging}{#1}
      \mplibtmptoks{}\ltxdomplibcode
    }
  \cs_set_eq:NN \mplibalttext \use_none:n
  \cs_set_eq:NN \mplibactualtext \use_none:n
```

2025/12/05: \begin{center}\mpfig ...\endmpfig\end{center} raises an Error! as we issue \everypar{} before flushing literals out. It is related to \partokencontext=2 recently introduced by LaTeX. Why we used vbox initially? where hbox seems to be sufficient. Anyway, among various solutions including \partokencontext\z@, \let\par\@@par, and \endgraf, we here attempt to address the issue by adding the following line, which LaTeX's \everypar should have done.

```
  \tl_put_left:Nn \mplibstoptoPDF \@newlistfalse
  \ExplSyntaxOff
  \endinput\fi
\ExplSyntaxOn
\tl_new:N \l__luamplib_tag_envname_tl
\tl_new:N \l__luamplib_tag_alt_tl
\tl_new:N \l__luamplib_tag_alt_dflt_tl
\tl_new:N \l__luamplib_tag_actual_tl
\tl_new:N \l__luamplib_tag_struct_tl
\tl_set:Nn\l__luamplib_tag_struct_tl {Figure}
\bool_new:N \l__luamplib_tag_usetext_bool
\bool_new:N \l__luamplib_tag_bboxcorr_bool
\seq_new:N  \l__luamplib_tag_bboxcorr_seq
```

```
\tl_new:N \l__luamplib_tag_bbox_draw_tl
\tl_new:N \l__luamplib_BBox_llx_tl
\tl_new:N \l__luamplib_BBox_lly_tl
\tl_new:N \l__luamplib_BBox_urx_tl
\tl_new:N \l__luamplib_BBox_ury_tl
\msg_new:nnn {luamplib}{figure-text-reuse}
{
  tex-text~box~#1~probably~is~incorrectly~tagged.~
  Reusing~a~box~in~text~mode~is~strongly~discouraged.~
  Check~the~resulting~PDF.
}
\msg_new:nnn {luamplib}{mplibgroup-text-mode}
{
  mplibgroup~'#1'~probably~is~incorrectly~tagged.~
  Using~mplibgroup~with~text~mode~is~not~recommended.~
  Check~the~resulting~PDF.
}
\msg_new:nnn{luamplib}{alt-text-missing}
{
  Alternate~text~for~#1~is~missing.~
  Using~the~default~value~'#2'~instead.
}
```

Sockets for tex-text boxes.

```
\socket_new:nn{tagsupport/luamplib/textext/set}{2}
\socket_new:nn{tagsupport/luamplib/textext/put}{2}
\socket_new_plug:nnn{tagsupport/luamplib/textext/set}{default}
{
```

TODO: we check text mode here. If we tag text boxes for all modes, we will get a lot of structure-has-no-parent warning; no good-looking, though it seems to be no harm.

```
  \bool_if:NTF \l__luamplib_tag_usetext_bool
  {
    \tag_mc_end_push:
    \tag_struct_begin:n{tag=NonStruct, stash, parent-tag=text}
    \cs_gset_nopar:cpe {luamplib.taggedbox.#1} {\tag_get:n{struct_num}}
```

TODO: We force an MC. Otherwise a and b in `btex a $x$ b etex` are not tagged.

```
    \tag_mc_begin:n{tag=text}
    #2
    \tag_mc_end:
    \tag_struct_end:
    \tag_mc_begin_pop:n{}
  }
  {
    \tag_suspend:n{\luamplibtagtextboxset}
    #2
    \tag_resume:n{\luamplibtagtextboxset}
  }
}
```

```
\socket_new_plug:nnn{tagsupport/luamplib/textext/put}{default}
{
  \bool_lazy_and:nnTF
  { \l__luamplib_tag_usetext_bool }
  { \cs_if_free_p:c {luamplib.notaggedbox.#1} }
  {
    \tag_resume:n{\mplibputtextbox}
    \tag_mc_end:
    \cs_if_exist:cTF {luamplib.taggedbox.#1}
    {
      \exp_args:Nc \tag_struct_use_num:n {luamplib.taggedbox.#1}
      #2
      \cs_undefine:c {luamplib.taggedbox.#1}
    }
    {
      \msg_warning:nnn{luamplib}{figure-text-reuse}{#1}
      \tag_mc_begin:n{}
      \int_set:Nn \l_tmpa_int {#1}
      \tag_mc_reset_box:N \l_tmpa_int
      #2
      \tag_mc_end:
    }
    \tag_mc_begin:n{artifact}
  }
  {
    \int_set:Nn \l_tmpa_int {#1}
    \tag_mc_reset_box:N \l_tmpa_int
    #2
  }
}
\socket_assign_plug:nn{tagsupport/luamplib/textext/set}{default}
\socket_assign_plug:nn{tagsupport/luamplib/textext/put}{default}
\cs_set_nopar:Npn \luamplibtagtextboxset
{
  \tag_socket_use:nnn{luamplib/textext/set}
}
```

For tex-text boxes starting with `[taggingoff]`, which we will not tag at all. They will be just in the artifact MC-chunks.

```
\cs_set_nopar:Npn \luamplibnotagtextboxset #1 #2
{
  \bool_set_eq:NN \l_tmpa_bool \l__luamplib_tag_usetext_bool
  \bool_set_false:N \l__luamplib_tag_usetext_bool
  \tag_socket_use:nnn{luamplib/textext/set}{#1}{#2}
  \cs_gset_nopar:cpn {luamplib.notaggedbox.#1}{#1}
  \bool_set_eq:NN \l__luamplib_tag_usetext_bool \l_tmpa_bool
}
\cs_set_nopar:Npn \mplibputtextbox #1
{
```

```
  \vbox to 0pt{\vss\hbox to 0pt{
    \socket_use:nnn{tagsupport/luamplib/textext/put}{#1}{\raise\dp#1\copy#1}
  \hss}}
}
```

TODO: Not sure whether asgroup/mplibgroup with text mode will be tagged correctly. Probably not. At least, this will raise a warning.

```
\cs_set_nopar:Npn \luamplibtagasgroupset
{
  \bool_set_false:N \l__luamplib_tag_usetext_bool
}
\cs_set_nopar:Npn \luamplibtagasgroupput
{
  \bool_if:NT \l__luamplib_tag_usetext_bool { \tag_resume:n{\luamplibtagasgroupput} }
  \tag_socket_use:nnn{luamplib/mplibgroup/put}
}
```

A socket for mplibgroup. Again, we issue a warning upon text mode.

```
\socket_new:nn{tagsupport/luamplib/mplibgroup/put}{2}
\socket_new_plug:nnn{tagsupport/luamplib/mplibgroup/put}{default}
{
  \cs_if_free:cT {luamplib.mplibgroup.text.#1}
  {
    \msg_warning:nnn {luamplib} {mplibgroup-text-mode} {#1}
    \cs_gset_nopar:cpn {luamplib.mplibgroup.text.#1} {#1}
  }
  \tag_mc_end:
  \tag_mc_begin:n{tag=text}
  #2
  \tag_mc_end:
  \tag_mc_begin:n{artifact}
}
\socket_assign_plug:nn{tagsupport/luamplib/mplibgroup/put}{default}
```

A macro for BBox attribute

```
\cs_set_nopar:Npn \__luamplib_tag_bbox_attribute:n #1
{
  \tl_set:Ne \l_tmpa_tl {luamplib.BBox.\tag_get:n{struct_num}}
  \tex_savepos:D
  \property_record:ee{\l_tmpa_tl}{xpos,ypos}
  \tl_set:Ne \l__luamplib_BBox_llx_tl
    { \dim_to_decimal_in_bp:n { \property_ref:een {\l_tmpa_tl}{xpos}{0}sp } }
  \tl_set:Ne \l__luamplib_BBox_lly_tl
    { \dim_to_decimal_in_bp:n { \property_ref:een {\l_tmpa_tl}{ypos}{0}sp - \dp#1 } }
  \tl_set:Ne \l__luamplib_BBox_urx_tl
    { \dim_to_decimal_in_bp:n { \l__luamplib_BBox_llx_tl bp + \wd#1 } }
  \tl_set:Ne \l__luamplib_BBox_ury_tl
    { \dim_to_decimal_in_bp:n { \l__luamplib_BBox_lly_tl bp + \ht#1 + \dp#1 } }
  \bool_if:NT \l__luamplib_tag_bboxcorr_bool
  {
```

```
    \int_zero:N \l_tmpa_int
    \tl_map_inline:nn
    {
      \l__luamplib_BBox_llx_tl
      \l__luamplib_BBox_lly_tl
      \l__luamplib_BBox_urx_tl
      \l__luamplib_BBox_ury_tl
    }
    {
      \int_incr:N \l_tmpa_int
      \tl_set:Ne ##1
      {
        \fp_eval:n
        {
          ##1
          +
          \dim_to_decimal_in_bp:n { \seq_item:NV \l__luamplib_tag_bboxcorr_seq \l_tmpa_int }
        }
      }
    }
  }
  \tag_struct_gput:ene {\tag_get:n{struct_num}} {attribute}
  {
    /O /Layout /BBox [
      \l__luamplib_BBox_llx_tl\c_space_tl
      \l__luamplib_BBox_lly_tl\c_space_tl
      \l__luamplib_BBox_urx_tl\c_space_tl
      \l__luamplib_BBox_ury_tl
    ]
  }
  \bool_if:NT \l__tag_graphic_debug_bool
  {
    \iow_log:e
    {
      luamplib/tagging~debug:~BBox~of~structure~\tag_get:n{struct_num}~is~
      \l__luamplib_BBox_llx_tl\c_space_tl
      \l__luamplib_BBox_lly_tl\c_space_tl
      \l__luamplib_BBox_urx_tl\c_space_tl
      \l__luamplib_BBox_ury_tl
    }
    \sys_if_output_pdf:TF
    {
      \tl_set:Ne \l__luamplib_tag_bbox_draw_tl
      {
        \pdfextension save\relax
        \opacity_select:n{0.5} \color_select:n{red}
        \pdfextension literal~text
        {
          \l__luamplib_BBox_llx_tl\c_space_tl
```

```
          \l__luamplib_BBox_lly_tl\c_space_tl
          \fp_eval:n { \l__luamplib_BBox_urx_tl - \l__luamplib_BBox_llx_tl }~
          \fp_eval:n { \l__luamplib_BBox_ury_tl - \l__luamplib_BBox_lly_tl }~
          re~f
        }
        \pdfextension restore\relax
      }
    }
    {
      \tl_set:Ne \l__luamplib_tag_bbox_draw_tl
      {
        \special{pdf:bcontent}
        \opacity_select:n{0.5} \color_select:n{red}
        \special{pdf:code~
          1~0~0~1~
          -\dim_to_decimal_in_bp:n { \property_ref:een{\l_tmpa_tl}{xpos}{0}sp + \wd#1 }~
          -\dim_to_decimal_in_bp:n { \property_ref:een{\l_tmpa_tl}{ypos}{0}sp }~
          cm
        }
        \special{pdf:code~
          \l__luamplib_BBox_llx_tl\c_space_tl
          \l__luamplib_BBox_lly_tl\c_space_tl
          \fp_eval:n { \l__luamplib_BBox_urx_tl - \l__luamplib_BBox_llx_tl }~
          \fp_eval:n { \l__luamplib_BBox_ury_tl - \l__luamplib_BBox_lly_tl }~
          re~f
        }
        \special{pdf:econtent}
      }
    }
  }
}
```

Sockets for main process

```
\socket_new:nn{tagsupport/luamplib/figure/begin}{1}
\socket_new:nn{tagsupport/luamplib/figure/end}{2}
\socket_new_plug:nnn{tagsupport/luamplib/figure/end}{transparent}{#2}
\socket_new_plug:nnn{tagsupport/luamplib/figure/begin}{alt}
{
    \tag_mc_end_push:
    \tl_if_empty:NT\l__luamplib_tag_alt_tl
    {
      \tl_if_empty:eTF{#1}
        { \tl_set:Nn \l__luamplib_tag_alt_tl {metapost~figure} }
        { \tl_set:Ne \l__luamplib_tag_alt_tl {metapost~figure~\text_purify:n{#1}} }
      \msg_warning:nnVV{luamplib}{alt-text-missing}
                       \l__luamplib_tag_envname_tl \l__luamplib_tag_alt_tl
    }
    \tag_struct_begin:n
    {
```

```
      tag=\l__luamplib_tag_struct_tl,
      alt=\l__luamplib_tag_alt_tl,
    }
    \tag_mc_begin:n{}
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/end}{alt}
{
    \__luamplib_tag_bbox_attribute:n {#1}
    #2
    \tl_use:N \l__luamplib_tag_bbox_draw_tl
    \tag_mc_end:
    \tag_struct_end:
    \tag_mc_begin_pop:n{}
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/begin}{actualtext}
{
    \tag_mc_end_push:
    \tag_struct_begin:n
    {
      tag=Span,
      actualtext=\l__luamplib_tag_actual_tl,
    }
    \tag_mc_begin:n{}
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/end}{actualtext}
{
    #2
    \tag_mc_end:
    \tag_struct_end:
    \tag_mc_begin_pop:n{}
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/begin}{artifact}
{
    \tag_mc_end_push:
    \tag_mc_begin:n{artifact}
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/end}{artifact}
{
    #2
    \tag_mc_end:
    \tag_mc_begin_pop:n{}
}
```

A socket for tagging init, so that we can declare `\SetKeys[luamplib/tagging]{...}` anywhere in the document.

```
\socket_new:nn{tagsupport/luamplib/figure/init}{0}
\socket_new_plug:nnn{tagsupport/luamplib/figure/init}{alt}
{
  \socket_assign_plug:nn{tagsupport/luamplib/figure/begin}{alt}
```

```
  \socket_assign_plug:nn{tagsupport/luamplib/figure/end}{alt}
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/init}{actualtext}
{
  \socket_assign_plug:nn{tagsupport/luamplib/figure/begin}{actualtext}
  \socket_assign_plug:nn{tagsupport/luamplib/figure/end}{actualtext}
```

In vmode, hmode will be forced by \noindent upon actualtext and text modes.

```
  \prependtomplibbox \mplibnoforcehmode
  \mode_if_vertical:T { \noindent \aftergroup\par }
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/init}{artifact}
{
  \socket_assign_plug:nn{tagsupport/luamplib/figure/begin}{artifact}
  \socket_assign_plug:nn{tagsupport/luamplib/figure/end}{artifact}
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/init}{text}
{
  \bool_set_true:N \l__luamplib_tag_usetext_bool
  \socket_assign_plug:nn{tagsupport/luamplib/figure/begin}{artifact}
  \socket_assign_plug:nn{tagsupport/luamplib/figure/end}{artifact}
  \prependtomplibbox \mplibnoforcehmode
  \mode_if_vertical:T { \noindent \aftergroup\par }
}
\socket_new_plug:nnn{tagsupport/luamplib/figure/init}{off}
{
  \socket_assign_plug:nn{tagsupport/luamplib/figure/begin}{noop}
  \socket_assign_plug:nn{tagsupport/luamplib/figure/end}{transparent}
}
\socket_assign_plug:nn{tagsupport/luamplib/figure/init}{alt}
```

Key-value options

```
\keys_define:nn{luamplib/tagging}
{
  ,alt .code:n =
  {
    \tl_set:Ne\l__luamplib_tag_alt_tl{\text_purify:n{#1}}
    \socket_assign_plug:nn{tagsupport/luamplib/figure/init}{alt}
  }
  ,actualtext .code:n =
  {
    \tl_set:Ne\l__luamplib_tag_actual_tl{\text_purify:n{#1}}
    \socket_assign_plug:nn{tagsupport/luamplib/figure/init}{actualtext}
  }
  ,artifact .code:n = { \socket_assign_plug:nn{tagsupport/luamplib/figure/init}{artifact} }
  ,text     .code:n = { \socket_assign_plug:nn{tagsupport/luamplib/figure/init}{text} }
  ,off      .code:n = { \socket_assign_plug:nn{tagsupport/luamplib/figure/init}{off} }
  ,tag      .code:n =
  {
    \str_case:nnF {#1}
```

```
    {
      {false}    { \keys_set:nn {luamplib/tagging} {off} }
      {artifact} { \keys_set:nn {luamplib/tagging} {artifact} }
    }
    {
      \tl_set:Nn\l__luamplib_tag_struct_tl{#1}
      \socket_assign_plug:nn{tagsupport/luamplib/figure/init}{alt}
    }
  }
  ,adjust-BBox .code:n =
  {
    \bool_set_true:N \l__luamplib_tag_bboxcorr_bool
    \seq_set_split:Nnn \l__luamplib_tag_bboxcorr_seq{~}{#1~0pt~0pt~0pt~0pt}
  }
  ,tagging-setup .code:n = { \keys_set_known:nn {luamplib/tagging} {#1} }
}
\keys_define:nn {luamplib/instance}
{
  ,instance     .code:n = { \tl_gset:Nn \currentmpinstancename {#1} }
  ,instancename .meta:n = { instance = {#1} }
  ,unknown      .code:n = { \tl_gset:NV \currentmpinstancename \l_keys_key_str }
}
```

Redefine our macros

```
\cs_set_nopar:Npn \mplibstarttoPDF #1 #2 #3 #4
{
  \prependtomplibbox
  \hbox dir~TLT\bgroup
    \tag_socket_use:nn{luamplib/figure/begin}\l__luamplib_tag_alt_dflt_tl
    \xdef\MPllx{#1}\xdef\MPlly{#2}%
    \xdef\MPurx{#3}\xdef\MPury{#4}%
    \xdef\MPwidth{\the\dimexpr#3bp-#1bp\relax}%
    \xdef\MPheight{\the\dimexpr#4bp-#2bp\relax}%
    \parskip0pt
    \leftskip0pt
    \parindent0pt
    \everypar{}%
    \setbox\mplibscratchbox\vbox\bgroup
      \tag_suspend:n{\mplibstarttoPDF}
      \noindent
}
\cs_set_nopar:Npn \mplibstoptoPDF
{
      \par
    \egroup
    \setbox\mplibscratchbox\hbox
      {\hskip-\MPllx bp
       \raise-\MPlly bp
       \box\mplibscratchbox}%
```

```
    \setbox\mplibscratchbox\vbox to \MPheight
      {\vfill
       \hsize\MPwidth
       \wd\mplibscratchbox0pt
       \ht\mplibscratchbox0pt
       \dp\mplibscratchbox0pt
       \box\mplibscratchbox}%
    \wd\mplibscratchbox\MPwidth
    \ht\mplibscratchbox\MPheight
    \tag_socket_use:nnn{luamplib/figure/end}{\mplibscratchbox}{\box\mplibscratchbox}
  \egroup
}
\RenewDocumentCommand\mplibcode{O{}}
{
  \tl_set:Nn \l__luamplib_tag_envname_tl {mplibcode}
  \tl_gclear:N \currentmpinstancename
  \keys_set_known:neN {luamplib/tagging} {#1} \l_tmpa_tl
  \keys_set:nV {luamplib/instance} \l_tmpa_tl
  \tl_set_eq:NN \l__luamplib_tag_alt_dflt_tl \currentmpinstancename
  \tag_socket_use:n{luamplib/figure/init}
  \mplibtmptoks{}\ltxdomplibcode
}
\RenewDocumentCommand\mpfig{s O{}}
{
  \begingroup
  \tl_set:Nn \l__luamplib_tag_envname_tl {mpfig}
  \keys_set_known:ne {luamplib/tagging} {#2}
  \tl_set_eq:NN \l__luamplib_tag_alt_dflt_tl \mpfiginstancename
  \tag_socket_use:n{luamplib/figure/init}
  \IfBooleanTF{#1} { \mplibprempfig * }
                   { \mplibmainmpfig }
}
\RenewDocumentCommand\usemplibgroup{O{} m}
{
  \begingroup
  \tl_set:Nn \l__luamplib_tag_envname_tl {usemplibgroup}
  \keys_set_known:ne {luamplib/tagging} {#1}
  \tag_socket_use:n{luamplib/figure/init}
  \prependtomplibbox\hbox dir~TLT\bgroup
    \tag_socket_use:nn{luamplib/figure/begin}{#2}
    \setbox\mplibscratchbox\hbox\bgroup
      \bool_if:NF \l__luamplib_tag_usetext_bool { \tag_suspend:n{\usemplibgroup} }
      \tag_socket_use:nnn{luamplib/mplibgroup/put}{#2}{\csname luamplib.group.#2\endcsname}
    \egroup
    \tag_socket_use:nnn{luamplib/figure/end}{\mplibscratchbox}{\unhbox\mplibscratchbox}
  \egroup
  \endgroup
}
```

Allow setting alt/actual text within METAPOST code. Of course we can use them in TEX code as

well.

```
\cs_new_nopar:Npn \mplibalttext #1
{
  \tl_set:Ne \l__luamplib_tag_alt_tl {\text_purify:n{#1}}
}
\cs_new_nopar:Npn \mplibactualtext #1
{
  \tl_set:Ne \l__luamplib_tag_actual_tl {\text_purify:n{#1}}
}
\ExplSyntaxOff
```

That's all folks!

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