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`, though it's behavior cannot be the same as the stand-alone **mpost**. Of course 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 version 2.7 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 \centering, \raggedleft etc. will have effects. \mplibnoforcehmode, being default, reverts this setting.[1]

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

\everymplib and \everyendmplib redefine the lua table 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 functionalities producing 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 § 1.2.10). You can try other effects as well, though we did not fully tested their proper functioning.

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=⟨*number*⟩" to the sentence. ($0 \leq \langle number \rangle \leq 1$)

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

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

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 § 1.2.5.

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, cannot properly render the isolated or knockout effect.

Transparency group is available with *plain* format as well, with extended functionality. See below § 1.2.12.

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}

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

[2] As for user's setting, enable, true and yes are identical; disable, false and no are identical.

[3] But the recommended way to reuse a figure is using \mplibgroup command. See below § 1.2.13.

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. As shown in the example below, VerbatimTeX ⟨*string*⟩ is a synonym of verbatimtex ... etex.[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.

By contrast, when \mpliblegacybehavior{disable} is declared, any verbatimtex ... etex will be executed, along with btex ... etex, sequentially one by one. So, some TEX code in verbatimtex ... etex will have effects on following btex ... etex codes.

```
\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.

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 contrary, \mplibcodeinherit{disable}

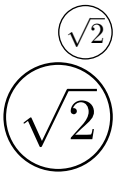
[4] But the recommended way to access METAPOST variables from TEX (or Lua) side is to use Lua code via luamplib.instances. For details see below § 1.3.2.

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. This optional 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 mplibcode environment. Plain TeX users also can use this functionality. 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 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). See the example above at § 1.1.12. The optional [...] denotes the option of xcolor's \color command. For spot colors, l3color (in PDF/DVI mode), colorspace, spotcolor (in PDF mode) and xespotcolor (in DVI mode) packages are supported as well.

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 worring about the location of the color command:

```
draw image (drawarrow (left--right) scaled 5)
  scaled 7
  withcolor \mpcolor{red!50}
  ;
```

Be aware, however, that even after v2.38.1 \mpcolor will still insert the 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 withcolor \mpcolor{spotA})
  scaled 7
  ;
```

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 .5[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 excluding .mp extension. Note that .mp files under $TEXMFMAIN/metapost/base and $TEXMFMAIN/metapost/context/base are already registered by default.

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⟩}";`

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. Inside `text`-mode figures, reusing TEX-text boxes is strongly discouraged.

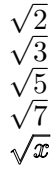
Note that the text in a TEX-text box which starts with `[taggingoff]` will not be tagged at all, and of course `[taggingoff]` and its trailing spaces will be gobbled by **luamplib**. For

[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.

[6] The key `text` also shares the limitation mentioned in the previous footnote.

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}
```



`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 § 1.2.12) commands as well.

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

[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.

1.2 MetaPost

1.2.1 mplibdimen ..., mplibcolor ...

These 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, which accepts a string argument, 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. For instance:

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

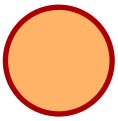
But the result may vary in its color model (gray/rgb/cmyk) according to the given TEX color. Therefore the example shown above would raise a METAPOST error: cmykcolor col; should have been declared. By contrast, mplibrgbtexcolor ⟨*string*⟩ always returns rgb-model expressions.

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 (⟨*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 § 1.2.9):

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



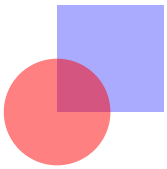
The PDF file size is much smaller than issueing two sentences with different colors, though the apparent effect is the same.

1.2.4 withtransparency (..., ...)

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

```
\mpfig
  fill unitsquare scaled 40
```

```
    withcolor 2/3[blue,white]
    ;
  fill fullcircle scaled 40
    withcolor red
    withtransparency (1, 0.5)          % or ("normal", 0.5)
    ;
\mpfig
```



1.2.5 ... 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* means a picture generated by btex ... etex, textext, TEX, maketext, mplibgraphictext (see below § 1.2.7 on this macro), or infont operator, though technically only the last one is a true textual picture.

```
draw btex \bfseries\TeX etex rotated 20 scaled 6
  withshadingmethod "linear"
  withshadingvector (0,3)
  withshadingstep (
    withshadingfraction 1/2
    withshadingcolors (red,green)
  )
  withshadingstep (
    withshadingfraction 1
    withshadingcolors (green,blue)
  )
  ;
```

- When you give shading effect to a picture generated by 'infont' operator, the result of withshadingvector will be the same as that of withshadingdirection, as luamplib considers only the bounding box of the picture in this case.

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

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

`withshadingfactor` ⟨*number*⟩ 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; `"yes"` for all other cases.

`withshadingdomain` ⟨*pair*⟩ Limiting values of parametric variable that varies on the axis of color gradient. Default value: `(0,1)`

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

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

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

1.2.6 ... withfademethod ...

This is a METAPOST operator which makes the color of an object gradiently transparent. 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 operand of `withfademethod` can be a picture as well as a path; (2) you cannot make gradient colors, but can only make gradient opacity.

Related macros to control optional values are:

`withfadeopacity (`*number, number*`)` 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 (`*number, number*`)` 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 § 1.2.12 on the analogous macro `withgroupbbox`.

An example:

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

1.2.7 `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 § 1.2.10). However the syntax is somewhat different.

```
draw mplibgraphictext "\bfseries Funny"
  rotated 20 scaled 3
  fakebold 2.3                          % fontspec option
  fillcolor "red!50"                    % color expression
  drawcolor 2/3 blue                    % or strokecolor 2/3 blue
  ;
```

`fakebold`, `fillcolor` and `drawcolor` (or `strokecolor`) are optional; default values are `2`, `"white"` and `"black"` respectively.[9] When the color expressions are given in string type, they are regarded as **color**, **xcolor** or **l3color**'s expressions. 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`.[10] 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.

[9] Users can use the `withmplibcolors` macro instead of `fillcolor` and `drawcolor` options. See § 1.2.3 on this macro.
[10] But this limitation is now lifted by the introduction of `withshadingmethod`. See above § 1.2.5.

1.2.8 `mplibglyph ... of ...`

From v2.30, we provide a new METAPOST operator `mplibglyph`, which returns a METAPOST picture containing outline paths of a glyph in opentype, truetype or type1 fonts. When a type1 font is specified, METAPOST primitive `glyph` will be called.

```
mplibglyph 50  of \fontid\font          % slot 50 of current font
mplibglyph "Q" of "TU/TeXGyrePagella(0)/m/n/10"      % font csname
mplibglyph "Q" of "texgyrepagella-regular.otf"       % raw filename
mplibglyph "Q" of "Times.ttc(2)"                     % subfont number
mplibglyph "Q" of "SourceHanSansK-VF.otf[Regular]"   % instance name
```

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 of a variable font.

1.2.9 `mplibdrawglyph ...`, `mplibstrokeglyph ...`, `mplibfillandstrokeglyph ...`

As the structure of the picture returned by `mplibglyph` will be 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 in the picture.

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).[11]

As this could be somewhat annoying to users, we provide the following commands as well: `mplibfillandstrokeglyph` ⟨*picture*⟩, `mplibstrokeglyph` ⟨*picture*⟩, and `mplibfillglyph` ⟨*picture*⟩, the last one being a synonym of `mplibdrawglyph` command.

An example:

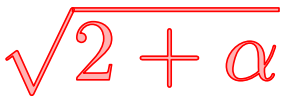
```
mplibfillandstrokeglyph
  mplibglyph "R" of \fontid\font scaled 1/12
  withpen pencircle scaled 1
  withmplibcolors ("orange", 2/3red)
  ;
```

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

1.2.10 mpliboutlinetext (...)

From v2.31, a new METAPOST operator mpliboutlinetext is available, which mimicks *metafun*'s outlinetext. So the syntax is the same: see the *metafun* manual § 8.7 (texdoc metafun). A simple example:

```
draw mpliboutlinetext.b ("$\sqrt{2+\alpha}$")
  (withcolor \mpcolor{red!30})
  (withpen pencircle scaled .2 withcolor red)
  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.

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

TEX macros \mppattern{⟨*name*⟩} ... \endmppattern define a tiling pattern 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 of the ⟨*name*⟩ by replicating it horizontally and vertically.[12] As said before at § 1.2.5, 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}
```

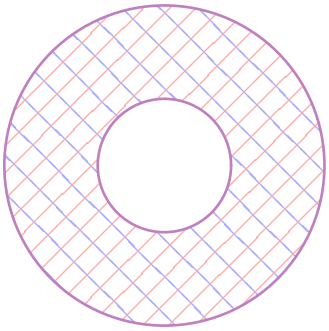
[12] withpattern is an operator virtually the same as withmppattern, but the former forces a METAPOST picture. Therefore you cannot but use draw command with withpattern operator. On the other hand, if some special command is not appended (see the example just below), ⟨*cyclic path*⟩ withmppattern ⟨*string*⟩ 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

```
\mpfig
  draw fullcircle scaled 50
    withpostscript "collect"
    ;
  draw fullcircle scaled 120
    withmppattern "mypatt"
    withpen pencircle scaled 1
    withcolor \mpcolor{red!50!blue!50}
    withpostscript "eoboth"
    ;
\endmpfig
```



The available options are listed in Table 1.

For the sake of convenience, the width and height values of tiling patterns will be written down into the log file. (depth is always zero.) Users can refer to them for option setting.

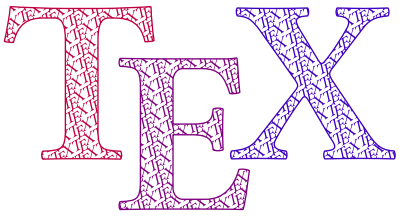
As for matrix option, METAPOST code such as "rotated 30 slanted .2" is allowed as well as string or table of four numbers. You can also set xshift and yshift values by using 'shifted' operator. But when xshift or yshift option is explicitly given, they have precedence over the effect of 'shifted' operator.

When you use special effect such as transparency in a pattern, resources option is needed: for instance, resources="/ExtGState 1 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 which shall have no color at all. 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}
  beginfig(1)
    picture tex;
    tex = mpliboutlinetext.p ("\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 (
        1/3[white,red],               % paints the pattern
        2/3 red
      )
      ;
  endfig;
\end{mplibcode}
```

1.2.12 ... asgroup ...

As said before, transparency group is available with *plain* as well as *metafun* format. The syntax is exactly the same: ⟨*picture*⟩ | ⟨*path*⟩ `asgroup ""|"isolated"|"knockout"|"isolated,knockout"`, which will return a METAPOST picture. 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 additional feature provided by **luamplib** is that 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 group 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.

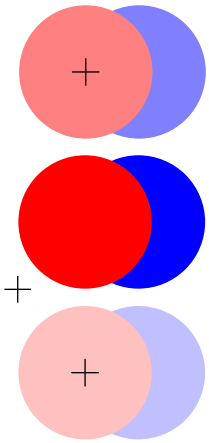
`withgroupbbox (`*pair*`,`*pair*`)` sets the bounding box of the transparency group, default value being `(llcorner p, urcorner p)`. This option might be needed especially when you draw with a thick pen a path that touches the boundary; you would probably want to append to the sentence '`withgroupbbox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

An example showing the difference between the TEX and METAPOST commands:

```
\mpfig
  draw image(
      fill fullcircle scaled 50 shifted 20right withcolor blue;
      fill fullcircle scaled 50 withcolor red ;
    )
    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, 1/4)
    ;
  draw (left--right) scaled 5;
  draw (up--down) scaled 5;
\endmpfig
```



Also note that normally the reused 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.

1.2.13 `\mplibgroup{...} ... \endmplibgroup`

These TEX macros are described here in this subsection, as they are deeply related to the `asgroup` operator. Users can define a transparency group or a normal *form XObject* with these macros

Table 2: options for \mplibgroup

Key	Value Type	Explanation
asgroup	*string*	"", "isolated", "knockout", or "isolated,knockout"
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

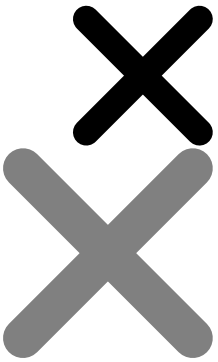
from TEX side. The syntax is similar to the \mppattern command (see above § 1.2.11).

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 30 rotated 45 ;
    draw (left--right) scaled 30 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, including empty string, is not given, a normal form XObject will be generated rather than a transparency group. Thus the individual objects, not the XObject as a whole, will be affected by outer transparency command.

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 § 1.2.12, excepting that the mplibgroup made by TEX code (not by METAPOST code) respects original height and depth.

1.2.14 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.

1.2.15 `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.

1.3 Lua

1.3.1 `runscript ...`

Using the primitive `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 value 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" )
```

Table 3: elements in luamplib table (partial)

Key	Type	Related TEX macro
codeinherit	*boolean*	\mplibcodeinherit
everyendmplib	*table*	\everyendmplib
everymplib	*table*	\everymplib
getcachedir	*function* (⟨*string*⟩)	\mplibcachedir
globaltextext	*boolean*	\mplibglobaltextext
legacyverbatimtex	*boolean*	\mpliblegacybehavior
noneedtoreplace	*table*	\mplibmakenocache
numbersystem	*string*	\mplibnumbersystem
setformat	*function* (⟨*string*⟩)	\mplibsetformat
showlog	*boolean*	\mplibshowlog
textextlabel	*boolean*	\mplibtextextlabel
verbatiminput	*boolean*	\mplibverbatim

```
  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 executed inside METAPOST code using runscript. Again, of course you can access a METAPOST value using your own TEX macro. For example:

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

1.3.3 Lua function luamplib.process_mplibcode

Users can execute 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 have effects on the process of process_mplibcode.

2 Implementation

2.1 Lua module

```
1
2 luatexbase.provides_module {
```

```
  name          = "luamplib",
  version       = "2.38.2",
  date          = "2026/01/14",
  description   = "Lua package to typeset Metapost with LuaTeX's MPLib.",
}

```

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

```
luamplib          = luamplib or { }
local luamplib    = luamplib

local format, abs = string.format, math.abs

```

Use our own function for warn/info/err.

```
local function termorlog (target, text, kind)
  if text then
    local mod, write, append = "luamplib", texio.write_nl, texio.write
    kind = kind
        or target == "term" and "Warning (more info in the log)"
        or target == "log" and "Info"
        or target == "term and log" and "Warning"
        or "Error"
    target = kind == "Error" and "term and log" or target
    local t = text:explode"\n+"
    write(target, format("Module %s %s:", mod, kind))
    if #t == 1 then
      append(target, format(" %s", t[1]))
    else
      for _,line in ipairs(t) do
        write(target, line)
      end
      write(target, format("(%s)     ", mod))
    end
    append(target, format(" on input line %s", tex.inputlineno))
    write(target, "")
    if kind == "Error" then error() end
  end
end
local function warn (...) -- beware '%' symbol
  termorlog("term and log", select("#",...) > 1 and format(...) or ...)
end
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 outputdir, cachedir
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 next, 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
          outputdir = dir
          break
        end
      end
      if outputdir then break end
    end
  end
end
outputdir = outputdir or '.'
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] 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
          termorlog("term", first)
          termorlog("log", log, "Warning")
        else
          warn(log)
        end
        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     }
305     local result, log
306     if not mpx then
307       result = { status = 99, error = "out of memory"}
308     else
309       result = mpx:execute(preamble)
310     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

```

dvipdfmx is supported, though nobody seems to use it.

```
local pdfmode = tex.outputmode > 0

```

make_text and some run_script uses LuaTEX's tex.runtoks.

```
local catlatex = luatexbase.registernumber("catcodetable@latex")
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.

```
local function run_tex_code (str, cat)
  texruntoks(function() texsprint(cat or catlatex, str) end)
end
```

For conversion of sp to bp.

```
local factor = 65536*(7227/7200)

```

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.

```
local texboxes = { globalid = 0, localid = 4096 }
local process_tex_text
do
  local textext_fmt = 'image(addto currentpicture doublepath unitsquare \z
    xscaled %f yscaled %f shifted (0,-%f) \z
    withprescript "mplibtexboxid=%i:%f:%f")'
  function process_tex_text (str, maketext)
    if str then
      if not maketext then str = str:gsub("\r.-$","") end
      local global = (has_instancename or luamplib.globaltextext or luamplib.codeinherit)
                     and "\\global" or ""
      local tex_box_id
      if global == "" then
        tex_box_id = texboxes.localid + 1
        texboxes.localid = tex_box_id
      else
        local boxid = texboxes.globalid + 1
        texboxes.globalid = boxid
        run_tex_code(format([[\expandafter\newbox\csname luamplib.box.%s\endcsname]], boxid))
        tex_box_id = tex.getcount'allocationnumber'
      end
      if str:find"^%[taggingoff%]" then
        str = str:gsub("^%[taggingoff%]%s*","")
        run_tex_code(format("\\luamplibnotagtextboxset{%i}{%s\\setbox%i\\hbox{%s}}",
                            tex_box_id, global, tex_box_id, str))
      else
        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
    return format("[%s]", tableconcat(colorsplit(col)," "))
  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
  local emboldenfonts = { }
  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 = font.getcopy(f or font.current()).size * fakebold / factor * 10
      emboldenfonts.width = width
    end
    return width
```

```
end
local function getrulewhatsit (line, wd, ht, dp)
  line, wd, ht, dp = line/1000, wd/factor, ht/factor, dp/factor
  local pl
  local fmt = "%f w %f %f %f %f re %s"
  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, "B") :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)
    end
  end
else
  tag_update_attrs = function() end
end
local function embolden (box, curr, fakebold)
  local head = curr
  while curr do
    if curr.head then
      curr.head = embolden(curr, curr.head, fakebold)
    elseif curr.replace then
      curr.replace = embolden(box, curr.replace, fakebold)
    elseif curr.leader then
      if curr.leader.head then
        curr.leader.head = embolden(curr.leader, curr.leader.head, fakebold)
      elseif curr.leader.id == node.id"rule" then
        local glue = node.effective_glue(curr, box)
        local line = getemboldenwidth(curr, fakebold)
        local wd,ht,dp = getrulemetric(box, curr.leader)
        if box.id == node.id"hlist" then
```

```
779           wd = glue
780         else
781           ht, dp = 0, glue
782         end
783         local pl = getrulewhatsit(line, wd, ht, dp)
784         local pack = box.id == node.id"hlist" and node.hpack or node.vpack
785         local list = pack(pl, glue, "exactly")
786         tag_update_attrs(list,curr)
787         head = node.insert_after(head, curr, list)
788         head, curr = node.remove(head, curr)
789       end
790     elseif curr.id == node.id"rule" and curr.subtype == 0 then
791       local line = getemboldenwidth(curr, fakebold)
792       local wd,ht,dp = getrulemetric(box, curr)
793       if box.id == node.id"vlist" then
794         ht, dp = 0, ht+dp
795       end
796       local pl = getrulewhatsit(line, wd, ht, dp)
797       local list
798       if box.id == node.id"hlist" then
799         list = node.hpack(pl, wd, "exactly")
800       else
801         list = node.vpack(pl, ht+dp, "exactly")
802       end
803       tag_update_attrs(list,curr)
804       head = node.insert_after(head, curr, list)
805       head, curr = node.remove(head, curr)
806     elseif curr.id == node.id"glyph" and curr.font > 0 then
807       local f = curr.font
808       local key = format("%s:%s",f,fakebold)
809       local i = emboldenfonts[key]
810       if not i then
811         local ft = font.getfont(f) or font.getcopy(f)
812         if pdfmode then
813           width = ft.size * fakebold / factor * 10
814           emboldenfonts.width = width
815           ft.mode, ft.width = 2, width
816           i = font.define(ft)
817         else
818           if ft.format ~= "opentype" and ft.format ~= "truetype" then
819             goto skip_type1
820           end
821           local name = ft.name:gsub('"','''):gsub(';$','')
822           name = format('%s;embolden=%s;',name,fakebold)
823           _, i = fonts.constructors.readanddefine(name,ft.size)
824         end
825         emboldenfonts[key] = i
826       end
827       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
    end
    return r
  end
  local function turning (t)
    local r, n = 0, #t
    for i=1,2 do
      tableinsert(t, t[i])
    end
    for i=1,n do
      r = r + getangle(t[i], t[i+1], t[i+2])
    end
    return r/360
  end
  local function glyphimage(t, fmt)
    local q,p,r = {{},{}}
    for i,v in ipairs(t) do
      local cmd = v[#v]
      if cmd == "m" then
        p = {format('(%s,%s)',v[1],v[2])}
        r = {{x=v[1],y=v[2]}}
```

```
    else
      local nt = t[i+1]
      local last = not nt or nt[#nt] == "m"
      if cmd == "l" then
        local pt = t[i-1]
        local seco = pt[#pt] == "m"
        if (last or seco) and r[1].x == v[1] and r[1].y == v[2] then
        else
          tableinsert(p, format('--(%s,%s)',v[1],v[2]))
          tableinsert(r, {x=v[1],y=v[2]})
        end
        if last then
          tableinsert(p, '--cycle')
        end
      elseif cmd == "c" then
        tableinsert(p, format('..controls(%s,%s)and(%s,%s)',v[1],v[2],v[3],v[4]))
        if last and r[1].x == v[5] and r[1].y == v[6] then
          tableinsert(p, '..cycle')
        else
          tableinsert(p, format('..(%s,%s)',v[5],v[6]))
          if last then
            tableinsert(p, '--cycle')
          end
          tableinsert(r, {x=v[5],y=v[6]})
        end
      else
        return mperr"unknown operator"
      end
      if last then
        tableinsert(q[ turning(r) > 0 and 1 or 2 ], tableconcat(p))
      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
```

```
924   return format('image(%s)', tableconcat(r))
925 end
926 if not table.tofile then require"lualibs-lpeg"; require"lualibs-table"; end
927 function luamplib.glyph (f, c)
928   local filename, subfont, instance, kind, shapedata
929   local fid = tonumber(f) or font.id(f)
930   if fid > 0 then
931     local fontdata = font.getfont(fid) or font.getcopy(fid)
932     filename, subfont, kind = fontdata.filename, fontdata.subfont, fontdata.format
933     instance = fontdata.specification and fontdata.specification.instance
934     filename = filename and filename:gsub("^harfloaded:","")
935   else
936     local name
937     f = f:match"^%s*(.+)%s*$"
938     name, subfont, instance = f:match"(.+)%((%d+)%)%[(.-)%]$"
939     if not name then
940       name, instance = f:match"(.+)%[(.-)%]$" -- SourceHanSansK-VF.otf[Heavy]
941     end
942     if not name then
943       name, subfont = f:match"(.+)%((%d+)%)$" -- Times.ttc(2)
944     end
945     name = name or f
946     subfont = (subfont or 0)+1
947     instance = instance and instance:lower()
948     for _,ftype in ipairs{"opentype", "truetype"} do
949       filename = kpse.find_file(name, ftype.." fonts")
950       if filename then
951         kind = ftype; break
952       end
953     end
954   end
955   if kind ~= "opentype" and kind ~= "truetype" then
956     f = fid and fid > 0 and tex.fontname(fid) or f
957     if kpse.find_file(f, "tfm") then
958       return format("glyph %s of %q", tonumber(c) or format("%q",c), f)
959     else
960       return mperr"font not found"
961     end
962   end
963   local time = lfsattributes(filename,"modification")
964   local k = format("shapes_%s(%s)[%s]", filename, subfont or "", instance or "")
965   local h = format(string.rep('%02x', 256/8), string.byte(sha2.digest256(k), 1, -1))
966   local newname = format("%s/%s.lua", cachedir or outputdir, h)
967   local newtime = lfsattributes(newname,"modification") or 0
968   if time == newtime then
969     shapedata = require(newname)
970   end
971   if not shapedata then
972     shapedata = fonts and fonts.handlers.otf.readers.loadshapes(filename,subfont,instance)
```

```
      if not shapedata then return mperr"loadshapes() failed. luaotfload not loaded?" end
      table.tofile(newname, shapedata, "return")
      lfstouch(newname, time, time)
    end
    local gid = tonumber(c)
    if not gid then
      local uni = utf8.codepoint(c)
      for i,v in pairs(shapedata.glyphs) do
        if c == v.name or uni == v.unicode then
          gid = i; break
        end
      end
    end
    if not gid then return mperr"cannot get GID (glyph id)" end
    local fac = 1000 / (shapedata.units or 1000)
    local t = shapedata.glyphs[gid].segments
    if not t then return "image()" end
    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
    kind = shapedata.format or kind
    return glyphimage(t, kind)
  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
        end
      elseif curr.head then
        local hd = (curr.height + curr.depth)/factor
        if hd <= vwidth then
          local dy, n, iy = dy, 0, 0
          if kind == 100 or kind == 103 then -- todo: gleaders
            local ady = abs(ody - dy)
            local ndy = math.ceil(ady / hd) * hd
            local diff = ndy - ady
            n = math.floor((vwidth-diff) / hd)
            dy = dy + (b2u and diff or -diff)
          else
            n = math.floor(vwidth / hd)
            if kind == 101 then
              local side = vwidth % hd / 2
              dy = dy + (b2u and side or -side)
            elseif kind == 102 then
              iy = vwidth % hd / (n+1)
              dy = dy + (b2u and iy or -iy)
            end
          end
          dy = dy + (b2u and curr.depth or -curr.height)/factor
          hd = b2u and hd or -hd
          iy = b2u and iy or -iy
          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+curr.shift/factor, yshift+dy)
            dy = dy + hd + iy
          end
        end
      end
    end
    dy = dy + (b2u and vwidth or -vwidth)
  elseif curr.id == node.id"kern" then
```

```
      dy = dy + curr.kern/factor * (b2u and 1 or -1)
    elseif curr.id == node.id"vlist" then
      dy = dy + (b2u and curr.depth or -curr.height)/factor
      res = outline_vert(res, curr, curr.head, xshift+curr.shift/factor, yshift+dy)
      dy = dy + (b2u and curr.height or -curr.depth)/factor
    elseif curr.id == node.id"hlist" then
      dy = dy + (b2u and curr.depth or -curr.height)/factor
      res = outline_horz(res, curr, curr.head, xshift+curr.shift/factor, yshift+dy)
      dy = dy + (b2u and curr.height or -curr.depth)/factor
    end
    curr = node.getnext(curr)
  end
  return res
end
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
```

```
1167        dx = dx - (r2l and width or 0)
1168        res = outline_horz(res, box, curr.replace, xshift+dx, yshift, width)
1169        dx = dx + (r2l and 0 or width)
1170      elseif curr.id == node.id"rule" then
1171        local wd, ht, dp = getrulemetric(box, curr, true)
1172        if wd ~= 0 then
1173          local hd = ht + dp
1174          dx = dx - (r2l and wd or 0)
1175          if hd ~= 0 and curr.subtype == 0 then
1176            res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+dx+wd/2, yshift+(ht-dp)/2)
1177          end
1178          dx = dx + (r2l and 0 or wd)
1179        end
1180      elseif curr.id == node.id"glue" then
1181        local width = node.effective_glue(curr, box)/factor
1182        dx = dx - (r2l and width or 0)
1183        if curr.leader then
1184          local curr, kind = curr.leader, curr.subtype
1185          if curr.id == node.id"rule" then
1186            local wd, ht, dp = getrulemetric(box, curr, true)
1187            local hd = ht + dp
1188            if hd ~= 0 then
1189              wd = width
1190              if wd ~= 0 and curr.subtype == 0 then
1191                res[#res+1] = rulefmt:format(#res+1, wd, hd, xshift+dx+wd/2, yshift+(ht-dp)/2)
1192              end
1193            end
1194          elseif curr.head then
1195            local wd = curr.width/factor
1196            if wd <= width then
1197              local dx = r2l and dx+width or dx
1198              local n, ix = 0, 0
1199              if kind == 100 or kind == 103 then -- todo: gleaders
1200                local adx = abs(dx-dirs[1].dx)
1201                local ndx = math.ceil(adx / wd) * wd
1202                local diff = ndx - adx
1203                n = math.floor((width-diff) / wd)
1204                dx = dx + (r2l and -diff-wd or diff)
1205              else
1206                n = math.floor(width / wd)
1207                if kind == 101 then
1208                  local side = width % wd /2
1209                  dx = dx + (r2l and -side-wd or side)
1210                elseif kind == 102 then
1211                  ix = width % wd / (n+1)
1212                  dx = dx + (r2l and -ix-wd or ix)
1213                end
1214              end
1215              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
      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 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 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;
    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:
      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 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.resadded = { }
  pdfetcs.fallback_update_resources = function (name,res,obj)
    texsprint{"\\special{pdf:put ", obj, " <<", res, ">>}"}
    if not pdfetcs.resadded[name] then
      texsprint{"\\luamplibateveryshipout{\\special{pdf:put @resources <</", name, " ", obj, ">>}}"}
      pdfetcs.resadded[name] = obj
    end
  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 opaq then
      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 = format("%.3f", opaq) :gsub(decimals,rmzeros)
      for i,v in ipairs{ {mode,opaq},{"Normal",1} } do
        os = format("<</BM/%s/ca %s/CA %s/AIS false>>",v[1],v[2],v[2])
        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
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
    else
      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
  end
  return shade_no
 end
end

```

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

```
if not pdfmode then
```

```
  pdfetcs.patternresources = {}
end
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")
      if not pdfmode then
        tableinsert(pdfetcs.patternresources, res) -- for gather_resources()
      end
    end
  end
end
function luamplib.dolatelua (on, os)
  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 shift = os:explode()
    if tonumber(h) ~= tonumber(shift[1]) or tonumber(v) ~= tonumber(shift[2]) then
      warn([[Add 'withprescript "sh_matrixshift=%s %s"' to the picture shading]], h, v)
    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))
  on = update_pdfobjs()
  if pdfmode then
    put2output(tableconcat{ "\\latelua{ luamplib.dolatelua(",on,",[[",os,"]]) }" })
  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}
```

```
    if is_defined"RecordProperties" then
```

```
      put2output(tableconcat{
        "\\csname tex_savepos:D\\endcsname\\RecordProperties{luamplib/getpos/",on,"}{xpos,ypos}\z
        \\special{pdf:put @mplibpdfobj",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
        ]>>}"
      })
    else
      local shift = prescript.sh_matrixshift or "0 0"
      texsprint{ "\\special{pdf:put @mplibpdfobj",on," <<",os,"/Matrix[1 0 0 1 ",shift,"]>>}" }
      put2output(tableconcat{ "\\latelua{ luamplib.dolatelua(",on,",[[",shift,"]]) }" })
    end
  end
  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)
  local t, do_pattern = { }, not optres
  local names = {"ExtGState","ColorSpace","Shading"}
  if do_pattern then
    names[#names+1] = "Pattern"
  end
  if pdfmode then
    if pdfmanagement then
      for _,v in ipairs(names) do
        if ltx.__pdf.Page.Resources[v] then
          t[#t+1] = format("/%s %s 0 R", v, ltx.pdf.object_id("__pdf/Page/Resources/"..v))
        end
      end
    else
      local res = pdfetcs.getpageres() or ""
      run_tex_code[[\mplibtmptoks\expandafter{\the\pdfvariable pageresources}]]
      res = res .. texgettoks'mplibtmptoks'
      if do_pattern then return res end
      res = res:explode"/+"
      for _,v in ipairs(res) do
        v = v:match"^%s*(.-)%s*$"
        if not v:find"Pattern" and not optres:find(v) then
          t[#t+1] = "/" .. v
        end
      end
    end
```

```
else
  if pdfmanagement then
    for _,v in ipairs(names) do
      run_tex_code ({
        "\\mplibtmptoks\\expanded{{",
        "\\pdfdict_if_empty:nF{g__pdf_Core/Page/Resources/", v, "}",
        "{/", v, " \\pdf_object_ref:n{__pdf/Page/Resources/", v, "}}}}",
      },ccexplat)
      t[#t+1] = texgettoks'mplibtmptoks'
    end
  elseif is_defined(pdfetcs.pgfextgs) then
    run_tex_code ({
      "\\mplibtmptoks\\expanded{{",
      "\\ifpgf@sys@pdf@extgs@exists /ExtGState @pgfextgs\\fi",
      "\\ifpgf@sys@pdf@colorspaces@exists /ColorSpace @pgfcolorspaces\\fi",
      do_pattern and "\\ifpgf@sys@pdf@patterns@exists /Pattern @pgfpatterns \\fi" or "",
      "}}",
    }, catat11)
    t[#t+1] = texgettoks'mplibtmptoks'
    if pdfetcs.resadded.Shading then
      t[#t+1] = format("/Shading %s", pdfetcs.resadded.Shading)
    end
  else
    for _,v in ipairs(names) do
      local vv = pdfetcs.resadded[v]
      if vv then
        t[#t+1] = format("/%s %s", v, vv)
      end
    end
  end
end
if do_pattern then return tableconcat(t) end
-- get pattern resources
local mytoks
if pdfmanagement then
  run_tex_code ({
    "\\mplibtmptoks\\expanded{{",
    "\\pdfdict_if_empty:nF{g__pdf_Core/Page/Resources/Pattern}",
    "{\\pdfdict_use:n{g__pdf_Core/Page/Resources/Pattern}}", "}}",
  },ccexplat)
  mytoks = texgettoks"mplibtmptoks"
  if not pdfmode then
    mytoks = mytoks:gsub("\\str_convert_pdfname:n%s*{(.-)}","%1") -- why not expanded?
  end
elseif is_defined(pdfetcs.pgfextgs) then
  if pdfmode then
    mytoks = get_macro"pgf@sys@pgf@resource@list@patterns"
  else
    local tt, abc = {}, get_macro"pgfutil@abc" or ""
```

```
      for v in abc:gmatch"@pgfpatterns%s*<<(.-)>>" do
        tt[#tt+1] = v
      end
      mytoks = tableconcat(tt)
    end
  else
    local tt = pdfmode and pdfetcs.Pattern_res or pdfetcs.patternresources
    mytoks = tt and tableconcat(tt)
  end
  if mytoks and mytoks ~= "" then
    t[#t+1] = format("/Pattern<<%s>>",mytoks)
  end
  return tableconcat(t)
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 = optres .. gather_resources(optres)
  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 }
  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
```

```
2545  end
2546  local bbox = prescript.mplibfadebbox:explode":"
2547  local dx, dy = -bbox[1], -bbox[2]
2548  local vec = prescript.mplibfadevector; vec = vec and vec:explode":"
2549  if not vec then
2550    if fd_type == "linear" then
2551      vec = {bbox[1], bbox[2], bbox[3], bbox[2]} -- left to right
2552    else
2553      local centerx, centery = (bbox[1]+bbox[3])/2, (bbox[2]+bbox[4])/2
2554      vec = {centerx, centery, centerx, centery} -- center for both circles
2555    end
2556  end
2557  local coords = { vec[1]+dx, vec[2]+dy, vec[3]+dx, vec[4]+dy }
2558  if fd_type == "linear" then
2559    coords = format("%f %f %f %f", tableunpack(coords))
2560  elseif fd_type == "circular" then
2561    local width, height = bbox[3]-bbox[1], bbox[4]-bbox[2]
2562    local radius = (prescript.mplibfaderadius or "0:"..math.sqrt(width^2+height^2)/2):explode":"
2563    tableinsert(coords, 3, radius[1])
2564    tableinsert(coords, radius[2])
2565    coords = format("%f %f %f %f %f %f", tableunpack(coords))
2566  else
2567    err("unknown fading method '%s'", fd_type)
2568  end
2569  fd_type = fd_type == "linear" and 2 or 3
2570  local opaq = (prescript.mplibfadeopacity or "1:0"):explode":"
2571  local on, os, new
2572  on = sh_pdfpageresources(fd_type, "0 1", "/DeviceGray", {{opaq[1]}}, {{opaq[2]}}, coords, 1)
2573  os = format("<</PatternType 2/Shading %s>>", format(pdfetcs.resfmt, on))
2574  on = update_pdfobjs(os)
2575  bbox = format("0 0 %f %f", bbox[3]+dx, bbox[4]+dy)
2576  local streamtext = format("q /Pattern cs/MPlibFd%s scn %s re f Q", on, bbox)
2577    :gsub(decimals,rmzeros)
2578  os = format("<</Pattern<</MPlibFd%s %s>>>>", on, format(pdfetcs.resfmt, on))
2579  on = update_pdfobjs(os)
2580  local resources = format(pdfetcs.resfmt, on)
2581  on = update_pdfobjs"<</S/Transparency/CS/DeviceGray>>"
2582  local attr = tableconcat{
2583    "/Subtype/Form",
2584    "/BBox[", bbox, "]",
2585    "/Matrix[1 0 0 1 ", format("%f %f", -dx,-dy), "]",
2586    "/Resources ", resources,
2587    "/Group ", format(pdfetcs.resfmt, on),
2588  } :gsub(decimals,rmzeros)
2589  on = update_pdfobjs(attr, streamtext)
2590  os = "<</SMask<</S/Luminosity/G " .. format(pdfetcs.resfmt, on) .. ">>>>"
2591  on, new = update_pdfobjs(os)
2592  local key = add_extgs_resources(on,new)
2593  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 = 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 = format("/Group<</S/Transparency/I %s/K %s>>",trgroup.isolated,trgroup.knockout)
    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 res = (opts.resources or "") .. gather_resources()
  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")
    opts.matrix = format("%f %f %f %f %f %f",tableunpack(luamplib.transformmatrix))
  end
  local grtype = 3
  if opts.bbox then
    attr[#attr+1] = format("/BBox[%s]", opts.bbox)
    grtype = 2
  end
  if opts.matrix then
    attr[#attr+1] = format("/Matrix[%s]", opts.matrix)
    grtype = opts.bbox and 4 or 1
  end
  if opts.asgroup then
    local t = { isolated = false, knockout = false }
    for _,v in ipairs(opts.asgroup:explode",+") do t[v] = true end
    attr[#attr+1] = format("/Group<</S/Transparency/I %s/K %s>>", t.isolated, t.knockout)
  end
  local trgroup = pdfetcs.tr_group
  trgroup.shifts[name] = { get_macro'MPllx', get_macro'MPlly' }
```

```
  local whd
  if pdfmode then
    attr = tableconcat(attr) :gsub(decimals,rmzeros)
    local index = tex.saveboxresource(boxid, attr, res, true, grtype)
    token.set_macro("luamplib.group."..name, tableconcat{
      "\\useboxresource ", index,
    }, "global")
    whd = format("%.3f %.3f 0", wd/factor, (ht+dp)/factor) :gsub(decimals,rmzeros)
  else
    trgroup.cnt = (trgroup.cnt or 0) + 1
    local objname = format("@mplibtrgr%s", trgroup.cnt)
    texsprint {
      "\\expandafter\\newbox\\csname luamplib.groupbox.", trgroup.cnt, "\\endcsname",
      "\\global\\setbox\\csname luamplib.groupbox.", trgroup.cnt, "\\endcsname",
      "\\hbox{\\unhbox ", boxid, "}\\luamplibatnextshipout{",
      "\\special{pdf:bcontent}",
      "\\special{pdf:bxobj ", objname, " width ", wd, "sp height ", ht, "sp depth ", dp, "sp}",
      "\\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
```

```
2782      end
2783    end
2784    return true
2785  end
2786
2787  local function flushnormalpath(path,open)
2788    local pth, ith
2789    for i=1,#path do
2790      pth = path[i]
2791      if not ith then
2792        pdf_literalcode("%f %f m",pth.x_coord,pth.y_coord)
2793      elseif curved(ith,pth) then
2794        pdf_literalcode("%f %f %f %f %f %f c",
2795          ith.right_x,ith.right_y,pth.left_x,pth.left_y,pth.x_coord,pth.y_coord)
2796      else
2797        pdf_literalcode("%f %f l",pth.x_coord,pth.y_coord)
2798      end
2799      ith = pth
2800    end
2801    if not open then
2802      local one = path[1]
2803      if curved(pth,one) then
2804        pdf_literalcode("%f %f %f %f %f %f c",
2805          pth.right_x,pth.right_y,one.left_x,one.left_y,one.x_coord,one.y_coord )
2806      else
2807        pdf_literalcode("%f %f l",one.x_coord,one.y_coord)
2808      end
2809    elseif #path == 1 then -- special case .. draw point
2810      local one = path[1]
2811      pdf_literalcode("%f %f l",one.x_coord,one.y_coord)
2812    end
2813  end
2814
2815  local function flushconcatpath(path,open)
2816    pdf_literalcode("%f %f %f %f %f %f cm", sx, rx, ry, sy, tx ,ty)
2817    local pth, ith
2818    for i=1,#path do
2819      pth = path[i]
2820      if not ith then
2821        pdf_literalcode("%f %f m",concat(pth.x_coord,pth.y_coord))
2822      elseif curved(ith,pth) then
2823        local a, b = concat(ith.right_x,ith.right_y)
2824        local c, d = concat(pth.left_x,pth.left_y)
2825        pdf_literalcode("%f %f %f %f %f %f c",a,b,c,d,concat(pth.x_coord, pth.y_coord))
2826      else
2827        pdf_literalcode("%f %f l",concat(pth.x_coord, pth.y_coord))
2828      end
2829      ith = pth
2830    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]
```

```
2870              local objecttype    = object.type
```

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

```
2871              local prescript     = object.prescript
2872              prescript = prescript and script2table(prescript) -- prescript is now a table
2873              local cr_over = do_preobj_CR(object,prescript) -- color
2874              local tr_opaq = do_preobj_TR(object,prescript) -- opacity
2875              local fading_ = do_preobj_FADE(object,prescript) -- fading
2876              local trgroup = do_preobj_GRP(object,prescript) -- transparency group
2877              local pattern_ = do_preobj_PAT(object,prescript) -- tiling pattern
2878              local shading_ = do_preobj_shading(object,prescript) -- shading pattern
2879              if prescript and prescript.mplibtexboxid then
2880                put_tex_boxes(object,prescript)
2881              elseif objecttype == "start_bounds" or objecttype == "stop_bounds" then --skip
2882              elseif objecttype == "start_clip" then
2883                local evenodd = not object.istext and object.postscript == "evenodd"
2884                start_pdf_code()
2885                flushnormalpath(object.path,false)
2886                pdf_literalcode(evenodd and "W* n" or "W n")
2887              elseif objecttype == "stop_clip" then
2888                stop_pdf_code()
2889                miterlimit, linecap, linejoin, dashed = -1, -1, -1, false
2890              elseif objecttype == "special" then
```

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

```
2891                if prescript and prescript.postmplibverbtex then
2892                  figcontents.post[#figcontents.post+1] = prescript.postmplibverbtex
2893                end
2894              elseif objecttype == "text" then
2895                local ot = object.transform -- 3,4,5,6,1,2
2896                start_pdf_code()
2897                pdf_literalcode("%f %f %f %f %f %f cm",ot[3],ot[4],ot[5],ot[6],ot[1],ot[2])
2898                pdf_textfigure(object.font,object.dsize,object.text,object.width,object.height,object.depth)
2899                stop_pdf_code()
2900              elseif not trgroup and fading_ ~= "stop" then
2901                local evenodd, collect, both = false, false, false
2902                local postscript = object.postscript
2903                if not object.istext then
2904                  if postscript == "evenodd" then
2905                    evenodd = true
2906                  elseif postscript == "collect" then
2907                    collect = true
2908                  elseif postscript == "both" then
2909                    both = true
2910                  elseif postscript == "eoboth" then
2911                    evenodd = true
2912                    both    = true
2913                  end
2914                end
2915                if collect then
```

```
                if not savedpath then
                  savedpath = { object.path or false }
                  savedhtap = { object.htap or false }
                else
                  savedpath[#savedpath+1] = object.path or false
                  savedhtap[#savedhtap+1] = object.htap or false
                end
              else
```

Removed from ConTEXt general: color stuff.

```
                local ml = object.miterlimit
                if ml and ml ~= miterlimit then
                  miterlimit = ml
                  pdf_literalcode("%f M",ml)
                end
                local lj = object.linejoin
                if lj and lj ~= linejoin then
                  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 = 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 n /MPlibSh%s sh Q",evenodd and "*" or "",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}
    [2026/01/14 v2.38.2 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\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,*,}
```

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