The package piton*

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Abstract

This document is the documented code of the LuaLaTeX package piton. It is *not* its user's guide. The guide of utilisation is the document `piton.pdf` (with a French translation: `piton-french.pdf`).

The development of the extension piton is done on the following GitHub depot:
`https://github.com/fpantigny/piton`

1 Introduction

The main job of the package piton is to take in as input a computer listing and to send back to LaTeX as output that code *with interlaced LaTeX instructions of formatting*.
In fact, all that job is done by a LPEG called `LPEG1[<language>]` where `<language>` is a Lua string which is the name of the computer language. That LPEG, when matched against the string of a computer listing, returns as capture a Lua table containing data to send to LaTeX. The only thing to do after will be to apply `tex.tprint` to each element of that table.[1]
In fact, there is a variant of the LPEG `LPEG1[<language>]`, called `LPEG2[<language>]`. The latter uses the first one and will be used to format the whole content of an environment `{Piton}` (with, in particular, small tuning for the beginning and the end).

Consider, for example, the following Python code:

```
def parity(x):
    return x%2
```

The capture returned by the LPEG `LPEG1['python']` (in Lua, this may also be written `LPEG1.python`) against that code is the Lua table containing the following elements :

*This document corresponds to the version 4.13 of piton, at the date of 2026/05/25.

[1] Recall that `tex.tprint` takes in as argument a Lua table whose first component is a "catcode table" and the second element a string. The string will be sent to LaTeX with the regime of catcodes specified by the catcode table. If no catcode table is provided, the standard catcodes of LaTeX will be used.

```
{ "\\__piton_begin_line:" }[a]
{ "{\PitonStyle{Keyword}{" }[b]
{ luatexbase.catcodetables.other[c], "def" }
{ "}}" }
{ luatexbase.catcodetables.other, " " }
{ "{\PitonStyle{Name.Function}{" }
{ luatexbase.catcodetables.other, "parity" }
{ "}}" }
{ luatexbase.catcodetables.other, "(" }
{ luatexbase.catcodetables.other, "x" }
{ luatexbase.catcodetables.other, ")" }
{ luatexbase.catcodetables.other, ":" }
{ "\\__piton_end_line: \\__piton_par: \\__piton_begin_line:" }
{ luatexbase.catcodetables.other, "    " }
{ "{\PitonStyle{Keyword}{" }
{ luatexbase.catcodetables.other, "return" }
{ "}}" }
{ luatexbase.catcodetables.other, " " }
{ luatexbase.catcodetables.other, "x" }
{ "{\PitonStyle{Operator}{" }
{ luatexbase.catcodetables.other, "%" }
{ "}}" }
{ "{\PitonStyle{Number}{" }
{ luatexbase.catcodetables.other, "2" }
{ "}}" }
{ "\\__piton_end_line:" }
```

[a] Each line of the computer listings will be encapsulated in a pair: `\_@@_begin_line:` – `\@@_end_line:`. The token `\@@_end_line:` must be explicit because it will be used as marker in order to delimit the argument of the command `\@@_begin_line:`. Both tokens `\_@@_begin_line:` and `\@@_end_line:` will be nullified in the command `\piton` (since there can't be lines breaks in the argument of a command `\piton`).

[b] The lexical elements for which we have a piton style will be formatted via the use of the command `\PitonStyle`. Such an element is typeset in LaTeX via the syntax `{\PitonStyle{`*style*`}{...}}` because the instructions inside an `\PitonStyle` may be both semi-global declarations like `\bfseries` and commands with one argument like `\fbox`.

[c] `luatexbase.catcodetables.other` is a mere number which corresponds to the "catcode table" whose all characters have the catcode "other" (which means that they will be typeset by LaTeX verbatim).

We give now the LaTeX code which is sent back by Lua to TeX (we have written on several lines for legibility but no character `\r` will be sent to LaTeX). The characters which are greyed-out are sent to LaTeX with the catcode "other" (=12). All the others characters are sent with the regime of catcodes of L3 (as set by `\ExplSyntaxOn`).

```
\__piton_begin_line:{\PitonStyle{Keyword}{def}}
␣{\PitonStyle{Name.Function}{parity}}(x):\__piton_end_line:\__piton_par:
\__piton_begin_line:␣␣␣␣{\PitonStyle{Keyword}{return}}
␣x{\PitonStyle{Operator}{%}}{\PitonStyle{Number}{2}}\__piton_end_line:
```

2 The L3 part of the implementation

2.1 Declaration of the package

```
⟨*STY⟩
\NeedsTeXFormat{LaTeX2e}
\ProvidesExplPackage
  {piton}
  {\PitonFileDate}
  {\PitonFileVersion}
  {Highlight computer listings with LPEG on LuaLaTeX}
\msg_new:nnn { piton } { latex-too-old }
  {
    Your~LaTeX~release~is~too~old. \\
```

```
    You~need~at~least~the~version~of~2025-06-01. \\
    If~you~use~Overleaf,~you~need~at~least~"TeX~Live~2025".\\
    The~package~'piton'~won't~be~loaded.
  }
\providecommand { \IfFormatAtLeastTF } { \@ifl@t@r \fmtversion }
\IfFormatAtLeastTF
  { 2025-06-01 }
  { }
  { \msg_critical:nn { piton } { latex-too-old } }
```

The command `\text` provided by the package amstext will be used to allow the use of the command `\piton{...}` (with the standard syntax) in mathematical mode.

```
\RequirePackage { amstext }
```

The command `\marginalia` of the package marginalia will be used for the margin notes created by the keys `paperclip` and `annotation`.

```
\RequirePackage { marginalia }
```

The package transparent is compatible with pdfmanagement (which is not loaded by piton but which is used for the key `join` when it is loaded).

```
\RequirePackage { transparent }
```

```
\cs_new_protected:Npn \@@_error:n { \msg_error:nn { piton } }
\cs_new_protected:Npn \@@_warning:n { \msg_warning:nn { piton } }
\cs_new_protected:Npn \@@_warning:nn { \msg_warning:nnn { piton } }
\cs_new_protected:Npn \@@_error:nn { \msg_error:nnn { piton } }
\cs_new_protected:Npn \@@_error:nnn { \msg_error:nnnn { piton } }
\cs_new_protected:Npn \@@_fatal:n { \msg_fatal:nn { piton } }
\cs_new_protected:Npn \@@_fatal:nn { \msg_fatal:nnn { piton } }
\cs_new_protected:Npn \@@_msg_new:nn { \msg_new:nnn { piton } }
```

With Overleaf (and also TeXPage), by default, a document is compiled in non-stop mode. When there is an error, there is no way to the user to use the key H in order to have more information. That's why we decide to put that piece of information (for the messages with such information) in the main part of the message when the key `messages-for-Overleaf` is used (at load-time).

```
\cs_new_protected:Npn \@@_msg_new:nnn #1 #2 #3
  {
    \bool_if:NTF \g_@@_messages_for_Overleaf_bool
      { \msg_new:nnn { piton } { #1 } { #2 \\ #3 } }
      { \msg_new:nnnn { piton } { #1 } { #2 } { #3 } }
  }
```

We also create commands which will generate usually an error but only a warning on Overleaf. The argument is given by curryfication.

```
\cs_new_protected:Npn \@@_error_or_warning:n
  { \bool_if:NTF \g_@@_messages_for_Overleaf_bool \@@_warning:n \@@_error:n }
\cs_new_protected:Npn \@@_error_or_warning:nn
  { \bool_if:NTF \g_@@_messages_for_Overleaf_bool \@@_warning:nn \@@_error:nn }
```

We try to detect whether the compilation is done on Overleaf. We use `\c_sys_jobname_str` because, with Overleaf, the value of `\c_sys_jobname_str` is always "`output`".

```
\bool_new:N \g_@@_messages_for_Overleaf_bool
\bool_gset:Nn \g_@@_messages_for_Overleaf_bool
  {
       \str_if_eq_p:on \c_sys_jobname_str { _region_ }  % for Emacs
    || \str_if_eq_p:on \c_sys_jobname_str { output }   % for Overleaf
  }
```

```
\@@_msg_new:nn { LuaLaTeX~mandatory }
  {
```

```
    LuaLaTeX~is~mandatory.\\
    The~package~'piton'~requires~the~engine~LuaLaTeX.\\
    \str_if_eq:onT \c_sys_jobname_str { output }
      { If~you~use~Overleaf,~you~can~switch~to~LuaLaTeX~in~
        "File~>~Settings~>~Compiler"~and~if~you~use~TeXPage,
        ~you~should~go~in~"Settings". \\ }
    \IfClassLoadedT { beamer }
      {
        Since~you~use~Beamer,~don't~forget~to~use~piton~in~frames~with~
        the~key~'fragile'.\\
      }
    \IfClassLoadedT { ltx-talk }
      {
        Since~you~use~'ltx-talk',~don't~forget~to~use~piton~in~
        environments~'frame*'.\\
      }
  }
\sys_if_engine_luatex:F { \@@_fatal:n { LuaLaTeX~mandatory } }

\RequirePackage { luacode }

\@@_msg_new:nnn { piton.lua~not~found }
  {
    The~file~'piton.lua'~can't~be~found.~
    If~you~want~to~know~how~to~retrieve~the~file~'piton.lua',~type~H~<return>.
  }
  {
    On~the~site~CTAN,~go~to~the~page~of~'piton':~https://ctan.org/pkg/piton.~
    The~file~'README.md'~explains~how~to~retrieve~the~files~'piton.sty'~and~
    'piton.lua'.
  }

\file_if_exist:nF { piton.lua } { \@@_fatal:n { piton.lua~not~found } }
```

We define a set of keys for the options at load-time.

```
\keys_define:nn { piton }
  {
    footnote .bool_gset:N = \g_@@_footnote_bool ,
    footnotehyper .bool_gset:N = \g_@@_footnotehyper_bool ,
    footnote .usage:n = load ,
    footnotehyper .usage:n = load ,

    beamer .bool_gset:N = \g_@@_beamer_bool ,
    beamer .usage:n = load ,

    unknown .code:n = \@@_error:n { Unknown~key~for~package }
  }
\@@_msg_new:nn { Unknown~key~for~package }
  {
    Unknown~key.\\
    You~have~used~the~key~'\l_keys_key_str'~when~loading~piton~
    but~the~only~keys~available~here~are~'beamer',~'footnote'~
    and~'footnotehyper'.~Other~keys~are~available~in~
    \token_to_str:N \PitonOptions.\\
    That~key~will~be~ignored.
  }
```

We process the options provided by the user at load-time.

```
\ProcessKeyOptions
```

```
\IfClassLoadedT { beamer } { \bool_gset_true:N \g_@@_beamer_bool }
\IfClassLoadedT { ltx-talk } { \bool_gset_true:N \g_@@_beamer_bool }
\IfPackageLoadedT { beamerarticle } { \bool_gset_true:N \g_@@_beamer_bool }
\lua_now:e
  {
    piton = piton~or~{ }
    piton.last_code = ''
    piton.last_language = ''
    piton.join = ''
    piton.write = ''
    piton.path_write = ''
    \bool_if:NT \g_@@_beamer_bool { piton.beamer = true }
  }


\RequirePackage { xcolor }
\@@_msg_new:nn { footnote~with~footnotehyper~package }
  {
    Footnote~forbidden.\\
    You~can't~use~the~option~'footnote'~because~the~package~
    footnotehyper~has~already~been~loaded.~
    If~you~want,~you~can~use~the~option~'footnotehyper'~and~the~footnotes~
    within~the~environments~of~piton~will~be~extracted~with~the~tools~
    of~the~package~footnotehyper.\\
    If~you~go~on,~the~package~footnote~won't~be~loaded.
  }
\@@_msg_new:nn { footnotehyper~with~footnote~package }
  {
    You~can't~use~the~option~'footnotehyper'~because~the~package~
    footnote~has~already~been~loaded.~
    If~you~want,~you~can~use~the~option~'footnote'~and~the~footnotes~
    within~the~environments~of~piton~will~be~extracted~with~the~tools~
    of~the~package~footnote.\\
    If~you~go~on,~the~package~footnotehyper~won't~be~loaded.
  }

\bool_if:NT \g_@@_footnote_bool
  {
```

The class beamer has its own system to extract footnotes and that's why we have nothing to do if beamer is used.

```
    \IfClassLoadedTF { beamer }
      { \bool_gset_false:N \g_@@_footnote_bool }
      {
        \IfPackageLoadedTF { footnotehyper }
          { \@@_error:n { footnote~with~footnotehyper~package } }
          { \usepackage { footnote } }
      }
  }
\bool_if:NT \g_@@_footnotehyper_bool
  {
```

The class beamer has its own system to extract footnotes and that's why we have nothing to do if beamer is used.

```
    \IfClassLoadedTF { beamer }
      { \bool_gset_false:N \g_@@_footnote_bool }
      {
        \IfPackageLoadedTF { footnote }
          { \@@_error:n { footnotehyper~with~footnote~package } }
          { \usepackage { footnotehyper } }
        \bool_gset_true:N \g_@@_footnote_bool
      }
  }
```

The flag `\g_@@_footnote_bool` is raised and so, we will only have to test `\g_@@_footnote_bool` in order to know if we have to insert an environment `{savenotes}`.

2.2 Parameters and technical definitions

```
\dim_new:N \l_@@_rounded_corners_dim
\bool_new:N \l_@@_in_label_bool
\dim_new:N \l_@@_tmpc_dim
```

The listing that we have to format will be stored in `\l_@@_listing_tl`. That applies both for the command `\PitonInputFile` and the environment `{Piton}` (or another environment defined by `\NewPitonEnvironment`).

```
\tl_new:N \l_@@_listing_tl
```

The content of an environment such as `{Piton}` will be composed first in the following box, but that box will (sometimes) be *unvboxed* at the end.
We need a global variable (see `\@@_add_bg_and_right_nb_to_output_box:`).

```
\box_new:N \g_@@_output_box
```

The following string will contain the name of the computer language considered (the initial value is `python`).

```
\str_new:N \l_piton_language_str
\str_set:Nn \l_piton_language_str { python }
```

Each time an environment of piton is used, the computer listing in the body of that environment will be stored in the following global string.

```
\tl_new:N \g_piton_last_code_tl
```

The following parameter corresponds to the key `path` (which is the path used to include files by `\PitonInputFile`). Each component of that sequence will be a string (type `str`).

```
\seq_new:N \l_@@_path_seq
```

The names of all the join files will be stored in the following sequence:

```
\seq_new:N \g_@@_join_seq
\str_new:N \l_@@_join_str
```

When the key `tcolorbox` is used, you will have to take into account the width of the graphical elements added by `tcolorbox` on both sides of the listing. We will put that quantity in the following variable.

```
\dim_new:N \l_@@_tcb_margins_dim
```

The following parameter corresponds to the key `box`.

```
\str_new:N \l_@@_box_str
```

In order to have a better control over the keys.

```
\bool_new:N \l_@@_in_PitonOptions_bool
\bool_new:N \l_@@_in_PitonInputFile_bool
```

We will compute (with Lua) the numbers of lines of the listings (or *chunks* of listings when `split-on-empty-lines` is in force) and store it in the following counter.

```
\int_new:N \g_@@_nb_lines_int
```

The same for the number of non-empty lines of the listings.

```
\int_new:N \l_@@_nb_non_empty_lines_int
```

The following counter will be used to count the lines during the composition. It will take into account all the lines, empty or not empty. It won't be used to print the numbers of the lines but will be used to allow or disallow line breaks (when `splittable` is in force) and for the color of the background (when `background-color` is used with a *list* of colors or when `\rowcolor` is used).

```
\int_new:N \g_@@_line_int
```

The following string corresponds to the key `background-color` of `\PitonOptions`.

```
\clist_new:N \l_@@_bg_color_clist
```

We will also keep in memory the length of the previous `clist` (for efficiency).

```
\int_new:N \l_@@_bg_colors_int
```

```
\tl_new:N \l_@@_space_in_string_tl
```

The following parameters correspond to the keys `begin-range` and `end-range` of the command `\PitonInputFile`.

```
\str_new:N \l_@@_begin_range_str
\str_new:N \l_@@_end_range_str
```

The following boolean corresponds to the key `math-comments` (available only in the preamble of the LaTeX document).

```
\bool_new:N \g_@@_math_comments_bool
```

The argument of `\PitonInputFile`.

```
\str_new:N \l_@@_file_name_str
```

The following line can't be deleted.

```
\bool_new:N \l_@@_tcolorbox_bool
```

The following boolean corresponds to the keys `paperclip` and `annotation`.

```
\bool_new:N \l_@@_paperclip_bool
\str_new:N \l_@@_paperclip_str
```

The listings embedded in the PDF by the key `paperclip` will be numbered by the following counter.

```
\int_new:N \g_@@_paperclip_int
```

The following boolean corresponds to the key `show-spaces`.

```
\bool_new:N \l_@@_show_spaces_bool
```

The following boolean corresponds to the key `break-lines-in-piton`.

```
\bool_new:N \l_@@_break_lines_in_piton_bool
```

The following flag will be raised when the key `max-width` is used (and when `width` is used with the key `min`, which is equivalent to `max-width=\linewidth`). Note also that the key `box` sets `width=min` (except if `min` is used with a numerical value).

```
\bool_new:N \l_@@_minimize_width_bool
```

The following dimension corresponds to the key `width`. It's meant to be the whole width of the environment (for instance, the width of the box of tcolorbox when the key `tcolorbox` is used). The initial value is 0 pt which means that the end user has not used the key. In that case, it will be set equal to the current value of `\linewidth` in `\@@_pre_composition:`.
However if `max-width` is used (or `width=min` which is equivalent to `max-width=\linewidth`), the actual width of the final environment in the PDF may (potentially) be smaller.

```
\dim_new:N \l_@@_width_dim
```

`\l_@@_listing_width_dim` will be the width of the listing taking into account the lines of code (of course) but also:

- `l_@@_left_margin_dim` (for the numbers of lines);
- a small margin when `background-color` is in force[2]).

```
\dim_new:N \l_@@_listing_width_dim
```

However, if `max-width` is used (or `width=min` which is equivalent to `max-width=\linewidth`), that length will be computed once again in `\@@_create_output_box:`

`\l_@@_code_width_dim` will be the length of the lines of code, without the potential margins (for the backgrounds and for `length-margin` for the number of lines).
It will be computed in `\@@_compute_code_width:`.

```
\dim_new:N \l_@@_code_width_dim
```

[2]Remark that the mere use of `\rowcolor` does not add those small margins.

```
\box_new:N \l_@@_line_box
```

The following dimension corresponds to the keys `left-margin` and `right-margin`.

```
\dim_new:N \l_@@_left_margin_dim
\dim_new:N \l_@@_right_margin_dim
```

The following boolean will be set when the key `left-margin=auto` is used.

```
\bool_new:N \l_@@_left_margin_auto_bool
\bool_new:N \l_@@_right_margin_auto_bool
```

The following boolean corresponds to the key `line-numbers/lmmono10-draw`.

```
\bool_new:N \l_@@_lmodern_drawn_bool
```

When the key `line-numbers/position` is set to `right`, we will have to keep in memory the numbers of the lines in the following sequence.

```
\seq_new:N \g_@@_visual_line_numbers_seq
```

Be careful. The following sequence `\g_@@_languages_seq` is not the list of the languages supported by piton. It's the list of the languages for which at least a user function has been defined. We need that sequence only for the command `\PitonClearUserFunctions` when it is used without its optional argument: it must clear the whole list of languages for which at least a user function has been defined.

```
\seq_new:N \g_@@_languages_seq
\cs_new_protected:Npn \@@_tab:
  {
    \bool_if:NTF \l_@@_show_spaces_bool
      {
        \hbox_set:Nn \l_tmpa_box
          { \prg_replicate:nn \l_@@_tab_size_int { ~ } }
        \dim_set:Nn \l_tmpa_dim { \box_wd:N \l_tmpa_box }
        \( \mathcolor { gray }
             { \hbox_to_wd:nn \l_tmpa_dim { \rightarrowfill } } \)
      }
      { \hbox:n { \prg_replicate:nn \l_@@_tab_size_int { ~ } } }
    \int_gadd:Nn \g_@@_indentation_int \l_@@_tab_size_int
  }
```

The following token list will be used only for the spaces in the strings.

```
\tl_set_eq:NN \l_@@_space_in_string_tl \nobreakspace
```

When the key `break-lines-in-piton` is set, that parameter will be replaced by `\space` (in `\piton` with the standard syntax) and when the key `show-spaces-in-strings` is set, it will be replaced by ␣ (U+2423).

At each line, the following counter will count the spaces at the beginning.

```
\int_new:N \g_@@_indentation_int
```

In the environment `{Piton}`, the command `\label` will be linked to the following command.

```
\cs_new_protected:Npn \@@_label:n #1
  {
    \bool_if:NTF \l_@@_line_numbers_bool
      {
        \@bsphack
        \protected@write \@auxout { }
          {
            \string \newlabel { #1 }
            {
              { \int_use:N \g_@@_visual_line_int }
              { \thepage }
              { }
              { line.#1 }
              { }
            }
```

```
          }
        \@esphack
        \IfPackageLoadedT { hyperref }
          { \Hy@raisedlink { \hyper@anchorstart { line.#1 } \hyper@anchorend } }
      }
      { \@@_error:n { label~with~lines~numbers } }
  }
```

The same goes for the command `\zlabel` if the `zref` package is loaded. Note that `\label` will also be linked to `\@@_zlabel:n` if the key `label-as-zlabel` is set to `true`.

```
\cs_new_protected:Npn \@@_zlabel:n #1
  {
    \bool_if:NTF \l_@@_line_numbers_bool
      {
        \@bsphack
        \protected@write \@auxout { }
          {
            \string \zref@newlabel { #1 }
              {
                \string \default { \int_use:N \g_@@_visual_line_int }
                \string \page { \thepage }
                \string \zc@type { line }
                \string \anchor { line.#1 }
              }
          }
        \@esphack
        \IfPackageLoadedT { hyperref }
          { \Hy@raisedlink { \hyper@anchorstart { line.#1 } \hyper@anchorend } }
      }
      { \@@_error:n { label~with~lines~numbers } }
  }
```

In the environments `{Piton}` the command `\rowcolor` will be linked to the following one.

```
\NewDocumentCommand { \@@_rowcolor:n } { o m }
  {
    \tl_gset:ce
      { g_@@_color_ \int_eval:n { \g_@@_line_int + 1 } _ tl }
      { \tl_if_novalue:nTF { #1 } { #2 } { [ #1 ] { #2 } } }
    \bool_gset_true:N \g_@@_rowcolor_inside_bool
  }
```

In the command `piton` (in fact in `\@@_piton_standard` and `\@@_piton_verbatim`, the command `\rowcolor` will be linked to the following one (in order to nullify its effect).

```
\NewDocumentCommand { \@@_noop_rowcolor } { o m } { }
```

The following commands correspond to the keys `marker/beginning` and `marker/end`. The values of that keys are functions that will be applied to the "*range*" specified by the end user in an individual `\PitonInputFile`. They will construct the markers used to find textually in the external file loaded by piton the part which must be included (and formatted).
These macros must *not* be protected.

```
\cs_new:Npn \@@_marker_beginning:n #1 { }
\cs_new:Npn \@@_marker_end:n #1 { }
```

The following token list will be evaluated at the end of `\@@_begin_line:`... `\@@_end_line:` and cleared at the end. It will be used by LPEG acting between the lines of the Python code in order to add instructions to be executed in vertical mode between the lines.

```
\tl_new:N \g_@@_after_line_tl
```

The spaces at the end of a line of code are deleted by piton. However, it's not actually true: they are replace by `\@@_trailing_space:`.

```
\cs_new_protected:Npn \@@_trailing_space: { }
```

When we have to rescan some pieces of code, we will use `\@@_piton:n` and that command `\@@_piton:n` will set `\@@_trailing_space:` equal to `\space`.

```
\bool_new:N \g_@@_color_is_none_bool
\bool_new:N \g_@@_next_color_is_none_bool

\bool_new:N \g_@@_rowcolor_inside_bool
```

2.3 Detected commands

There are four keys for "detected commands and environments": `detected-commands`, `raw-detected-commands`, `beamer-commands` and `beamer-environments`.
In fact, there is also `vertical-detected-commands` but has a special treatment.
For each of those keys, we keep a clist of the names of such detected commands and environments. For the commands, the corresponding `clist` will contain the name of the commands *wihtout* the backlash.

```
\clist_new:N \l_@@_detected_commands_clist
\clist_new:N \l_@@_raw_detected_commands_clist
\clist_new:N \l_@@_beamer_commands_clist
\clist_set:Nn \l_@@_beamer_commands_clist
  { uncover, only , visible , invisible , alert , action}
\clist_new:N \l_@@_beamer_environments_clist
\clist_set:Nn \l_@@_beamer_environments_clist
  { uncoverenv , onlyenv , visibleenv , invisibleenv , alertenv , actionenv }
```

Remark that, since we have used clists, these clists, as token lists are "purified": there is no empty component and for each component, there is no space on both sides.

Of course, the value of those clists may be modified during the preamble of the document by using the corresponding key (`detected-commands`, etc.).
However, after the `\begin{document}`, it's no longer possible to modify those clists because their contents will be used in the construction of the main LPEG for each computer language.

However, in a `\AtBeginDocument`, we will convert those clists into "toks registers" of TeX.

```
\hook_gput_code:nnn { begindocument } { . }
  {
    \newtoks \PitonDetectedCommands
    \newtoks \PitonRawDetectedCommands
    \newtoks \PitonBeamerCommands
    \newtoks \PitonBeamerEnvironments
```

L3 does *not* support those "toks registers" but it's still possible to affect to the "toks registers" the content of the clists with a L3-like syntax.

```
    \exp_args:NV \PitonDetectedCommands \l_@@_detected_commands_clist
    \exp_args:NV \PitonRawDetectedCommands \l_@@_raw_detected_commands_clist
    \exp_args:NV \PitonBeamerCommands \l_@@_beamer_commands_clist
    \exp_args:NV \PitonBeamerEnvironments \l_@@_beamer_environments_clist
  }
```

Then at the beginning of the document, when we will load the Lua file `piton.lua`, we will read those "toks registers" within Lua (with `tex.toks`) and convert them into Lua tables (and, then, use those tables to construct LPEG).

When the key `vertical-detected-commands` is used, we will have to redefine the corresponding commands in `\@@_pre_composition:`.
The instructions for these redefinitions will be put in the following token list.

```
\tl_new:N \g_@@_def_vertical_commands_tl
```

The following commands must *not* be protected.

```
\cs_new:Npn \@@_retrieve_backslash:n #1
  {
    \str_if_eq:eeTF \c_backslash_str { \str_head:n { #1 } }
      { \str_tail:n { #1 } }
      { #1 }
  }

\cs_new_protected:Npn \@@_detected_commands:n #1
  {
    \clist_set:Nn \l_tmpa_clist { #1 }
    \clist_clear:N \l_tmpb_clist
    \clist_map_inline:Nn \l_tmpa_clist
      { \clist_put_right:Ne \l_tmpb_clist { \@@_retrieve_backslash:n { ##1 } } }
    \clist_if_in:NnTF \l_tmpb_clist { rowcolor }
      {
        \@@_error:n { rowcolor~in~detected-commands }
        \clist_remove_all:Nn \l_tmpb_clist { rowcolor }
      }
    \clist_put_right:No \l_@@_detected_commands_clist \l_tmpb_clist
  }

\cs_new_protected:Npn \@@_raw_detected_commands:n #1
  {
    \clist_set:Nn \l_tmpa_clist { #1 }
    \clist_clear:N \l_tmpb_clist
    \clist_map_inline:Nn \l_tmpa_clist
      { \clist_put_right:Ne \l_tmpb_clist { \@@_retrieve_backslash:n { ##1 } } }
    \clist_put_right:No \l_@@_raw_detected_commands_clist \l_tmpb_clist
  }

\cs_new_protected:Npn \@@_vertical_detected_commands:n #1
  {
    \clist_set:Nn \l_tmpa_clist { #1 }
    \clist_clear:N \l_tmpb_clist
    \clist_map_inline:Nn \l_tmpa_clist
      { \clist_put_right:Ne \l_tmpb_clist { \@@_retrieve_backslash:n { ##1 } } }
    \clist_put_right:No \l_@@_raw_detected_commands_clist \l_tmpb_clist
    \clist_map_inline:Nn \l_tmpb_clist
      {
        \cs_set_eq:cc { @@ _ old _ ##1 : } { ##1 }
        \cs_new_protected:cn { @@ _ new _ ##1 : n }
          {
            \bool_if:nTF
              { \l_@@_tcolorbox_bool || ! \str_if_empty_p:N \l_@@_box_str }
              {
                \tl_gput_right:Nn \g_@@_after_line_tl
                  { \use:c { @@ _old _ ##1 : } { ####1 } }
              }
              {
                \cs_if_exist:cTF { g_@@_after_line _ \int_use:N \g_@@_line_int }
                  { \tl_gput_right:cn }
                  { \tl_gset:cn }
                  { g_@@_after_line _ \int_eval:n { \g_@@_line_int + 1 }_tl }
                  { \use:c { @@ _old _ ##1 : } { ####1 } }
              }
          }
        \tl_gput_right:Nn \g_@@_def_vertical_commands_tl
          { \cs_set_eq:cc { ##1 } { @@ _ new _ ##1 : n } }
      }
  }
```

2.4 Treatment of a line of code

```
\cs_new_protected:Npn \@@_replace_spaces:n #1
  {
    \tl_set:Nn \l_tmpa_tl { #1 }
    \bool_if:NTF \l_@@_show_spaces_bool
      {
        \tl_set:Nn \l_@@_space_in_string_tl { ␣ } % U+2423
        \tl_replace_all:NVn \l_tmpa_tl \c_catcode_other_space_tl { ␣ } % U+2423
      }
      {
```

If the key `break-lines-in-Piton` is in force, we replace all the characters U+0020 (that is to say the spaces) by `\@@_breakable_space:`. Remark that, except the spaces inserted in the LaTeX comments (and maybe in the math comments), all these spaces are of catcode "other" (=12) and are unbreakable.

```
        \bool_if:NT \l_@@_break_lines_in_Piton_bool
          {
            \tl_if_eq:NnF \l_@@_space_in_string_tl { ␣ }
              { \tl_set_eq:NN \l_@@_space_in_string_tl \@@_breakable_space: }
```

In the following code, we have to replace all the spaces in the token list `\l_tmpa_tl`. That means that this replacement must be "recursive": even the spaces which are within brace groups (`{...}`) must be replaced. For instance, the spaces in long strings of Python are within such groups since there are within a command `\PitonStyle{String.Long}{...}`. That's why the use of `\tl_replace_all:Nnn` is not enough.
The first implementation was using `\tl_regex_replace_all:nnN`
`\tl_regex_replace_all:nnN { \x20 } { \c { @@_breakable_space: } } \l_tmpa_tl`
but that programming was certainly slow.
Now, we use `\tl_replace_all:NVn` *but*, in the styles `String.Long.Internal` we replace the spaces with `\@@_breakable_space:` by another use of the same technic with `\tl_replace_all:NVn`. We do the same job for the *doc strings* of Python and for the comments.

```
            \tl_replace_all:NVn \l_tmpa_tl
              \c_catcode_other_space_tl
              \@@_breakable_space:
          }
      }
   \l_tmpa_tl
  }
\cs_generate_variant:Nn \@@_replace_spaces:n { o }
```

In the contents provided by Lua, each line of the Python code will be surrounded by `\@@_begin_line:` and `\@@_end_line:`.
`\@@_begin_line:` is a TeX command with a delimited argument (`\@@_end_line:` is the marker for the end of the argument).
However, we define also `\@@_end_line:` as no-op, because, when the last line of the listing is the end of an environment of Beamer (eg `\end{uncoverenv}`), we will have a token `\@@_end_line:` added at the end without any corresponding `\@@_begin_line:`).

```
\cs_set_protected:Npn \@@_end_line: { }

\cs_set_protected:Npn \@@_begin_line: #1 \@@_end_line:
  {
    \group_begin:
    \int_gzero:N \g_@@_indentation_int
```

We put the potential number of line, the potential left and right margins.

```
    \hbox_set:Nn \l_@@_line_box
      {
        \skip_horizontal:N \l_@@_left_margin_dim
        \bool_if:NT \l_@@_line_numbers_bool
          {
```

`\l_tmpa_int` will be equal to 1 when the current line is not empty.

```
            \int_set:Nn \l_tmpa_int
              {
                \lua_now:e
                  {
                    tex.sprint
                      (
```

The following expression gives an integer of Lua (*integer* is a sub-type of *number* introduced in Lua 5.3), the output will be of the form `"3"` (and not `"3.0"`) which is what we want for `\int_set:Nn`.

```
                        piton.empty_lines
                          [ \int_eval:n { \g_@@_line_int + 1 } ]
                      )
                  }
              }
            \bool_lazy_or:nnT
              { \int_compare_p:nNn \l_tmpa_int = \c_one_int }
              { ! \l_@@_skip_empty_lines_bool }
              { \int_gincr:N \g_@@_visual_line_int }

            \bool_lazy_or:nnTF
              { \int_compare_p:nNn \l_tmpa_int = \c_one_int }
              { ! \l_@@_skip_empty_lines_bool && \l_@@_label_empty_lines_bool }
              {
                \bool_lazy_or:nnTF
                  { \int_compare_p:nNn { \l_@@_numbers_step_int } = 1 }
                  {
                    \int_compare_p:nNn
                      {
                        \int_mod:nn
                          { \g_@@_visual_line_int }
                          { \l_@@_numbers_step_int }
                      }
                      = \c_one_int
                  }
                  {
                    \str_if_eq:eeTF \l_@@_line_numbers_position_str { left }
                      \@@_print_number_left:
                      {
                        \seq_gput_right:Ne \g_@@_visual_line_numbers_seq
                          { \int_use:N \g_@@_visual_line_int }
                      }
                  }
                  {
                    \str_if_eq:eeT \l_@@_line_numbers_position_str { right }
                      { \seq_gput_right:Nn \g_@@_visual_line_numbers_seq { } }
                  }
              }
              {
                \str_if_eq:eeT \l_@@_line_numbers_position_str { right }
                  { \seq_gput_right:Nn \g_@@_visual_line_numbers_seq { } }
              }
          }
```

If there is a background, we must remind that there is a left margin of 0.5 em for the background (which will be added later).

```
          \int_compare:nNnT \l_@@_bg_colors_int > { \c_zero_int }
            {
```

... but if only if the key `left-margin` is not used !

```
              \dim_compare:nNnT \l_@@_left_margin_dim = \c_zero_dim
                { \skip_horizontal:n { 0.5 em } }
            }


          \bool_if:NTF \l_@@_minimize_width_bool
            {
```

```
            \hbox_set:Nn \l_tmpa_box
              {
                \language = -1
                \raggedright
                \strut
                \@@_replace_spaces:n { #1 }
                \strut \hfil
              }
            \dim_compare:nNnTF { \box_wd:N \l_tmpa_box } < \l_@@_code_width_dim
               { \box_use:N \l_tmpa_box }
               { \@@_vtop_of_code:n { #1 } }
          }
          { \@@_vtop_of_code:n { #1 } }
      }
```

Now, the line of code is composed in the box `\l_@@_line_box`.

```
    \box_set_dp:Nn \l_@@_line_box { \box_dp:N \l_@@_line_box + 1.25 pt }
    \box_set_ht:Nn \l_@@_line_box { \box_ht:N \l_@@_line_box + 1.25 pt }
    \box_use_drop:N \l_@@_line_box
    \group_end:
    \g_@@_after_line_tl
    \tl_gclear:N \g_@@_after_line_tl
  }
```

The following command will be used in `\@@_begin_line:` … `\@@_end_line:`.

```
\cs_new_protected:Npn \@@_vtop_of_code:n #1
  {
    \vbox_top:n
      {
        \hsize = \l_@@_code_width_dim
        \language = -1
        \raggedright
        \strut
        \@@_replace_spaces:n { #1 }
        \strut \hfil
      }
  }
```

The following command will be used when the key `background-color` is used or when the key `line-numbers` is used in conjunction with `line-numbers/position=right`.
The content of the line has been previously set in `\l_@@_line_box`.
That command is used only once, in `\@@_add_bg_and_right_nb_to_output_box:`.

```
\cs_new_protected:Npn \@@_add_bg_and_right_nb_to_line_and_use:
  {
    \vtop
      {
        \offinterlineskip
        \hbox
          {
```

The command `\@@_compute_and_set_color:` sets the current color but also sets the booleans `\g_@@_color_is_none_bool` and `\g_@@_next_color_is_none_bool`. It uses the current value of `\l_@@_bg_color_clist`, the value of `\g_@@_line_int` (the number of the current line) but also potential token lists of the form `\g_@@_color_12_tl` if the end user has used the command `\rowcolor`.

```
            \group_begin:
            \@@_compute_and_set_color:
```

The colored panels are overlapping. However, if the special color `none` is used we must not put such overlapping.

```
            \dim_set:Nn \l_tmpa_dim { \box_dp:N \l_@@_line_box }
            \bool_if:NT \g_@@_next_color_is_none_bool
              { \dim_sub:Nn \l_tmpa_dim { 2.5 pt } }
```

When `\g_@@_color_is_none_bool` is in force, we will compose a `\vrule` of width 0 pt. We need that `\vrule` because it will be a strut.

```
            \bool_if:NTF \g_@@_color_is_none_bool
              { \dim_zero:N \l_tmpb_dim }
              { \dim_set_eq:NN \l_tmpb_dim \l_@@_listing_width_dim }
            \dim_set:Nn \l_@@_tmpc_dim { \box_ht:N \l_@@_line_box }
```

Now, the colored panel.

```
            \dim_compare:nNnTF \l_@@_rounded_corners_dim > \c_zero_dim
              {
                \int_compare:nNnTF \g_@@_line_int = \c_one_int
                  {
                    \begin{tikzpicture}[baseline = 0cm]
                    \fill (0,0)
                          [rounded~corners = \l_@@_rounded_corners_dim]
                          -- (0,\l_@@_tmpc_dim)
                          -- (\l_tmpb_dim,\l_@@_tmpc_dim)
                          [sharp~corners] -- (\l_tmpb_dim,-\l_tmpa_dim)
                          -- (0,-\l_tmpa_dim)
                          -- cycle ;
                    \end{tikzpicture}
                  }
                  {
                    \int_compare:nNnTF \g_@@_line_int = \g_@@_nb_lines_int
                      {
                        \begin{tikzpicture}[baseline = 0cm]
                        \fill (0,0) -- (0,\l_@@_tmpc_dim)
                              -- (\l_tmpb_dim,\l_@@_tmpc_dim)
                              [rounded~corners = \l_@@_rounded_corners_dim]
                              -- (\l_tmpb_dim,-\l_tmpa_dim)
                              -- (0,-\l_tmpa_dim)
                              -- cycle ;
                        \end{tikzpicture}
                      }
                      {
                        \vrule height \l_@@_tmpc_dim
                        depth \l_tmpa_dim
                        width \l_tmpb_dim
```

For the case when `line-numbers/position=right` is in force with `line-numbers`.

```
                        \dim_compare:nNnT \l_tmpb_dim = \c_zero_dim
                          { \skip_horizontal:N \l_@@_listing_width_dim }
                      }
                  }
              }
              {
                \vrule height \l_@@_tmpc_dim
                depth \l_tmpa_dim
                width \l_tmpb_dim
```

For the case when `line-numbers/position=right` is in force with `line-numbers`.

```
                \dim_compare:nNnT \l_tmpb_dim = \c_zero_dim
                  { \skip_horizontal:N \l_@@_listing_width_dim }
              }
```

The group is for the color of the background.

```
            \group_end:
            \bool_if:NT \l_@@_line_numbers_bool
              {
                \str_if_eq:eeT \l_@@_line_numbers_position_str { right }
                  {
                    \seq_gpop_right:NN \g_@@_visual_line_numbers_seq \l_tmpa_tl
                    \@@_print_number_right:
                  }
              }
          }
```

```
        \bool_if:NT \g_@@_next_color_is_none_bool
          { \skip_vertical:n { 2.5 pt } }
        \skip_vertical:n { - \box_ht_plus_dp:N \l_@@_line_box }
        \box_use_drop:N \l_@@_line_box
      }
  }
```

End of `\@@_add_bg_and_right_nb_to_line_and_use:`

The command `\@@_compute_and_set_color:` sets the current color but also sets the booleans `\g_@@_color_is_none_bool` and `\g_@@_next_color_is_none_bool`. It uses the current value of `\l_@@_bg_color_clist`, the value of `\g_@@_line_int` (the number of the current line) but also potential token lists of the form `\g_@@_color_12_tl` if the end user has used the command `\rowcolor`.

```
\cs_set_protected:Npn \@@_compute_and_set_color:
  {
    \int_compare:nNnTF \l_@@_bg_colors_int = \c_zero_int
      { \tl_set:Nn \l_tmpa_tl { none } }
      {
        \int_set:Nn \l_tmpb_int
          { \int_mod:nn \g_@@_line_int \l_@@_bg_colors_int + 1 }
        \tl_set:Ne \l_tmpa_tl { \clist_item:Nn \l_@@_bg_color_clist \l_tmpb_int }
      }
```

The row may have a color specified by the command `\rowcolor`. We check that point now.

```
    \cs_if_exist:cT { g_@@_color_ \int_use:N \g_@@_line_int _ tl }
      {
        \tl_set_eq:Nc \l_tmpa_tl { g_@@_color_ \int_use:N \g_@@_line_int _ tl}
```

We don't need any longer the variable and that's why we delete it (it must be free for the next environment of piton).

```
        \cs_undefine:c { g_@@_color_ \int_use:N \g_@@_line_int _ tl}
      }
    \tl_if_eq:NnTF \l_tmpa_tl { none }
      { \bool_gset_true:N \g_@@_color_is_none_bool }
      {
        \bool_gset_false:N \g_@@_color_is_none_bool
        \@@_color:o \l_tmpa_tl
      }
```

We are looking for the next color because we have to know whether that color is the special color `none` (for the vertical adjustment of the background color).

```
    \int_compare:nNnTF { \g_@@_line_int + 1 } = \g_@@_nb_lines_int
      { \bool_gset_false:N \g_@@_next_color_is_none_bool }
      {
        \int_compare:nNnTF \l_@@_bg_colors_int = \c_zero_int
          { \tl_set:Nn \l_tmpa_tl { none } }
          {
            \int_set:Nn \l_tmpb_int
              { \int_mod:nn { \g_@@_line_int + 1 } \l_@@_bg_colors_int + 1 }
            \tl_set:Ne \l_tmpa_tl { \clist_item:Nn \l_@@_bg_color_clist \l_tmpb_int }
          }
        \cs_if_exist:cT { g_@@_color_ \int_eval:n { \g_@@_line_int + 1 } _ tl }
          {
            \tl_set_eq:Nc \l_tmpa_tl
              { g_@@_color_ \int_eval:n { \g_@@_line_int + 1 } _ tl }
          }
        \tl_if_eq:NnTF \l_tmpa_tl { none }
          { \bool_gset_true:N \g_@@_next_color_is_none_bool }
          { \bool_gset_false:N \g_@@_next_color_is_none_bool }
      }
  }
```

The following command `\@@_color:n` will accept both the instruction `\@@_color:n { red!15 }` and the instruction `\@@_color:n { [rgb]{0.9,0.9,0} }`.

```
\cs_set_protected:Npn \@@_color:n #1
  {
```

```
    \tl_if_head_eq_meaning:nNTF { #1 } [
      {
        \tl_set:Nn \l_tmpa_tl { #1 }
        \tl_set_rescan:Nno \l_tmpa_tl { } \l_tmpa_tl
        \exp_last_unbraced:No \color \l_tmpa_tl
      }
      { \color { #1 } }
  }
\cs_generate_variant:Nn \@@_color:n { o }
```

The command `\@@_par:` will be inserted by Lua between two lines of the computer listing.

- In fact, it will be inserted between two commands `\@@_begin_line:`...`\@@_end_of_line:`.
- When the key `break-lines-in-Piton` is in force, a line of the computer listing (the *input*) may result in several lines in the PDF (the *output*).
- Remind that `\@@_par:` has a rather complex behaviour because it will finish and start paragraphs.

```
\cs_new_protected:Npn \@@_par:
  {
```

We recall that `\g_@@_line_int` is *not* used for the number of line printed in the PDF (when `line-numbers` is in force)...

```
    \int_gincr:N \g_@@_line_int
```

... it will be used to allow or disallow page breaks, and also by the command `\rowcolor`.
Each line in the listing is composed in a box of TeX (which may contain several lines when the key `break-lines-in-Piton` is in force) put in a paragraph.

```
    \par
```

We now add a `\kern` because each line of code is overlapping vertically by a quantity of 2.5 pt in order to have a good background (when `background-color` is in force). We need to use a `\kern` (in fact `\par\kern...`) and not a `\vskip` because page breaks should *not* be allowed on that kern.

```
    \kern -2.5 pt
```

Now, we control page breaks after the paragraph.

```
    \@@_add_penalty_for_the_line:
  }
```

After the command `\@@_par:`, we will usually have a command `\@@_begin_line:`.

The following command `\@@_breakable_space:` is for breakable spaces in the environments `{Piton}` and the listings of `\PitonInputFile` and *not* for the commands `\piton`.

```
\cs_set_protected:Npn \@@_breakable_space:
  {
    \discretionary
      { \hbox:n { \color { gray } \l_@@_end_of_broken_line_tl } }
      {
        \hbox_overlap_left:n
          {
            {
              \normalfont \footnotesize \color { gray }
              \l_@@_continuation_symbol_tl
            }
            \skip_horizontal:n { 0.3 em }
            \int_compare:nNnT \l_@@_bg_colors_int > \c_zero_int
              { \skip_horizontal:n { 0.5 em } }
          }
        \bool_if:NT \l_@@_indent_broken_lines_bool
          {
            \hbox:n
              {
                \prg_replicate:nn { \g_@@_indentation_int } { ~ }
                { \color { gray } \l_@@_csoi_tl }
```

```
            }
        }
    }
    { \hbox { ~ } }
}
```

2.5 PitonOptions

```
\bool_new:N \l_@@_line_numbers_bool
\bool_new:N \l_@@_skip_empty_lines_bool
\bool_set_true:N \l_@@_skip_empty_lines_bool
\bool_new:N \l_@@_line_numbers_absolute_bool
\tl_new:N \l_@@_line_numbers_format_tl
\tl_set:Nn \l_@@_line_numbers_format_tl { \footnotesize \color { gray } }
\bool_new:N \l_@@_label_empty_lines_bool
\bool_set_true:N \l_@@_label_empty_lines_bool
\int_new:N \l_@@_number_lines_start_int
\str_new:N \l_@@_line_numbers_position_str
\str_set:Nn \l_@@_line_numbers_position_str { left }
\bool_new:N \l_@@_resume_bool
\bool_new:N \g_@@_label_as_zlabel_bool


\keys_define:nn { PitonOptions / marker }
  {
    beginning .cs_set:Np = \@@_marker_beginning:n #1 ,
    beginning .value_required:n = true ,
    end .cs_set:Np = \@@_marker_end:n #1 ,
    end .value_required:n = true ,
    include-lines .bool_set:N = \l_@@_marker_include_lines_bool ,
    unknown .code:n = \@@_error:n { Unknown~key~for~marker }
  }


\keys_define:nn { PitonOptions / line-numbers }
  {
    true .code:n = \bool_set_true:N \l_@@_line_numbers_bool ,
    false .code:n = \bool_set_false:N \l_@@_line_numbers_bool ,

    start .code:n =
      \bool_set_true:N \l_@@_line_numbers_bool
      \int_set:Nn \l_@@_number_lines_start_int { #1 }  ,
    start .value_required:n = true ,

    skip-empty-lines .code:n =
      \bool_if:NF \l_@@_in_PitonOptions_bool
        { \bool_set_true:N \l_@@_line_numbers_bool }
      \str_if_eq:nnTF { #1 } { false }
        { \bool_set_false:N \l_@@_skip_empty_lines_bool }
        { \bool_set_true:N \l_@@_skip_empty_lines_bool } ,

    label-empty-lines .code:n =
      \bool_if:NF \l_@@_in_PitonOptions_bool
        { \bool_set_true:N \l_@@_line_numbers_bool }
      \str_if_eq:nnTF { #1 } { false }
        { \bool_set_false:N \l_@@_label_empty_lines_bool }
        { \bool_set_true:N \l_@@_label_empty_lines_bool } ,

    absolute .code:n =
      \bool_if:NTF \l_@@_in_PitonOptions_bool
        { \bool_set_true:N \l_@@_line_numbers_absolute_bool }
        { \bool_set_true:N \l_@@_line_numbers_bool }
      \bool_if:NT \l_@@_in_PitonInputFile_bool
```

```
        {
          \bool_set_true:N \l_@@_line_numbers_absolute_bool
          \bool_set_false:N \l_@@_skip_empty_lines_bool
        } ,
    absolute .value_forbidden:n = true ,

    resume .code:n =
      \bool_set_true:N \l_@@_resume_bool
      \bool_if:NF \l_@@_in_PitonOptions_bool
        { \bool_set_true:N \l_@@_line_numbers_bool } ,
    resume .value_forbidden:n = true ,

    sep .dim_set:N = \l_@@_numbers_sep_dim ,
    sep .value_required:n = true ,
    sep .initial:n = 0.7 em ,

    step .int_set:N = \l_@@_numbers_step_int ,
    step .initial:n = 1 ,
    step .value_required:n = true ,

    position .choices:nn = { left , right }
      { \str_set_eq:NN \l_@@_line_numbers_position_str \l_keys_choice_tl } ,
    position .value_required:n = true ,

    format .tl_set:N = \l_@@_line_numbers_format_tl ,
    format .value_required:n = true ,

    lmmono10-drawn .bool_set:N = \l_@@_lmodern_drawn_bool ,
    lmmono10-drawn .default:n = true ,

    unknown .code:n =
      \@@_unknown_key:nn
        { PitonOptions / line-numbers }
        { Unknown~key~for~line-numbers }

  }
```

Be careful! The name of the following set of keys must be considered as public! Hence, it should *not* be changed.

```
\keys_define:nn { PitonOptions }
  {
    indentations-for-Foxit .choices:nn = { true , false }
      {
        \tl_if_eq:VnTF \l_keys_value_tl { true }
          { \@@_define_leading_space_Foxit: }
          { \@@_define_leading_space_normal: }
      } ,
    box .choices:nn = { c , t , b , m }
      { \str_set_eq:NN \l_@@_box_str \l_keys_choice_tl } ,
    box .default:n = c ,
    break-strings-anywhere .bool_set:N = \l_@@_break_strings_anywhere_bool ,
    break-numbers-anywhere .bool_set:N = \l_@@_break_numbers_anywhere_bool ,
```

First, we put keys that should be available only in the preamble.

```
    detected-commands .code:n = \@@_detected_commands:n { #1 } ,
    detected-commands .value_required:n = true ,
    detected-commands .usage:n = preamble ,
    vertical-detected-commands .code:n = \@@_vertical_detected_commands:n { #1 } ,
    vertical-detected-commands .value_required:n = true ,
    vertical-detected-commands .usage:n = preamble ,
    raw-detected-commands .code:n = \@@_raw_detected_commands:n { #1 } ,
    raw-detected-commands .value_required:n = true ,
    raw-detected-commands .usage:n = preamble ,
    detected-beamer-commands .code:n =
```

```
      \@@_error_if_not_in_beamer:
      \clist_put_right:Nn \l_@@_beamer_commands_clist { #1 } ,
    detected-beamer-commands .value_required:n = true ,
    detected-beamer-commands .usage:n = preamble ,
    detected-beamer-environments .code:n =
      \@@_error_if_not_in_beamer:
      \clist_put_right:Nn \l_@@_beamer_environments_clist { #1 } ,
    detected-beamer-environments .value_required:n = true ,
    detected-beamer-environments .usage:n = preamble ,
```

Remark that the command `\lua_escape:n` is fully expandable. That's why we use `\lua_now:e`.

```
    begin-escape .code:n =
      \lua_now:e { piton.begin_escape = "\lua_escape:n{#1}" } ,
    begin-escape .value_required:n = true ,
    begin-escape .usage:n = preamble ,

    end-escape   .code:n =
      \lua_now:e { piton.end_escape = "\lua_escape:n{#1}" } ,
    end-escape   .value_required:n = true ,
    end-escape .usage:n = preamble ,

    begin-escape-math .code:n =
      \lua_now:e { piton.begin_escape_math = "\lua_escape:n{#1}" } ,
    begin-escape-math .value_required:n = true ,
    begin-escape-math .usage:n = preamble ,

    end-escape-math .code:n =
      \lua_now:e { piton.end_escape_math = "\lua_escape:n{#1}" } ,
    end-escape-math .value_required:n = true ,
    end-escape-math .usage:n = preamble ,

    comment-latex .code:n = \lua_now:n { comment_latex = "#1" } ,
    comment-latex .value_required:n = true ,
    comment-latex .usage:n = preamble ,

    label-as-zlabel .bool_gset:N = \g_@@_label_as_zlabel_bool ,
    label-as-zlabel .usage:n = preamble ,

    math-comments .bool_gset:N = \g_@@_math_comments_bool ,
    math-comments .usage:n = preamble ,
```

Now, general keys.

```
    language      .code:n =
      \str_set:Ne \l_piton_language_str { \str_lowercase:n { #1 } } ,
    language      .value_required:n  = true ,
    path          .code:n =
      \seq_clear:N \l_@@_path_seq
      \clist_map_inline:nn { #1 }
        {
          \str_set:Nn \l_tmpa_str { ##1 }
          \seq_put_right:No \l_@@_path_seq { \l_tmpa_str }
        } ,
    path              .value_required:n  = true ,
```

The initial value of the key `path` is not empty: it's `.`, that is to say a comma separated list with only one component which is `.`, the current directory.

```
    path              .initial:n         = . ,
    path-write        .str_set:N         = \l_@@_path_write_str ,
    path-write        .value_required:n  = true ,
    font-command      .tl_set:N          = \l_@@_font_command_tl ,
    font-command      .initial:n         = \ttfamily ,
    font-command      .value_required:n  = true ,
    font-command+     .code:n
      = { \tl_put_right:Nn \l_@@_font_command_tl { #1 } } ,
```

```
    font-command+    .value_required:n  = true ,
    font-command~+   .meta:n            = { font-command+ = #1 } ,
    font-command~+   .value_required:n  = true ,
    gobble           .int_set:N         = \l_@@_gobble_int ,
    gobble           .default:n         = -1 ,
    auto-gobble      .code:n            = \int_set:Nn \l_@@_gobble_int { -1 } ,
    auto-gobble      .value_forbidden:n = true ,
    env-gobble       .code:n            = \int_set:Nn \l_@@_gobble_int { -2 } ,
    env-gobble       .value_forbidden:n = true ,
    tabs-auto-gobble .code:n            = \int_set:Nn \l_@@_gobble_int { -3 } ,
    tabs-auto-gobble .value_forbidden:n = true ,

    splittable-on-empty-lines .bool_set:N = \l_@@_splittable_on_empty_lines_bool ,

    split-on-empty-lines .bool_set:N = \l_@@_split_on_empty_lines_bool ,
```

When the key `split-on-empty-lines` is in force, the correspondint token list will be inserted between the chunks of code (the computer listing provided by the end user is split in chunks on the empty lines in the code). That parameter must contain elements to be inserted in *vertical* mode by TeX.

```
    split-separation .tl_set:N         = \l_@@_split_separation_tl ,
    split-separation .value_required:n = true ,
    split-separation .initial:n = \vspace { \baselineskip } \vspace { -1.25pt } ,

    split-separation+ .code:n =
      \tl_put_right:Nn \l_@@_split_separation_tl { #1 } ,
    split-separation+ .value_required:n = true ,
    split-separation~+ .meta:n = { split-separation+ = #1 } ,
    add-to-split-separation .meta:n = { split-separation+ = #1 } ,

    marker .code:n =
      \bool_lazy_or:nnTF
        \l_@@_in_PitonInputFile_bool
        \l_@@_in_PitonOptions_bool
        { \keys_set:nn { PitonOptions / marker } { #1 } }
        { \@@_error:n { Invalid~key } } ,
    marker .value_required:n = true ,

    line-numbers .code:n =
      \keys_set:nn { PitonOptions / line-numbers } { #1 } ,
```

The following line is mandatory.

```
    line-numbers .default:n = true ,
```

The following counter corresponds to the key `splittable` of `\PitonOptions`. If the value of `\l_@@_splittable_int` is equal to n, then no line break can occur within the first n lines or the last n lines of a listing (or a *chunk* of listings when the key `split-on-empty-lines` is in force).

```
    splittable       .int_set:N         = \l_@@_splittable_int ,
    splittable       .default:n         = 1 ,
    splittable       .initial:n         = 100 ,
    background-color .code:n =
      \clist_set:Nn \l_@@_bg_color_clist { #1 }
```

We keep the lenght of the clist `\l_@@_bg_color_clist` in a counter for efficiency only.

```
      \int_set:Nn \l_@@_bg_colors_int { \clist_count:N \l_@@_bg_color_clist } ,
    background-color .value_required:n  = true ,
```

The package piton will also detect the lines of code which correspond to the user input in a Python console, that is to say the lines of code beginning with `>>>` and `....` It's possible, with the key `prompt-background-color`, to require a background for these lines of code (and the other lines of code will have the standard background color specified by `background-color`).

```
    prompt-background-color .tl_set:N         = \l_@@_prompt_bg_color_tl ,
    prompt-background-color .value_required:n = true ,
    prompt-background-color .initial:n        = gray!15 ,
```

With the tuning `write=false`, the content of the environment won't be parsed and won't be printed on the PDF. However, the Lua variables `piton.last_code` and `piton.last_language` will be set (and, hence, `piton.get_last_code` will be operational). The keys `join` and `write` will be honoured.

```
    print .bool_set:N = \l_@@_print_bool ,
    print .value_required:n = true ,
    print .initial:n = true ,

    width .code:n =
      \str_if_eq:nnTF  { #1 } { min }
        {
          \bool_set_true:N \l_@@_minimize_width_bool
          \dim_zero:N \l_@@_width_dim
        }
        {
          \bool_set_false:N \l_@@_minimize_width_bool
          \dim_set:Nn \l_@@_width_dim { #1 }
        } ,
    width .value_required:n  = true ,

    max-width .code:n =
      \bool_set_true:N \l_@@_minimize_width_bool
      \dim_set:Nn \l_@@_width_dim { #1 } ,
    max-width .value_required:n = true ,

    paperclip .code:n =
      \bool_set_true:N \l_@@_paperclip_bool
      \tl_if_novalue:nTF { #1 }
        { \str_set:Nn \l_@@_paperclip_str { } }
        { \str_set:Nn \l_@@_paperclip_str { #1 } } ,

    annotation .bool_set:N = \l_@@_annotation_bool ,

    write .str_set:N = \l_@@_write_str ,
    write .value_required:n = true ,
    no-write .code:n = \str_set_eq:NN \l_@@_write_str \c_empty_str ,
    no-write .value_forbidden:n = true ,
    join .code:n =
      \str_set:Nn \l_@@_join_str { #1 }
      \seq_if_in:NnF \g_@@_join_seq { #1 }
        { \seq_gput_right:No \g_@@_join_seq { #1 } } ,
    join .value_required:n = true ,
    join-separation .str_set:N = \l_@@_join_separation_str ,
    join-separation .value_required:n = true ,
    no-join .code:n = \str_set_eq:NN \l_@@_join_str \c_empty_str ,
    no-join .value_forbidden:n = true ,

    left-margin .code:n =
      \str_if_eq:nnTF { #1 } { auto }
        {
          \dim_zero:N \l_@@_left_margin_dim
          \bool_set_true:N \l_@@_left_margin_auto_bool
        }
        {
          \dim_set:Nn \l_@@_left_margin_dim { #1 }
          \bool_set_false:N \l_@@_left_margin_auto_bool
        } ,
    left-margin      .value_required:n  = true ,

    right-margin .code:n =
      \str_if_eq:nnTF { #1 } { auto }
        {
          \dim_zero:N \l_@@_right_margin_dim
          \bool_set_true:N \l_@@_right_margin_auto_bool
        }
        {
          \dim_set:Nn \l_@@_right_margin_dim { #1 }
```

```
      \bool_set_false:N \l_@@_right_margin_auto_bool
    } ,
right-margin     .value_required:n  = true ,

tab-size         .int_set:N         = \l_@@_tab_size_int ,
tab-size         .value_required:n  = true ,
tab-size         .initial:n         = 4 ,

show-spaces      .bool_set:N        = \l_@@_show_spaces_bool ,
show-spaces      .value_forbidden:n = true ,

show-spaces-in-strings .code:n      =
    \tl_set:Nn \l_@@_space_in_string_tl { ␣ } , % U+2423
show-spaces-in-strings .value_forbidden:n = true ,

break-lines-in-Piton .bool_set:N    = \l_@@_break_lines_in_Piton_bool ,
break-lines-in-Piton .initial:n     = true ,

break-lines-in-piton .bool_set:N    = \l_@@_break_lines_in_piton_bool ,

break-lines .meta:n = { break-lines-in-piton , break-lines-in-Piton } ,
break-lines .value_forbidden:n      = true ,

indent-broken-lines .bool_set:N     = \l_@@_indent_broken_lines_bool ,

end-of-broken-line  .tl_set:N       = \l_@@_end_of_broken_line_tl ,
end-of-broken-line  .value_required:n = true ,
end-of-broken-line  .initial:n      = \hspace* { 0.5em } \textbackslash ,

continuation-symbol .tl_set:N       = \l_@@_continuation_symbol_tl ,
continuation-symbol .value_required:n = true ,
continuation-symbol .initial:n      = + ,

continuation-symbol-on-indentation .tl_set:N = \l_@@_csoi_tl ,
continuation-symbol-on-indentation .value_required:n = true ,
continuation-symbol-on-indentation .initial:n = $\hookrightarrow \;$ ,

first-line .code:n = \@@_in_PitonInputFile:n
  { \int_set:Nn \l_@@_first_line_int { #1 } } ,
first-line .value_required:n = true ,

last-line .code:n = \@@_in_PitonInputFile:n
  { \int_set:Nn \l_@@_last_line_int { #1 } } ,
last-line .value_required:n = true ,

begin-range .code:n = \@@_in_PitonInputFile:n
  { \str_set:Nn \l_@@_begin_range_str { #1 } } ,
begin-range .value_required:n = true ,

end-range .code:n = \@@_in_PitonInputFile:n
  { \str_set:Nn \l_@@_end_range_str { #1 } } ,
end-range .value_required:n = true ,

range .code:n = \@@_in_PitonInputFile:n
  {
    \str_set:Nn \l_@@_begin_range_str { #1 }
    \str_set:Nn \l_@@_end_range_str { #1 }
  } ,
range .value_required:n = true ,

env-used-by-split .code:n =
  \lua_now:n { piton.env_used_by_split = '#1' } ,
env-used-by-split .initial:n = Piton ,
```

```
965
966     resume .meta:n = line-numbers/resume ,
967
968     unknown .code:n =
969       \@@_unknown_key:nn
970         { PitonOptions }
971         { Unknown~key~for~PitonOptions } ,
972
973     % deprecated
974     all-line-numbers .code:n =
975       \bool_set_true:N \l_@@_line_numbers_bool
976       \bool_set_false:N \l_@@_skip_empty_lines_bool ,
977     rounded-corners .code:n =
978       \AtBeginDocument
979         {
980           \IfPackageLoadedTF { tikz }
981             { \dim_set:Nn \l_@@_rounded_corners_dim { #1 } }
982             { \@@_err_rounded_corners_without_Tikz: }
983         } ,
984     rounded-corners .default:n = 4 pt
985   }
986 \hook_gput_code:nnn { begindocument } { . }
987   {
988     \IfPackageLoadedTF { tcolorbox }
989       {
990         \pgfkeysifdefined { / tcb / libload / breakable }
991           {
992             \keys_define:nn { PitonOptions }
993               {
994                 tcolorbox .bool_set:N = \l_@@_tcolorbox_bool ,
995               }
996           }
997           {
998             \keys_define:nn { PitonOptions }
999               { tcolorbox .code:n = \@@_error:n { library~breakable~not~loaded } }
1000          }
1001      }
1002      {
1003        \keys_define:nn { PitonOptions }
1004          { tcolorbox .code:n = \@@_error:n { tcolorbox~not~loaded } }
1005      }
1006  }


1007 \cs_new_protected:Npn \@@_err_rounded_corners_without_Tikz:
1008   {
1009     \@@_error:n { rounded-corners~without~Tikz }
1010     \cs_gset:Npn \@@_err_rounded_corners_without_Tikz: { }
1011   }


1012 \cs_new_protected:Npn \@@_in_PitonInputFile:n #1
1013   {
1014     \bool_if:NTF \l_@@_in_PitonInputFile_bool
1015       { #1 }
1016       { \@@_error:n { Invalid~key } }
1017   }


1018 \NewDocumentCommand \PitonOptions { m }
1019   {
1020     \bool_set_true:N \l_@@_in_PitonOptions_bool
1021     \keys_set:nn { PitonOptions } { #1 }
1022     \bool_set_false:N \l_@@_in_PitonOptions_bool
1023   }
```

When using `\NewPitonEnvironment` a user may use `\PitonOptions` inside. However, the set of keys available should be different that in standard `\PitonOptions`. That's why we define a version of `\PitonOptions` with no restriction on the set of available keys and we will link that version to `\PitonOptions` in such environment.

```
\NewDocumentCommand \@@_fake_PitonOptions { }
  { \keys_set:nn { PitonOptions } }
```

2.6 The numbers of the lines

The following counter will be used to count the lines in the code when the user requires the numbers of the lines to be printed (with `line-numbers`) whereas the counter `\g_@@_line_int` previously defined is *not* used for that functionality.

```
\int_new:N \g_@@_visual_line_int
\cs_new_protected:Npn \@@_incr_visual_line:
  { \bool_if:NF \l_@@_skip_empty_lines_bool { \int_gincr:N \g_@@_visual_line_int } }
```

The following command will be used when the numbers of lines are printed on the left (`line-numbers/position=left`). The number of line is in the counter `\g_@@_visual_line_int`.

```
\cs_new_protected:Npn \@@_print_number_left:
  {
    \hbox_overlap_left:n
      {
        \@@_actually_print_number:n { \int_to_arabic:n { \g_@@_visual_line_int } }
        \skip_horizontal:N \l_@@_numbers_sep_dim
      }
  }
```

The following command will be used when the numbers of lines are printed on the right (`line-numbers/position=right`). The number of line is in `\l_tmpa_tl`.

```
\cs_new_protected:Npn \@@_print_number_right:
  {
    \hbox_overlap_left:n
      {
        \@@_actually_print_number:n { \l_tmpa_tl }
        \int_compare:nNnT \l_@@_bg_colors_int > 0
          { \skip_horizontal:n { 0.1 em } }
      }
  }
```

`\@@_actually_print_number:` itself prints the number without the `\hbox_overlap_left:n`. It is used by both `\@@_print_number_left:` and `\@@_print_number_right:`

```
\cs_new_protected:Npn \@@_actually_print_number:n #1
  {
    \group_begin:
    \bool_if:NTF \l_@@_lmodern_drawn_bool
```

We put braces after `\l_@@_line_numbers_format_tl`. Thus, the user may use the key `line-numbers/format` with a value such as `\fbox`.

```
      { \l_@@_line_numbers_format_tl { \@@_draw_number:e { #1 } } }
      {
```

`\space` is mandatory in the "PostScript string" `(\space)` here.

```
        \pdfextension literal { /Artifact << /ActualText (\space) >> BDC }
        \l_@@_line_numbers_format_tl { #1 }
        \pdfextension literal { EMC }
      }
    \group_end:
  }
```

2.7 The main commands and environments for the end user

```
\NewDocumentCommand { \NewPitonLanguage } { O { } m ! o }
  {
    \tl_if_novalue:nTF { #3 }
```

The last argument is provided by currying.

```
      { \@@_NewPitonLanguage:nnn { #1 } { #2 } }
```

The two last arguments are provided by currying.

```
      { \@@_NewPitonLanguage:nnnnn { #1 } { #2 } { #3 } }
  }
```

The following property list will contain the definitions of the computer languages as provided by the end user. However, if a language is defined over another base language, the corresponding list will contain the *whole* definition of the language.

```
\prop_new:N \g_@@_languages_prop
```

```
\keys_define:nn { NewPitonLanguage }
  {
    morekeywords .code:n = ,
    otherkeywords .code:n = ,
    sensitive .code:n = ,
    keywordsprefix .code:n = ,
    moretexcs .code:n = ,
    morestring .code:n = ,
    morecomment .code:n = ,
    moredelim .code:n = ,
    moredirectives .code:n = ,
    tag .code:n = ,
    alsodigit .code:n = ,
    alsoletter .code:n = ,
    alsoother .code:n = ,
    unknown .code:n = \@@_error:n { Unknown~key~NewPitonLanguage }
  }
```

The function `\@@_NewPitonLanguage:nnn` will be used when the language is *not* defined above a base language (and a base dialect).

```
\cs_new_protected:Npn \@@_NewPitonLanguage:nnn #1 #2 #3
  {
```

We store in `\l_tmpa_tl` the name of the language with the potential dialect, that is to say, for example : `[AspectJ]{Java}`. We use `\tl_if_blank:nF` because the end user may have written `\NewPitonLanguage[ ]{Java}{...}`.

```
    \tl_set:Ne \l_tmpa_tl
      {
        \tl_if_blank:nF { #1 } { [ \str_lowercase:n { #1 } ] }
        \str_lowercase:n { #2 }
      }
```

The following set of keys is only used to raise an error when a key in unknown!

```
    \keys_set:nn { NewPitonLanguage } { #3 }
```

We store in LaTeX the definition of the language because some languages may be defined with that language as base language.

```
    \prop_gput:Non \g_@@_languages_prop \l_tmpa_tl { #3 }
```

The Lua part of the package piton will be loaded in a `\AtBeginDocument`. Hence, we will put also in a `\AtBeginDocument` the use of the Lua function `piton.new_language` (which does the main job).

```
    \@@_NewPitonLanguage:on \l_tmpa_tl { #3 }
  }
\cs_new_protected:Npn \@@_NewPitonLanguage:nn #1 #2
  {
    \hook_gput_code:nnn { begindocument } { . }
      { \lua_now:e { piton.new_language("#1","\lua_escape:n{#2}") } }
```

```
  }
\cs_generate_variant:Nn \@@_NewPitonLanguage:nn { o }
```

Now the case when the language is defined upon a base language.

```
\cs_new_protected:Npn \@@_NewPitonLanguage:nnnnn #1 #2 #3 #4 #5
  {
```

We store in `\l_tmpa_tl` the name of the base language with the dialect, that is to say, for example : `[AspectJ]{Java}`. We use `\tl_if_blank:nF` because the end user may have used `\NewPitonLanguage[Handel]{C}[ ]{C}{...}`

```
    \tl_set:Ne \l_tmpa_tl
      {
        \tl_if_blank:nF { #3 } { [ \str_lowercase:n { #3 } ] }
        \str_lowercase:n { #4 }
      }
```

We retrieve in `\l_tmpb_tl` the definition (as provided by the end user) of that base language. Caution: `\g_@@_languages_prop` does not contain all the languages provided by piton but only those defined by using `\NewPitonLanguage`.

```
    \prop_get:NoNTF \g_@@_languages_prop \l_tmpa_tl \l_tmpb_tl
```

We can now define the new language by using the previous function.

```
      { \@@_NewPitonLanguage:nnno { #1 } { #2 } { #5 } \l_tmpb_tl }
      { \@@_error:n { Language~not~defined } }
  }

\cs_new_protected:Npn \@@_NewPitonLanguage:nnnn #1 #2 #3 #4
```

In the following line, we write `#4,#3` and not `#3,#4` because we want that the keys which correspond to base language appear before the keys which are added in the language we define.

```
  { \@@_NewPitonLanguage:nnn { #1 } { #2 } { #4 , #3 } }
\cs_generate_variant:Nn \@@_NewPitonLanguage:nnnn { n n n o }

\NewDocumentCommand { \piton } { }
  { \peek_meaning:NTF \bgroup { \@@_piton_standard } { \@@_piton_verbatim } }
\NewDocumentCommand { \@@_piton_standard } { m }
  {
    \group_begin:
    \tl_if_eq:NnF \l_@@_space_in_string_tl { ␣ }
      {
```

Remind that, when `break-strings-anywhere` is in force, multiple commands `\-` will be inserted between the characters of the string to allow the breaks. The `\exp_not:N` before `\space` is mandatory.

```
        \bool_lazy_or:nnT
          \l_@@_break_lines_in_piton_bool
          \l_@@_break_strings_anywhere_bool
          { \tl_set:Nn \l_@@_space_in_string_tl { \exp_not:N \space } }
      }
```

The following tuning of LuaTeX in order to avoid all breaks of lines on the hyphens.

```
    \automatichyphenmode = 1
```

Remark that the argument of `\piton` (with the normal syntax) is expanded in the TeX sens, (see the `\tl_set:Ne` below) and that's why we can provide the following escapes to the end user:

```
    \cs_set_eq:NN \\ \c_backslash_str
    \cs_set_eq:NN \% \c_percent_str
    \cs_set_eq:NN \{ \c_left_brace_str
    \cs_set_eq:NN \} \c_right_brace_str
    \cs_set_eq:NN \$ \c_dollar_str
```

The standard command `\␣` is *not* expandable and we need here expandable commands. With the following code, we define an expandable command.

```
    \cs_set_eq:cN { ~ } \space
    \cs_set_eq:NN \@@_begin_line: \prg_do_nothing:
```

We redefine \rowcolor inside of \piton commands to do nothing.

```
    \cs_set_eq:NN \rowcolor \@@_noop_rowcolor
    \tl_set:Ne \l_tmpa_tl
      {
        \lua_now:e
          { piton.ParseBis('\l_piton_language_str',token.scan_string()) }
          { #1 }
      }
    \bool_if:NTF \l_@@_show_spaces_bool
      { \tl_replace_all:NVn \l_tmpa_tl \c_catcode_other_space_tl { ␣ } } % U+2423
      {
        \bool_if:NT \l_@@_break_lines_in_piton_bool
```

With the following line, the spaces of catacode 12 (which were not breakable) are replaced by \space, and, thus, become breakable.

```
          { \tl_replace_all:NVn \l_tmpa_tl \c_catcode_other_space_tl \space }
      }
```

The command \text is provided by the package amstext (loaded by piton).

```
    \if_mode_math:
       \text { \l_@@_font_command_tl \l_tmpa_tl }
    \else:
       \l_@@_font_command_tl \l_tmpa_tl
    \fi:
    \group_end:
  }

\NewDocumentCommand { \@@_piton_verbatim } { v }
  {
    \group_begin:
    \automatichyphenmode = 1
    \cs_set_eq:NN \@@_begin_line: \prg_do_nothing:
```

We redefine \rowcolor inside of \piton commands to do nothing.

```
    \cs_set_eq:NN \rowcolor \@@_noop_rowcolor
    \tl_set:Ne \l_tmpa_tl
      {
        \lua_now:e
          { piton.Parse('\l_piton_language_str',token.scan_string()) }
          { #1 }
      }
    \bool_if:NT \l_@@_show_spaces_bool
      { \tl_replace_all:NVn \l_tmpa_tl \c_catcode_other_space_tl { ␣ } } % U+2423
    \if_mode_math:
       \text { \l_@@_font_command_tl \l_tmpa_tl }
    \else:
       \l_@@_font_command_tl \l_tmpa_tl
    \fi:
    \group_end:
  }
```

The following command does *not* correspond to a user command. It will be used when we will have to "rescan" some chunks of computer code. For example, it will be the initial value of the Piton style InitialValues (the default values of the arguments of a Python function).

```
\cs_new_protected:Npn \@@_piton:n #1
  { \tl_if_blank:nF { #1 } { \@@_piton_i:n { #1 } } }

\cs_new_protected:Npn \@@_piton_i:n #1
  {
    \group_begin:
    \cs_set_eq:NN \@@_begin_line: \prg_do_nothing:
```

```
    \cs_set:cpn { pitonStyle _ \l_piton_language_str  _ Prompt } { }
    \cs_set:cpn { pitonStyle _ Prompt } { }
    \cs_set_eq:NN \@@_leading_space: \space
    \cs_set_eq:NN \@@_trailing_space: \space
    \tl_set:Ne \l_tmpa_tl
      {
        \lua_now:e
          { piton.ParseTer('\l_piton_language_str',token.scan_string()) }
          { #1 }
      }
    \bool_if:NT \l_@@_show_spaces_bool
      { \tl_replace_all:NVn \l_tmpa_tl \c_catcode_other_space_tl { ␣ } } % U+2423
    \@@_replace_spaces:o \l_tmpa_tl
    \group_end:
  }
```

`\@@_pre_composition:` will be used both in `\PitonInputFile` and in the environments such as `{Piton}`.

```
\cs_new_protected:Npn \@@_pre_composition:
  {
    \dim_compare:nNnT \l_@@_width_dim = \c_zero_dim
      {
        \dim_set_eq:NN \l_@@_width_dim \linewidth
```

When the key `box` is used, `width=min` is activated (except when `width` has been used with a numerical value).

```
        \str_if_empty:NF \l_@@_box_str
          { \bool_set_true:N \l_@@_minimize_width_bool }
      }
```

We compute `\l_@@_listing_width_dim`. However, if `max-width` is used (or `width=min` which uses `max-width`), that length will be computed again in `\@@_create_output_box:` but **even in the case**, we have to compute that value now (because the maximal width set by `max-width` may be reached by some lines of the listing—and those lines would be wrapped).

```
    \dim_set:Nn \l_@@_listing_width_dim
      {
        \bool_if:NTF \l_@@_tcolorbox_bool
          {
            \l_@@_width_dim -
            ( \kvtcb@left@rule
            + \kvtcb@leftupper
            + \kvtcb@boxsep * 2
            + \kvtcb@rightupper
            + \kvtcb@right@rule )
          }
          { \l_@@_width_dim }
      }
    \legacy_if:nT { @inlabel } { \bool_set_true:N \l_@@_in_label_bool }
    \automatichyphenmode = 1
    \bool_if:NF \l_@@_resume_bool { \int_gzero:N \g_@@_visual_line_int }
    \g_@@_def_vertical_commands_tl
    \int_gzero:N \g_@@_line_int
    \int_gzero:N \g_@@_nb_lines_int
    \dim_zero:N \parindent
    \dim_zero:N \lineskip
    \dim_zero:N \parskip

    \seq_gclear:N \g_@@_visual_line_numbers_seq

    \cs_set_eq:NN \rowcolor \@@_rowcolor:n
```

For efficiency, we keep in `\l_@@_bg_colors_int` the length of `\l_@@_bg_color_clist`.

```
    \int_compare:nNnT \l_@@_bg_colors_int > { \c_zero_int }
      { \bool_set_true:N \l_@@_bg_bool }
```

```
    \bool_gset_false:N \g_@@_rowcolor_inside_bool
    \IfPackageLoadedTF { zref-base }
      {
        \bool_if:NTF \g_@@_label_as_zlabel_bool
          { \cs_set_eq:NN \label \@@_zlabel:n }
          { \cs_set_eq:NN \label \@@_label:n }
        \cs_set_eq:NN \zlabel \@@_zlabel:n
      }
      { \cs_set_eq:NN \label \@@_label:n }
    \l_@@_font_command_tl
  }
```

When the parameters `line-numbers`, `line-numbers/position=left` and `left-margin` are in force (or if `line-numbers`, `line-numbers=right` and `right-margin` are in force), we have to compute the width of the maximal number of lines at the end of the environment to fix the correct value to `left-margin` (or `right-margin`).
The command `\@@_compute_margin:N` will do that job.
It's argument must be either `\l_@@_left_margin_dim` either `\l_@@_right_margin_dim`.

```
\cs_new_protected:Npn \@@_compute_margin:N #1
  {
     \use:e
       {
         \bool_if:NTF \l_@@_skip_empty_lines_bool
           { \lua_now:n { piton.CountNonEmptyLines(token.scan_argument()) } }
           { \lua_now:n { piton.CountLines(token.scan_argument()) } }
         { \l_@@_listing_tl }
       }
     \hbox_set:Nn \l_tmpa_box
       {
         \l_@@_line_numbers_format_tl
         \int_to_arabic:n
           {
              \g_@@_visual_line_int
              +
              \bool_if:NTF \l_@@_skip_empty_lines_bool
                { \l_@@_nb_non_empty_lines_int }
                { \g_@@_nb_lines_int }
           }
       }
     \dim_set:Nn #1 { \box_wd:N \l_tmpa_box + \l_@@_numbers_sep_dim + 0.1 em }
  }
```

The following command computes `\l_@@_code_width_dim`.
It will be used only once (in `\@@_create_output_box:`).
If there is a background (even a background with the color `none`), we subtract 0.5 em on both sides. However, if there is a left margin or a right margin, we use those margins. If the key `left-margin` has been used with the special value `auto` (this is meaningful only in conjonction with the key `line-numbers` and a value of `line-numbers/position` equal to `left`), the actual value for the left margin has yet computed (and stored in `left-margin`). Idem for the right margin.

```
\cs_new_protected:Npn \@@_compute_code_width:
  {
    \dim_set:Nn \l_@@_code_width_dim
      {
        \l_@@_listing_width_dim
        -
        (
          \int_compare:nNnTF \l_@@_bg_colors_int > { \c_zero_int }
          {
            \dim_compare:nNnTF \l_@@_left_margin_dim > \c_zero_dim
              { \l_@@_left_margin_dim }
              { 0.5 em }
            +
```

```
            \dim_compare:nNnTF \l_@@_right_margin_dim > \c_zero_dim
              { \l_@@_right_margin_dim }
              { 0.5 em }
          }
          { \l_@@_left_margin_dim + \l_@@_right_margin_dim }
        )
    }
}
```

The following command computes `\l_@@_listing_width_dim` and it will be used when `max-width` (or `width=min`) is used. Remind that the key `box` sets `width=min` (except when `width` is used with a numerical value).
It will be used only once (in `\@@_create_output_box:`).
The computation is the inverse of the computation done in `\@@_compute_code_width:`.

```
\cs_new_protected:Npn \@@_recompute_listing_width:
  {
    \dim_set:Nn \l_@@_listing_width_dim
      {
        \box_wd:N \g_@@_output_box
        +
        \int_compare:nNnTF \l_@@_bg_colors_int > \c_zero_int
          {
            \dim_compare:nNnTF \l_@@_left_margin_dim > \c_zero_dim
              { \l_@@_left_margin_dim }
              { 0.5 em }
            +
            \dim_compare:nNnTF \l_@@_right_margin_dim > \c_zero_dim
              { \l_@@_right_margin_dim }
              { 0.5 em }
          }
          { \l_@@_left_margin_dim + \l_@@_right_margin_dim }
      }
  }

\cs_new_protected:Npn \@@_store_body:n #1
  {
```

Now, we have to replace all the occurrences of `\obeyedline` by a character of end of line (`\r` in the strings of Lua).

```
    \tl_set:Ne \obeyedline { \char_generate:nn { 13 } { 11 } }
    \tl_set:Ne \l_@@_listing_tl { #1 }
    \tl_set_eq:NN \ProcessedArgument \l_@@_listing_tl
  }
```

The first argument of the following macro is one of the four strings: `New`, `Renew`, `Provide` and `Declare`.

```
\cs_new_protected:Nn \@@_DefinePitonEnvironment:nnnnn
  {
    \use:c { #1 DocumentEnvironment } { #2 } { #3 > { \@@_store_body:n } c }
      {
        \cs_set_eq:NN \PitonOptions \@@_fake_PitonOptions
        #4
        \@@_pre_composition:
        \int_compare:nNnT { \l_@@_number_lines_start_int } > { \c_zero_int }
          {
            \int_gset:Nn \g_@@_visual_line_int
              { \l_@@_number_lines_start_int - 1 }
          }
        \bool_if:NT \g_@@_beamer_bool
          { \@@_translate_beamer_env:o { \l_@@_listing_tl } }
        \bool_if:NT \g_@@_footnote_bool \savenotes
        \@@_composition:
        \bool_lazy_or:nnT { \l_@@_paperclip_bool } { \l_@@_annotation_bool }
          { \@@_create_paperclip_annotation: }
        \bool_if:NT \g_@@_footnote_bool \endsavenotes
```

```
        #5
      }
      { \ignorespacesafterend }
  }
```

\marginalia is a command of the package marginalia (loaded by piton).

```
\cs_new_protected:Npn \@@_create_paperclip_annotation:
  {
    \marginalia
      {
        \vspace* { - 0.8 em }
        \hbox:n
          {
            \vrule~height~0~pt~depth~12~pt~width~0~pt
            \bool_if:NT \l_@@_annotation_bool
              {
                \lua_now:n
                  {
```

The function piton.utf16 does a conversion from utf8 to utf16 big endian encoded in hexadecimal (with the BOM of big endian), which is suitable to be put in a string between angular brackets of the PDF. It's easier for a stream!

```
                    pdf.immediateobj
                      ( "<" .. piton.utf16 ( piton.get_last_code ( ) ) .. ">" )
                  }
                \pdfextension annot~width~5pt~height~10pt~depth~0pt
                  {
                    /Subtype /Text
                    /Contents~\pdf_object_ref_last:
                    /Name /Note
                    /Subj (Computer~listing)
```

The following tries to specify that the note should not receive answers (since it is meant for an easy copy-past of the computer listing).

```
                    /ReplyType /Group
```

Adds the bit 10 which means LockedContents.

```
                    /F~512
                    /C [0.8~0.8~0.8]
                  }
                \hspace* { 7 mm }
              }
            \bool_if:NT \l_@@_paperclip_bool { \@@_create_paperclip: }
          }
      }
  }


\cs_new_protected:Npn \@@_create_paperclip:
  {
    \str_if_empty:NT \l_@@_paperclip_str
      {
        \int_gincr:N \g_@@_paperclip_int
        \str_set:Ne \l_@@_paperclip_str { listing_\int_use:N \g_@@_paperclip_int .txt }
      }
```

Here, we don't understand why the tostring is mandatory.

```
    \lua_now:n { pdf.immediateobj ( "stream" , tostring ( piton.get_last_code() ) ) }
    \box_move_down:nn
      { 10 pt }
      {
        \hbox:n
          {
            \pdfextension annot~width~10pt~height~20pt~depth~0pt
              {
                /Subtype /FileAttachment
```

```
                /Name /Paperclip
                /F~8 % no zoom
```

`/Contents` will be used as info-bulle and description of the file in the panel of the embedded files.

```
                /Contents (The~computer~listing)
                /FS <<
                       /Type /Filespec
                       /F (\l_@@_paperclip_str)
                       /EF << /F~\pdf_object_ref_last: >>
                       /AFRelationship /Supplement
                    >>
                }
            }
        }
    }
```

For the following commands, the arguments are provided by curryfication.

```
\NewDocumentCommand { \NewPitonEnvironment } { }
  { \@@_DefinePitonEnvironment:nnnnn { New } }
\NewDocumentCommand { \DeclarePitonEnvironment } { }
  { \@@_DefinePitonEnvironment:nnnnn { Declare } }
\NewDocumentCommand { \RenewPitonEnvironment } { }
  { \@@_DefinePitonEnvironment:nnnnn { Renew } }
\NewDocumentCommand { \ProvidePitonEnvironment } { }
  { \@@_DefinePitonEnvironment:nnnnn { Provide } }


\cs_new_protected:Npn \@@_translate_beamer_env:n
  { \lua_now:e { piton.TranslateBeamerEnv(token.scan_argument ( ) ) } }
\cs_generate_variant:Nn \@@_translate_beamer_env:n { o }


\cs_new_protected:Npn \@@_composition:
  {
    \str_if_empty:NT \l_@@_box_str
      {
        \mode_if_vertical:F
          { \bool_if:NF \l_@@_in_PitonInputFile_bool { \newline } }
      }
    \bool_if:NT \l_@@_line_numbers_bool
      {
        \bool_lazy_and:nnT
          { \l_@@_left_margin_auto_bool }
          { \str_if_eq_p:ee \l_@@_line_numbers_position_str { left } }
          { \@@_compute_margin:N \l_@@_left_margin_dim }
        \bool_lazy_and:nnT
          { \l_@@_right_margin_auto_bool }
          { \str_if_eq_p:ee \l_@@_line_numbers_position_str { right } }
          { \@@_compute_margin:N \l_@@_right_margin_dim }
      }
    \lua_now:e
      {
        piton.join_separation = "\l_@@_join_separation_str"
        piton.join = "\l_@@_join_str"
        piton.write = "\l_@@_write_str"
        piton.path_write = "\l_@@_path_write_str"
      }
    \noindent
    \bool_if:NTF \l_@@_print_bool
      {
```

When `split-on-empty-lines` is in force, each chunk will be formated by an environment `{Piton}` (or the environment specified by `env-used-by-split`). Within each of these environments, we will

come back here (but, of course, `split-on-empty-line` will have been set to `false`). The mechanism "`retrieve`" is mandatory.

```
      \bool_if:NTF \l_@@_split_on_empty_lines_bool
        { \par \@@_retrieve_gobble_split_parse:o \l_@@_listing_tl }
        {
          \@@_create_output_box:
```

Now, the listing has been composed in `\g_@@_output_box` and `\l_@@_listing_width_dim` contains the width of the listing (with the potential margin for the numbers of lines).

```
          \bool_if:NTF \l_@@_tcolorbox_bool
            {
              \str_if_empty:NTF \l_@@_box_str
                \@@_composition_iii:
                \@@_composition_iv:
            }
            {
              \str_if_empty:NTF \l_@@_box_str
                \@@_composition_i:
                \@@_composition_ii:
            }
        }
    }
    { \@@_gobble_parse_no_print:o \l_@@_listing_tl }
}
```

`\@@_composition_i:` is for the main case: the key `tcolorbox` is not used, nor the key `box`.
We can't do a mere `\vbox_unpack:N \g_@@_output_box` because that would not work inside a list of LaTeX (`{itemize}` or `{enumerate}`).
The composition in the box `\g_@@_output_box` was mandatory to be able to deal with the case of a conjunction of the keys `width=min` and `background-color=...`.

```
\cs_new_protected:Npn \@@_composition_i:
  {
```

First, we "reverse" the box `\g_@@_output_box`: we put in the box `\g_tmpa_box` the boxes present in `\g_@@_output_box`, but in reversed order. The vertical spaces and the penalties are discarded.

```
    \box_clear:N \g_tmpa_box
```

The box `\g_@@_line_box` will be used as an auxiliary box.

```
    \box_clear_new:N \g_@@_line_box
```

We unpack `\g_@@_output_box` in `\l_tmpa_box` used as a scratched box.

```
    \vbox_set:Nn \l_tmpa_box
      {
        \vbox_unpack_drop:N \g_@@_output_box
        \bool_gset_false:N \g_tmpa_bool
        \unskip \unskip
        \bool_gset_false:N \g_tmpa_bool
        \bool_do_until:nn \g_tmpa_bool
          {
            \unskip \unskip \unskip
            \unpenalty \unkern
            \box_set_to_last:N \l_@@_line_box
            \box_if_empty:NTF \l_@@_line_box
              { \bool_gset_true:N \g_tmpa_bool }
              {
                \vbox_gset:Nn \g_tmpa_box
                  {
                    \vbox_unpack:N \g_tmpa_box
                    \box_use:N \l_@@_line_box
                  }
              }
          }
      }
```

Now, we will loop over the boxes in `\g_tmpa_box` and compose the boxes in the TeX flow.

```
    \bool_gset_false:N \g_tmpa_bool
```

```
    \int_zero:N \g_@@_line_int
    \bool_do_until:nn \g_tmpa_bool
      {
```

We retrieve the last box of `\g_tmpa_box` (and store it in `\g_@@_line_box`) and keep the other boxes in `\g_tmpa_box`.

```
        \vbox_gset:Nn \g_tmpa_box
          {
            \vbox_unpack_drop:N \g_tmpa_box
            \box_gset_to_last:N \g_@@_line_box
          }
```

If the box that we have retrieved is void, that means that, in fact, there is no longer boxes in `\g_tmpa_box` and we will exit the loop.

```
        \box_if_empty:NTF \g_@@_line_box
          { \bool_gset_true:N \g_tmpa_bool }
          {
            \box_use:N \g_@@_line_box
            \int_gincr:N \g_@@_line_int
            \par
            \kern -2.5 pt
```

We will determine the penalty by reading the Lua table `piton.lines_status`. That will use the current value of `\g_@@_line_int`.

```
            \@@_add_penalty_for_the_line:
```

We now add the instructions corresponding to the *vertical detected commands* that are potentially used in the corresponding line of the listing.

```
            \cs_if_exist_use:cT { g_@@_after_line _ \int_use:N \g_@@_line_int }
              { \cs_undefine:c { g_@@_after_line _ \int_use:N \g_@@_line_int } }
            \int_compare:nNnT \g_@@_line_int < \g_@@_nb_lines_int
              { \mode_leave_vertical: }
          }
      }
    \skip_vertical:n { 2.5 pt }
  }
```

`\@@_composition_ii:` will be used when the key `box` is in force but *not* the key `tcolorbox`.

```
\cs_new_protected:Npn \@@_composition_ii:
  {
    \use:e { \begin { minipage } [ \l_@@_box_str ] }
      { \l_@@_listing_width_dim }
```

Here, `\vbox_unpack:N`, instead of `\box_use:N` is mandatory for the vertical position of the box.

```
    \vbox_unpack:N \g_@@_output_box
```

`\kern` is mandatory here (`\skip_vertical:n` won't work).

```
    \kern 2.5 pt
    \end { minipage }
  }
```

`\@@_composition_iii:` will be used when the key `tcolorbox` is in force but *not* the key `box`.

```
\cs_new_protected:Npn \@@_composition_iii:
  {
    \use:e
      {
        \begin { tcolorbox }
```

Even though we use the key `breakable` of `{tcolorbox}`, our environment will be breakable only when the key `splittable` of piton is used.

```
          [ breakable , text~width = \l_@@_listing_width_dim ]
      }
    \par
    \vbox_unpack:N \g_@@_output_box
    \end { tcolorbox }
  }
```

\@@_composition_iv: will be used when both keys tcolorbox and box are in force.

```
\cs_new_protected:Npn \@@_composition_iv:
  {
    \use:e
      {
        \begin { tcolorbox }
          [
            hbox ,
            text~width = \l_@@_listing_width_dim ,
            nobeforeafter ,
            box~align =
              \str_case:Nn \l_@@_box_str
                {
                  t { top }
                  b { bottom }
                  c { center }
                  m { center }
                }
          ]
      }
    \box_use:N \g_@@_output_box
    \end { tcolorbox }
  }
```

The following function will add the correct vertical penalty after a line of code in order to control the breaks of the pages. We use the Lua table piton.lines_status which has been written by piton.ComputeLinesStatus for this aim. Each line has a "status" (equal to 0, 1 or 2) and that status directly says whether a break is allowed.

```
\cs_new_protected:Npn \@@_add_penalty_for_the_line:
  {
    \int_case:nn
      {
        \lua_now:e
          {
            tex.sprint
              ( piton.lines_status [ \int_use:N \g_@@_line_int ] )
          }
      }
      { 1 { \penalty 100 } 2 \nobreak }
  }
```

\@@_create_output_box: is used only once, in \@@_composition:.
It creates (and modifies when there are backgrounds or numbers of the lines on the right) \g_@@_output_box.

```
\cs_new_protected:Npn \@@_create_output_box:
  {
    \@@_compute_code_width:
    \vbox_gset:Nn \g_@@_output_box
      { \@@_retrieve_gobble_parse:o \l_@@_listing_tl }
    \bool_if:NT \l_@@_minimize_width_bool { \@@_recompute_listing_width: }
    \bool_lazy_any:nT
      {
        { \int_compare_p:nNn \l_@@_bg_colors_int > \c_zero_int }
        { \g_@@_rowcolor_inside_bool }
        {
          \l_@@_line_numbers_bool
          &&
          \str_if_eq_p:ee \l_@@_line_numbers_position_str { right }
        }
      }
      \@@_add_bg_and_right_nb_to_output_box:
  }
```

We add the backgrounds after the composition of the box `\g_@@_output_box` by a loop over the lines in that box. Idem when the key `line-numbers` is used in conjunction with `line-numbers/position=right`.
The backgrounds will have a width equal to `\l_@@_listing_width_dim`.
That command will be used only once, in `\@@_create_output_box:`.

```
\cs_new_protected:Npn \@@_add_bg_and_right_nb_to_output_box:
  {
    \int_gset_eq:NN \g_@@_line_int \g_@@_nb_lines_int
```

`\l_tmpa_box` is only used to *unpack* the vertical box `\g_@@_output_box`.

```
    \vbox_set:Nn \l_tmpa_box
      {
        \vbox_unpack_drop:N \g_@@_output_box
```

We will raise `\g_tmpa_bool` to exit the loop `\bool_do_until:nn` below.

```
        \bool_gset_false:N \g_tmpa_bool
        \unskip \unskip
```

We begin the loop.

```
        \bool_do_until:nn \g_tmpa_bool
          {
            \unskip \unskip \unskip
            \int_set_eq:NN \l_tmpa_int \lastpenalty
            \unpenalty \unkern
```

In standard TeX (not LuaTeX), the only way to loop over the sub-boxes of a given box is to use the TeX primitive `\lastbox` (via `\box_set_to_last:N` of L3). Of course, it would be interesting to replace that programming by a programming in Lua of LuaTeX...

```
            \box_set_to_last:N \l_@@_line_box
            \box_if_empty:NTF \l_@@_line_box
              { \bool_gset_true:N \g_tmpa_bool }
              {
```

`\g_@@_line_int` will be used in `\@@_add_bg_and_right_nb_to_line_and_use:`.

```
                \vbox_gset:Nn \g_@@_output_box
                  {
```

The command `\@@_add_bg_and_right_nb_to_line_and_use:` will add a background to the line (in `\l_@@_line_box`) but will also put the line in the current box. The background will have a width equal to `\l_@@_listing_width_dim`.

```
                    \@@_add_bg_and_right_nb_to_line_and_use:
                    \kern -2.5 pt
                    \penalty \l_tmpa_int
                    \vbox_unpack:N \g_@@_output_box
                  }
              }
            \int_gdecr:N \g_@@_line_int
          }
      }
  }
```

The following will be used when the end user has used `print=false`.

```
\cs_new_protected:Npn \@@_gobble_parse_no_print:n
  {
    \lua_now:e
      {
        piton.GobbleParseNoPrint
         (
           '\l_piton_language_str' ,
           \int_use:N \l_@@_gobble_int ,
           token.scan_argument ( )
         )
      }
  }
\cs_generate_variant:Nn \@@_gobble_parse_no_print:n { o }
```

The following function will be used when the key `split-on-empty-lines` is not in force. It will retrieve the first empty line, gobble the spaces at the beginning of the lines and parse the code. The argument is provided by curryfication.

```
\cs_new_protected:Npn \@@_retrieve_gobble_parse:n
  {
    \lua_now:e
      {
        piton.RetrieveGobbleParse
          (
            '\l_piton_language_str' ,
            \int_use:N \l_@@_gobble_int ,
            \bool_if:NTF \l_@@_splittable_on_empty_lines_bool
              { \int_eval:n { - \l_@@_splittable_int } }
              { \int_use:N \l_@@_splittable_int } ,
            token.scan_argument ( )
          )
      }
  }
\cs_generate_variant:Nn \@@_retrieve_gobble_parse:n { o }
```

The following function will be used when the key `split-on-empty-lines` is in force. It will gobble the spaces at the beginning of the lines (if the key `gobble` is in force), then split the code at the empty lines and, eventually, parse the code. The argument is provided by curryfication.

```
\cs_new_protected:Npn \@@_retrieve_gobble_split_parse:n
  {
    \lua_now:e
      {
        piton.RetrieveGobbleSplitParse
          (
            '\l_piton_language_str' ,
            \int_use:N \l_@@_gobble_int ,
            \int_use:N \l_@@_splittable_int ,
            token.scan_argument ( )
          )
      }
  }
\cs_generate_variant:Nn \@@_retrieve_gobble_split_parse:n { o }
```

Now, we define the environment `{Piton}`, which is the main environment provided by the package piton. Of course, you use `\NewPitonEnvironment`.

```
\bool_if:NTF \g_@@_beamer_bool
  {
    \NewPitonEnvironment { Piton } { D < > { .- }  O { } }
      {
        \keys_set:nn { PitonOptions } { #2 }
        \begin { actionenv } < #1 >
      }
      { \end { actionenv } }
  }
  {
    \NewPitonEnvironment { Piton } { O { } }
      { \keys_set:nn { PitonOptions } { #1 } }
      { }
  }


\NewDocumentCommand { \PitonInputFileTF } { d < > O { } m m m }
  {
    \mode_if_vertical:F { \par }
    \group_begin:
    \seq_concat:NNN
      \l_file_search_path_seq
      \l_@@_path_seq
```

```
      \l_file_search_path_seq
    \file_get_full_name:nNTF { #3 } \l_@@_file_name_str
      {
        \@@_input_file:nn { #1 } { #2 }
        #4
      }
      { #5 }
    \group_end:
  }

\cs_new_protected:Npn \@@_unknown_file:n #1
  { \msg_error:nnn { piton } { Unknown~file } { #1 } }
\NewDocumentCommand { \PitonInputFile } { d < > O { } m }
  {
    \PitonInputFileTF < #1 > [ #2 ] { #3 } { }
      {
```

The following line is for `latexmk` (suggestion of Y. Salmon).

```
        \iow_log:n { No~file~#3 }
        \@@_unknown_file:n { #3 }
      }
  }
\NewDocumentCommand { \PitonInputFileT } { d < > O { } m m }
  {
    \PitonInputFileTF < #1 >  [ #2 ] { #3 } { #4 }
      {
```

The following line is for `latexmk` (suggestion of Y. Salmon).

```
        \iow_log:n { No~file~#3 }
        \@@_unknown_file:n { #3 }
      }
  }
\NewDocumentCommand { \PitonInputFileF } { d < > O { } m m }
  { \PitonInputFileTF < #1 >  [ #2 ] { #3 } { } { #4 } }
```

The following command uses as implicit argument the name of the file in `\l_@@_file_name_str`.

```
\cs_new_protected:Npn \@@_input_file:nn #1 #2
  {
```

We recall that, if we are in Beamer, the command `\PitonInputFile` is "overlay-aware" and that's why there is an optional argument between angular brackets (`<` and `>`).

```
    \tl_if_novalue:nF { #1 }
      {
        \bool_if:NTF \g_@@_beamer_bool
          { \begin { uncoverenv } < #1 > }
          { \@@_error_or_warning:n { overlay~without~beamer } }
      }
    \group_begin:
```

The following line is to allow tools such as `latexmk` to be aware that the file read by `\PitonInputFile` is loaded during the compilation of the LaTeX document.

```
      \iow_log:e { (\l_@@_file_name_str) }
      \int_zero_new:N \l_@@_first_line_int
      \int_zero_new:N \l_@@_last_line_int
      \int_set_eq:NN \l_@@_last_line_int \c_max_int
      \bool_set_true:N \l_@@_in_PitonInputFile_bool
      \keys_set:nn { PitonOptions } { #2 }
      \bool_if:NT \l_@@_line_numbers_absolute_bool
        { \bool_set_false:N \l_@@_skip_empty_lines_bool }
      \bool_if:nTF
        {
          (
            \int_compare_p:nNn \l_@@_first_line_int > \c_zero_int
            || \int_compare_p:nNn \l_@@_last_line_int < \c_max_int
          )
          && ! \str_if_empty_p:N \l_@@_begin_range_str
```

```
        }
        {
          \@@_error_or_warning:n { bad~range~specification }
          \int_zero:N \l_@@_first_line_int
          \int_set_eq:NN \l_@@_last_line_int \c_max_int
        }
        {
          \str_if_empty:NF \l_@@_begin_range_str
            {
              \@@_compute_range:
              \bool_lazy_or:nnT
                \l_@@_marker_include_lines_bool
                { ! \str_if_eq_p:NN \l_@@_begin_range_str \l_@@_end_range_str }
                {
                  \int_decr:N \l_@@_first_line_int
                  \int_incr:N \l_@@_last_line_int
                }
            }
        }
      \@@_pre_composition:
      \bool_if:NT \l_@@_line_numbers_absolute_bool
        { \int_gset:Nn \g_@@_visual_line_int { \l_@@_first_line_int - 1 } }
      \int_compare:nNnT \l_@@_number_lines_start_int > \c_zero_int
        {
          \int_gset:Nn \g_@@_visual_line_int
            { \l_@@_number_lines_start_int - 1 }
        }
```

The following case arises when the code `line-numbers/absolute` is in force without the use of a marked range.

```
      \int_compare:nNnT \g_@@_visual_line_int < \c_zero_int
        { \int_gzero:N \g_@@_visual_line_int }
      \lua_now:e
        {
```

The following command will store the content of the file (or only a part of that file) in `\l_@@_listing_tl`.

```
          piton.ReadFile(
           '\l_@@_file_name_str' ,
           \int_use:N \l_@@_first_line_int ,
           \int_use:N \l_@@_last_line_int )
        }
      \@@_composition:
    \group_end:
```

We recall that, if we are in Beamer, the command `\PitonInputFile` is "overlay-aware" and that's why we close now an environment `{uncoverenv}` that we have opened at the beginning of the command.

```
    \tl_if_novalue:nF { #1 }
      { \bool_if:NT \g_@@_beamer_bool { \end { uncoverenv } } }
  }
```

The following command computes the values of `\l_@@_first_line_int` and `\l_@@_last_line_int` when `\PitonInputFile` is used with textual markers.

```
\cs_new_protected:Npn \@@_compute_range:
  {
```

We store the markers in L3 strings (`str`) in order to do safely the following replacement of `\#`.

```
    \str_set:Ne \l_tmpa_str { \@@_marker_beginning:n { \l_@@_begin_range_str } }
    \str_set:Ne \l_tmpb_str { \@@_marker_end:n { \l_@@_end_range_str } }
```

We replace the sequences `\#` which may be present in the prefixes and suffixes added to the markers by the functions `\@@_marker_beginning:n` and `\@@_marker_end:n`.

```
    \tl_replace_all:Nee \l_tmpa_str { \c_backslash_str \c_hash_str } \c_hash_str
    \tl_replace_all:Nee \l_tmpb_str { \c_backslash_str \c_hash_str } \c_hash_str
    \lua_now:e
```

```
      {
        piton.ComputeRange
          ( '\l_tmpa_str' , '\l_tmpb_str' , '\l_@@_file_name_str' )
      }
  }
```

2.8 The styles

The following command is fundamental: it will be used by the Lua code.

```
\NewDocumentCommand { \PitonStyle } { m }
  {
    \cs_if_exist_use:cF { pitonStyle _ \l_piton_language_str  _ #1 }
      { \use:c { pitonStyle _ #1 } }
  }
```

The following variant will be rarely used. It applies only a local style and only when that style exists (no error will be raised when the style does not exist). That command will be used in particular for the language "`expl`".

```
\NewDocumentCommand { \OptionalLocalPitonStyle } { m }
  { \cs_if_exist_use:c { pitonStyle _ \l_piton_language_str  _ #1 } }

\NewDocumentCommand { \SetPitonStyle } { O { } m }
  {
    \str_clear_new:N \l_@@_SetPitonStyle_option_str
    \str_set:Ne \l_@@_SetPitonStyle_option_str { \str_lowercase:n { #1 } }
    \str_if_eq:onT { \l_@@_SetPitonStyle_option_str } { current-language }
      { \str_set_eq:NN \l_@@_SetPitonStyle_option_str \l_piton_language_str }
    \keys_set:nn { piton / Styles } { #2 }
  }

\cs_new_protected:Npn \@@_math_scantokens:n #1
  { \normalfont \scantextokens { \begin{math} #1 \end{math} } }

\clist_new:N \g_@@_styles_clist
\clist_gset:Nn \g_@@_styles_clist
  {
    Comment ,
    Comment.Internal ,
    Comment.LaTeX ,
    Discard ,
    Delim ,
    Exception ,
    FormattingType ,
    Identifier.Internal ,
    Identifier ,
    InitialValues ,
    Interpol.Inside ,
    Keyword ,
    Keyword.Governing ,
    Keyword.Constant ,
    Keyword2 ,
    Keyword3 ,
    Keyword4 ,
    Keyword5 ,
    Keyword6 ,
    Keyword7 ,
    Keyword8 ,
    Keyword9 ,
    Name.Builtin ,
    Name.Class ,
    Name.Constructor ,
```

```
    Name.Decorator ,
    Name.Field ,
    Name.Function ,
    Name.Module ,
    Name.Namespace ,
    Name.Table ,
    Name.Type ,
    Number ,
    Number.Internal ,
    Operator ,
    Operator.Word ,
    Preproc ,
    Prompt ,
    Punct ,
    String.Doc ,
    String.Doc.Internal ,
    String.Interpol ,
    String.Long ,
    String.Long.Internal ,
    String.Short ,
    String.Short.Internal ,
    Tag ,
    TypeParameter ,
    UserFunction ,
```

`TypeExpression` is an internal style for expressions which defines types in OCaml.

```
    TypeExpression ,
```

Now, specific styles for the languages created with `\NewPitonLanguage` with the syntax of listings.

```
    Directive
  }
\clist_map_inline:Nn \g_@@_styles_clist
  {
    \keys_define:nn { piton / Styles }
      {
        #1 .value_required:n = true ,
        #1 .code:n =
          \tl_set:cn
            {
              pitonStyle _
              \str_if_empty:NF \l_@@_SetPitonStyle_option_str
                { \l_@@_SetPitonStyle_option_str _ }
              #1
            }
            { ##1 }
      }
  }

\keys_define:nn { piton / Styles }
  {
    String       .meta:n = { String.Long = #1 , String.Short = #1 } ,
    String       .value_required:n = true ,
    Comment.Math .tl_set:c = pitonStyle _ Comment.Math  ,
    Comment.Math .value_required:n = true ,
    unknown      .code:n = \@@_unknown_style:
  }
```

For the langage `expl`, it's possible to create "on the fly" some styles of the form `Module.`*`name`* or `Type.`*`name`*. For the other languages, it's not possible.

```
\cs_new_protected:Npn \@@_unknown_style:
  {
    \str_if_eq:eeTF \l_@@_SetPitonStyle_option_str { expl }
      {
```

```
        \seq_set_split:Nne \l_tmpa_seq { . } \l_keys_key_str
        \seq_get_left:NN \l_tmpa_seq \l_tmpa_str
```

Now, the first part of the key (before the first period) is stored in `\l_tmpa_str`.

```
        \bool_lazy_and:nnTF
          { \int_compare_p:nNn { \seq_count:N \l_tmpa_seq } > { 1 } }
          {
            \str_if_eq_p:Vn \l_tmpa_str { Module }
            ||
            \str_if_eq_p:Vn \l_tmpa_str { Type }
          }
```

Now, we will create a new style.

```
          { \tl_set:co { pitonStyle _ expl _ \l_keys_key_str } \l_keys_value_tl }
          { \@@_error:n { Unknown~key~for~SetPitonStyle } }
      }
      { \@@_error:n { Unknown~key~for~SetPitonStyle } }
  }


\SetPitonStyle[OCaml]
  {
    TypeExpression =
      {
        \SetPitonStyle [ OCaml ]
          {
            Identifier = \PitonStyle { Name.Type } ,
            Name.Builtin = \PitonStyle { Name.Type}
          }
        \@@_piton:n
      }
  }
```

We add the word `String` to the list of the styles because we will use that list in the error message for an unknown key in `\SetPitonStyle`.

```
\clist_gput_left:Nn \g_@@_styles_clist { String }
```

Of course, we sort that clist.

```
\clist_gsort:Nn \g_@@_styles_clist
  {
    \str_compare:nNnTF { #1 } < { #2 }
      \sort_return_same:
      \sort_return_swapped:
  }


\cs_set_eq:NN \@@_break_strings_anywhere:n \prg_do_nothing:

\cs_set_eq:NN \@@_break_numbers_anywhere:n \prg_do_nothing:

\cs_new_protected:Npn \@@_actually_break_anywhere:n #1
  {
    \tl_set:Nn \l_tmpa_tl { #1 }
```

We have to begin by a substitution for the spaces. Otherwise, they would be gobbled in the `\tl_map_inline:Nn`.

```
    \tl_replace_all:NVn \l_tmpa_tl \c_catcode_other_space_tl \space
    \seq_clear:N \l_tmpa_seq
    \tl_map_inline:Nn \l_tmpa_tl { \seq_put_right:Nn \l_tmpa_seq { ##1 } }
    \seq_use:Nn \l_tmpa_seq { \- }
  }
```

```
\cs_new_protected:Npn \@@_comment:n #1
  { \PitonStyle { Comment } { \PitonSpaceSubstitute { #1 } } }
```

We use a standard name for the following command (and not a internal name of L3 such as `\@@_space_substitute:n` because it will be inserted in the main LaTeX stream by Lua when `morecomment` is used in `\NewPitonLanguage`.
We should probably change that with an "internal style".

```
\cs_new_protected:Npn \PitonSpaceSubstitute #1 % noqa
  {
    \bool_if:NTF \l_@@_break_lines_in_Piton_bool
      {
        \tl_set:Nn \l_tmpa_tl { #1 }
        \tl_replace_all:NVn \l_tmpa_tl
          \c_catcode_other_space_tl
          \@@_breakable_space:
        \l_tmpa_tl
      }
      { #1 }
  }


\cs_new_protected:Npn \@@_string_long:n #1
  {
    \PitonStyle { String.Long }
      {
        \bool_if:NTF \l_@@_break_strings_anywhere_bool
          { \@@_actually_break_anywhere:n { #1 } }
          {
```

We have, when `break-lines-in-Piton` is in force, to replace the spaces by `\@@_breakable_space:` because, when we have done a similar job in `\@@_replace_spaces:n` used in `\@@_begin_line:`, that job was not able to do the replacement in the brace group `{...}` of `\PitonStyle{String.Long}{...}` because we used a `\tl_replace_all:NVn`. At that time, it would have been possible to use a `\tl_regex_replace_all:Nnn` but it is notoriously slow.

```
            \bool_if:NTF \l_@@_break_lines_in_Piton_bool
              {
                \tl_set:Nn \l_tmpa_tl { #1 }
                \tl_replace_all:NVn \l_tmpa_tl
                  \c_catcode_other_space_tl
                  \@@_breakable_space:
                \l_tmpa_tl
              }
              { #1 }
          }
      }
  }
\cs_new_protected:Npn \@@_string_short:n #1
  {
    \PitonStyle { String.Short }
      {
        \bool_if:NT \l_@@_break_strings_anywhere_bool
          { \@@_actually_break_anywhere:n }
        { #1 }
      }
  }
\cs_new_protected:Npn \@@_string_doc:n #1
  {
    \PitonStyle { String.Doc }
      {
        \bool_if:NTF \l_@@_break_lines_in_Piton_bool
          {
            \tl_set:Nn \l_tmpa_tl { #1 }
            \tl_replace_all:NVn \l_tmpa_tl
```

```
            \c_catcode_other_space_tl
            \@@_breakable_space:
          \l_tmpa_tl
        }
        { #1 }
    }
  }
\cs_new_protected:Npn \@@_number:n #1
  {
    \PitonStyle { Number }
      {
        \bool_if:NT \l_@@_break_numbers_anywhere_bool
          { \@@_actually_break_anywhere:n }
        { #1 }
      }
  }
```

2.9 The initial styles

The initial styles are inspired by the style "manni" of Pygments.

```
\SetPitonStyle
  {
    Comment               = \color [ HTML ] { 0099FF } \itshape ,
    Comment.Internal      = \@@_comment:n ,
    Exception             = \color [ HTML ] { CC0000 } ,
    Keyword               = \color [ HTML ] { 006699 } \bfseries ,
    Keyword.Governing     = \color [ HTML ] { 006699 } \bfseries ,
    Keyword.Constant      = \color [ HTML ] { 006699 } \bfseries ,
    Name.Builtin          = \color [ HTML ] { 336666 } ,
    Name.Decorator        = \color [ HTML ] { 9999FF },
    Name.Class            = \color [ HTML ] { 00AA88 } \bfseries ,
    Name.Function         = \color [ HTML ] { CC00FF } ,
    Name.Namespace        = \color [ HTML ] { 00CCFF } ,
    Name.Constructor      = \color [ HTML ] { 006000 } \bfseries ,
    Name.Field            = \color [ HTML ] { AA6600 } ,
    Name.Module           = \color [ HTML ] { 0060A0 } \bfseries ,
    Name.Table            = \color [ HTML ] { 309030 } ,
    Number                = \color [ HTML ] { FF6600 } ,
    Number.Internal       = \@@_number:n ,
    Operator              = \color [ HTML ] { 555555 } ,
    Operator.Word         = \bfseries ,
    String                = \color [ HTML ] { CC3300 } ,
    String.Long.Internal  = \@@_string_long:n ,
    String.Short.Internal = \@@_string_short:n ,
    String.Doc.Internal   = \@@_string_doc:n ,
    String.Doc            = \color [ HTML ] { CC3300 } \itshape ,
    String.Interpol       = \color [ HTML ] { AA0000 } ,
    Comment.LaTeX         = \normalfont \color [ rgb ] { .468, .532, .6 } ,
    Name.Type             = \color [ HTML ] { 336666 } ,
    InitialValues         = \@@_piton:n ,
    Interpol.Inside       = { \l_@@_font_command_tl \@@_piton:n } ,
    TypeParameter         = \color [ HTML ] { 336666} \itshape ,
    Preproc               = \color [ HTML ] { AA6600} \slshape ,
```

We need the command `\@@_identifier:n` because of the command `\SetPitonIdentifier`. The command `\@@_identifier:n` will potentially call the style `Identifier` (which is a user-style, not an internal style).

```
    Identifier.Internal   = \@@_identifier:n ,
    Identifier            = ,
    Directive             = \color [ HTML ] { AA6600} ,
    Tag                   = \colorbox { gray!10 } ,
```

```
    UserFunction          = \PitonStyle { Identifier } ,
    Prompt                = ,
    Discard               = \use_none:n
  }
```

2.10 Styles specific to the language expl

```
\clist_new:N \g_@@_expl_styles_clist
\clist_gset:Nn \g_@@_expl_styles_clist
  {
    Scope.l ,
    Scope.g ,
    Scope.c
  }
\clist_map_inline:Nn \g_@@_expl_styles_clist
  {
    \keys_define:nn { piton / Styles }
      {
        #1 .value_required:n = true ,
        #1 .code:n =
          \tl_set:cn
            {
              pitonStyle _
              \str_if_empty:NF \l_@@_SetPitonStyle_option_str
                { \l_@@_SetPitonStyle_option_str _ }
              #1
            }
            { ##1 }
      }
  }
\SetPitonStyle [ expl ]
  {
    Scope.l          = ,
    Scope.g          = \bfseries ,
    Scope.c          = \slshape ,
    Type.bool        = \color [ HTML ] { AA6600} ,
    Type.box         = \color [ HTML ] { 267910 } ,
    Type.clist       = \color [ HTML ] { 309030 } ,
    Type.fp          = \color [ HTML ] { FF3300 } ,
    Type.int         = \color [ HTML ] { FF6600 } ,
    Type.seq         = \color [ HTML ] { 309030 } ,
    Type.skip        = \color [ HTML ] { 0CC060 } ,
    Type.str         = \color [ HTML ] { CC3300 } ,
    Type.tl          = \color [ HTML ] { AA2200 } ,
    Module.bool      = \color [ HTML ] { AA6600} ,
    Module.box       = \color [ HTML ] { 267910 } ,
    Module.cs        = \bfseries \color [ HTML ] { 006699 } ,
    Module.exp       = \bfseries \color [ HTML ] { 404040 } ,
    Module.hbox      = \color [ HTML ] { 267910 } ,
    Module.prg       = \bfseries ,
    Module.clist     = \color [ HTML ] { 309030 } ,
    Module.fp        = \color [ HTML ] { FF3300 } ,
    Module.int       = \color [ HTML ] { FF6600 } ,
    Module.seq       = \color [ HTML ] { 309030 } ,
    Module.skip      = \color [ HTML ] { 0CC060 } ,
    Module.str       = \color [ HTML ] { CC3300 } ,
    Module.tl        = \color [ HTML ] { AA2200 } ,
    Module.vbox      = \color [ HTML ] { 267910 }
  }
```

If the key `math-comments` has been used in the preamble of the LaTeX document, we change the

style `Comment.Math` which should be considered only at an "internal style". However, maybe we will document in a future version the possibility to write change the style *locally* in a document)].

```
\hook_gput_code:nnn { begindocument } { . }
  {
    \bool_if:NT \g_@@_math_comments_bool
      { \SetPitonStyle { Comment.Math = \@@_math_scantokens:n } }
  }
```

2.11 Highlighting some identifiers

```
\NewDocumentCommand { \SetPitonIdentifier } { o m m }
  {
    \clist_set:Nn \l_tmpa_clist { #2 }
    \tl_if_novalue:nTF { #1 }
      {
        \clist_map_inline:Nn \l_tmpa_clist
          { \cs_set:cpn { PitonIdentifier _ ##1 } { #3 } }
      }
      {
        \str_set:Ne \l_tmpa_str { \str_lowercase:n { #1 } }
        \str_if_eq:onT \l_tmpa_str { current-language }
          { \str_set_eq:NN \l_tmpa_str \l_piton_language_str }
        \clist_map_inline:Nn \l_tmpa_clist
          { \cs_set:cpn { PitonIdentifier _ \l_tmpa_str _ ##1 } { #3 } }
      }
  }
\cs_new_protected:Npn \@@_identifier:n #1
  {
    \str_set:Nn \l_tmpa_str { #1 }
    \cs_if_exist_use:cF { PitonIdentifier _ \l_piton_language_str _ \l_tmpa_str }
      {
        \cs_if_exist_use:cF { PitonIdentifier _ \l_tmpa_str }
          { \PitonStyle { Identifier } }
      }
    { #1 }
  }
```

In particular, we have an highlighting of the identifiers which are the names of Python functions previously defined by the user. Indeed, when a Python function is defined, the style `Name.Function.Internal` is applied to that name. We define now that style (we define it directly and we short-cut the function `\SetPitonStyle`).

```
\cs_new_protected:cpn { pitonStyle _ Name.Function.Internal } #1
  {
```

First, the element is composed in the TeX flow with the style `Name.Function` which is provided to the end user.

```
    { \PitonStyle { Name.Function } { #1 } }
      \str_set:Nn \l_tmpa_str { #1 }
```

Now, we specify that the name of the new Python function is a known identifier that will be formatted with the Piton style `UserFunction`. Of course, here the affectation is global because we have to exit many groups and even the environments `{Piton}`).

```
    \cs_gset_protected:cpn { PitonIdentifier _ \l_piton_language_str _ \l_tmpa_str }
      { \PitonStyle { UserFunction } }
```

Now, we put the name of that new user function in the dedicated sequence (specific of the current language). **That sequence will be used only by** `\PitonClearUserFunctions`.

```
    \seq_if_exist:cF { g_@@_functions _ \l_piton_language_str _ seq }
      { \seq_new:c { g_@@_functions _ \l_piton_language_str _ seq } }
    \seq_gput_right:co { g_@@_functions _ \l_piton_language_str _ seq } \l_tmpa_str
```

We update `\g_@@_languages_seq` which is used only by the command `\PitonClearUserFunctions` when it's used without its optional argument.

```
    \seq_if_in:NoF \g_@@_languages_seq { \l_piton_language_str }
```

```
      { \seq_gput_left:No \g_@@_languages_seq { \l_piton_language_str } }
  }

\NewDocumentCommand \PitonClearUserFunctions { ! o }
  {
    \tl_if_novalue:nTF { #1 }
```

If the command is used without its optional argument, we will deleted the user language for all the computer languages.

```
      { \@@_clear_all_functions: }
      { \@@_clear_list_functions:n { #1 } }
  }

\cs_new_protected:Npn \@@_clear_list_functions:n #1
  {
    \clist_set:Nn \l_tmpa_clist { #1 }
    \clist_map_function:NN \l_tmpa_clist \@@_clear_functions_i:n
    \clist_map_inline:nn { #1 }
      { \seq_gremove_all:Nn \g_@@_languages_seq { ##1 } }
  }

\cs_new_protected:Npn \@@_clear_functions_i:n #1
  { \@@_clear_functions_ii:n { \str_lowercase:n { #1 } } }
```

The following command clears the list of the user-defined functions for the language provided in argument (mandatory in lower case).

```
\cs_new_protected:Npn \@@_clear_functions_ii:n #1
  {
    \seq_if_exist:cT { g_@@_functions _ #1 _ seq }
      {
        \seq_map_inline:cn { g_@@_functions _ #1 _ seq }
          { \cs_undefine:c { PitonIdentifier _ #1 _ ##1} }
        \seq_gclear:c { g_@@_functions _ #1 _ seq }
      }
  }
\cs_generate_variant:Nn \@@_clear_functions_ii:n { e }

\cs_new_protected:Npn \@@_clear_functions:n #1
  {
    \@@_clear_functions_i:n { #1 }
    \seq_gremove_all:Nn \g_@@_languages_seq { #1 }
  }
```

The following command clears all the user-defined functions for all the computer languages.

```
\cs_new_protected:Npn \@@_clear_all_functions:
  {
    \seq_map_function:NN \g_@@_languages_seq \@@_clear_functions_i:n
    \seq_gclear:N \g_@@_languages_seq
  }

\AtEndDocument
  {
```

For the files written on the disk (with the key `write`), all the job is done by Lua.

```
    \lua_now:n { piton.write_files_now ( ) }
```

For the files joined in the PDF, we have a modern version which uses the package pdfmanagement of LaTeX and a legacy mechanism.

```
    \IfPDFManagementActiveTF
      { \@@_join_files: }
      { \@@_join_files_legacy: }
  }
```

If the new pakcage pdfmanagement is used, we insert the file directly in the catalog of the PDF file.

```
\cs_new_protected:Npn \@@_join_files:
  {
    \seq_map_inline:Nn \g_@@_join_seq
      {
        \lua_now:n { pdf.immediateobj ( "stream" , piton.join_files["##1"] ) }
        \str_set_convert:Nnnn \l_tmpa_str { ##1 } { } { utf16/hex }
        \pdfmanagement_add:nne { Catalog / Names } { EmbeddedFiles }
          {
            <<
               /Type /Filespec
               /UF <\l_tmpa_str>
               /EF << /F~\pdf_object_ref_last: >>
               /Desc (Computer~listing)
               /AFRelationship /Supplement
            >>
          }
      }
  }
```

The legacy version of `\@@_join_files:` will be used when the new package pdfmanagement is *not* used. It that case, we can't insert the file directly in the catalog of the pdf file. Therefore, we insert the file linked to a annotation in a page of the PDF file. We try to make the annotation itself invisible with several technics.

```
\cs_new_protected:Npn \@@_join_files_legacy:
  {
    \seq_map_inline:Nn \g_@@_join_seq
      {
        \str_set_convert:Nnnn \l_tmpa_str { ##1 } { } { utf16/hex }
        \lua_now:n { pdf.immediateobj ( "stream" , piton.join_files["##1"] ) }
        \pdfextension annot~width~0pt~height~0pt~depth~0pt
```

The entry `/F` in the PDF dictionnary of the annotation is an unsigned 32-bit integer containing flags specifying various characteristics of the annotation. The bit in position 2 means *Hidden*. However, despite that bit which means *Hidden*, some PDF readers show the annotation. That's why we have used `width 0pt height 0pt depth 0pt`.

```
          {
            /Subtype /FileAttachment
            /F~2
            /Name /Paperclip
            /Contents (Computer~listing)
            /FS <<
                    /Type /Filespec
```

We have previously converted the name of the embedded file in `utf16/hex` with the BOM of big endian and now we can write a PDF string between `<` and `>` (with that encoding).

```
                    /UF <\l_tmpa_str>
```

It would have been possible to write `\pdffeedback lastobj~0~R` instead `\pdf_object_ref_last:` since LuaTeX is the only engine allowed by piton. Remark that `\pdf_object_ref_last:` is in the LaTeX kernel (not in the package pdfmanagement).

```
                    /EF << /F~\pdf_object_ref_last: >>
                    /AFRelationship /Supplement
                >>
            }
      }
  }
```

2.12 Spaces of indentation

```
\cs_new_protected:Npn \@@_define_leading_space_normal:
  {
    \cs_set_protected:Npn \@@_leading_space:
```

```
      {
        \int_gincr:N \g_@@_indentation_int
```

Be careful: the `\hbox:n` is mandatory.

```
        \hbox:n { ~ }
      }
  }
\cs_new_protected:Npn \@@_define_leading_space_Foxit:
  {
    \cs_set_protected:Npn \@@_leading_space:
      {
        \int_gincr:N \g_@@_indentation_int
        \pdfextension literal { /Artifact << /ActualText (\space) >> BDC }
          {
            \color { white }
            \transparent { 0 }
            . % previously : ␣ U+2423
          }
        \pdfextension literal { EMC }
      }
  }
\@@_define_leading_space_Foxit:
```

2.13 Security

```
\AddToHook { env / piton / before }
  { \@@_fatal:n { No~environment~piton } }
```

2.14 The error messages of the package

When there is a unknown key, we try a "normal form" of the key and, when that normal form exists, we add that information in the error message.
The normal form is the lower case form of the key, with all the spaces replaced by hyphens (there is never spaces in the keys of piton).
`#1` is a clist of names of sets of keys and `#2` is the error message to send.

```
\cs_new_protected:Npn \@@_unknown_key:nn #1 #2
  {
    \str_set_eq:NN \l_tmpa_str \l_keys_key_str
    \str_replace_all:Nnn \l_tmpa_str { ~ } { - }
    \str_set:Ne \l_tmpa_str { \str_lowercase:f { \l_tmpa_str } }
    \bool_set_false:N \l_tmpa_bool
    \clist_map_inline:nn { #1 }
      {
        \keys_if_exist:neT { ##1 } { \l_tmpa_str }
          {
            \@@_error:n { key~with~normal~form~exists }
            \bool_set_true:N \l_tmpa_bool
            \clist_map_break:
          }
      }
    \bool_if:NF \l_tmpa_bool { \@@_error:n { #2 } }
  }
\@@_msg_new:nn { key~with~normal~form~exists }
  {
    The~key~'\l_keys_key_str'~does~not~exists.~It~will~be~ignored.\\
    Maybe~you~want~to~use~the~key~'\l_tmpa_str'.
  }
\@@_msg_new:nn { No~environment~piton }
  {
    There~is~no~environment~piton!\\
    There~is~an~environment~{Piton}~and~a~command~
    \token_to_str:N \piton\ but~there~is~no~environment~
```

```
    {piton}.
  }
\@@_msg_new:nn { rounded-corners~without~Tikz }
  {
    TikZ~not~used \\
    You~can't~use~the~key~'rounded-corners'~because~
    you~have~not~loaded~the~package~TikZ.~
    If~you~go~on,~your~key~will~be~ignored.~
    You~won't~have~similar~error~till~the~end~of~the~document.
  }
\@@_msg_new:nn { tcolorbox~not~loaded }
  {
    tcolorbox~not~loaded \\
    You~can't~use~the~key~'tcolorbox'~because~
    you~have~not~loaded~the~package~tcolorbox.~
    Use~\token_to_str:N \usepackage[breakable]{tcolorbox}.~
    If~you~go~on,~that~key~will~be~ignored.
  }
\@@_msg_new:nn { library~breakable~not~loaded }
  {
    breakable~not~loaded \\
    You~can't~use~the~key~'tcolorbox'~because~
    you~have~not~loaded~the~library~'breakable'~of~tcolorbox'.~
    Use~\token_to_str:N \tcbuselibrary{breakable}~in~the~preamble~
    of~your~document.~
    If~you~go~on,~that~key~will~be~ignored.
  }
\@@_msg_new:nn { Language~not~defined }
  {
    Language~not~defined \\
    The~language~'\l_tmpa_tl'~has~not~been~defined~previously.~
    If~you~go~on,~your~command~\token_to_str:N \NewPitonLanguage\
    will~be~ignored.
  }
\@@_msg_new:nn { bad~version~of~piton.lua }
  {
    Bad~number~version~of~'piton.lua'\\
    The~file~'piton.lua'~loaded~has~not~the~same~number~of~
    version~as~the~file~'piton.sty'.~You~can~go~on~but~you~should~
    address~that~issue.
  }
\@@_msg_new:nn { Unknown~key~NewPitonLanguage }
  {
    Unknown~key~for~\token_to_str:N \NewPitonLanguage.\\
    The~key~'\l_keys_key_str'~is~unknown.~
    This~key~will~be~ignored.
  }
\@@_msg_new:nn { Unknown~key~for~SetPitonStyle }
  {
    The~style~'\l_keys_key_str'~is~unknown.\\
    This~setting~will~be~ignored.~
    The~available~styles~are~(in~alphabetic~order):~
    \clist_use:Nnnn \g_@@_styles_clist { ~and~ } { ,~ } { ~and~ }.
  }
\@@_msg_new:nn { Invalid~key }
  {
    Wrong~use~of~key.\\
    You~can't~use~the~key~'\l_keys_key_str'~here.~
    Your~key~will~be~ignored.
  }
```

```
\@@_msg_new:nn { Unknown~key~for~line-numbers }
  {
    Unknown~key. \\
    The~key~'line-numbers / \l_keys_key_str'~is~unknown.~
    The~available~keys~of~the~family~'line-numbers'~are~(in~
    alphabetic~order):~
    absolute,~false,~label-empty-lines,~lmmono10-drawn,~
    ~position,~resume,~skip-empty-lines,~
    sep,~start~and~true.~
    Your~key~will~be~ignored.
  }
\@@_msg_new:nn { Unknown~key~for~marker }
  {
    Unknown~key. \\
    The~key~'marker / \l_keys_key_str'~is~unknown.~
    The~available~keys~of~the~family~'marker'~are~(in~
    alphabetic~order):~ beginning,~end~and~include-lines.~
    Your~key~will~be~ignored.
  }
\@@_msg_new:nn { bad~range~specification }
  {
    Incompatible~keys.\\
    You~can't~specify~the~range~of~lines~to~include~by~using~both~
    markers~and~explicit~number~of~lines.~
    Your~whole~file~'\l_@@_file_name_str'~will~be~included.
  }
\cs_new_nopar:Nn \@@_thepage:
  {
    \thepage
    \cs_if_exist:NT \insertframenumber
      {
        ~(frame~\insertframenumber
        \cs_if_exist:NT \beamer@slidenumber { ,~slide~\insertslidenumber }
        )
      }
  }
```

We don't give the name `syntax error` for the following error because you should not give a name with a space because such space could be replaced by U+2423 when the key `show-spaces` is in force in the command `\piton`.

```
\@@_msg_new:nn { SyntaxError }
  {
    Syntax~Error~on~page~\@@_thepage:.\\
    Your~code~of~the~language~'\l_piton_language_str'~is~not~
    syntactically~correct.~
    It~won't~be~printed~in~the~PDF~file.
  }
\@@_msg_new:nn { FileError }
  {
    File~Error.\\
    It's~not~possible~to~write~on~the~file~'#1' \\
    \sys_if_shell_unrestricted:F
      { (try~to~compile~with~'lualatex~-shell-escape').\\ }
    If~you~go~on,~nothing~will~be~written~on~that~file.
  }
\@@_msg_new:nn { InexistentDirectory }
  {
    Inexistent~directory.\\
    The~directory~'\l_@@_path_write_str'~
    given~in~the~key~'path-write'~does~not~exist.~
    Nothing~will~be~written~on~'\l_@@_write_str'.
  }
```

```
\@@_msg_new:nn { begin~marker~not~found }
  {
    Marker~not~found.\\
    The~range~'\l_@@_begin_range_str'~provided~to~the~
    command~\token_to_str:N \PitonInputFile\ has~not~been~found.~
    The~whole~file~'\l_@@_file_name_str'~will~be~inserted.
  }
\@@_msg_new:nn { end~marker~not~found }
  {
    Marker~not~found.\\
    The~marker~of~end~of~the~range~'\l_@@_end_range_str'~
    provided~to~the~command~\token_to_str:N \PitonInputFile\
    has~not~been~found.~The~file~'\l_@@_file_name_str'~will~
    be~inserted~till~the~end.
  }
\@@_msg_new:nn { Unknown~file }
  {
    Unknown~file. \\
    The~file~'#1'~is~unknown.~
    Your~command~\token_to_str:N \PitonInputFile\ will~be~ignored.
  }
\cs_new_protected:Npn \@@_error_if_not_in_beamer:
  {
    \bool_if:NF \g_@@_beamer_bool
      { \@@_error_or_warning:n { Without~beamer } }
  }
\@@_msg_new:nn { Without~beamer }
  {
    Key~'\l_keys_key_str'~without~Beamer.\\
    You~should~not~use~the~key~'\l_keys_key_str'~since~you~
    are~not~in~Beamer.~However,~you~can~go~on.
  }
\@@_msg_new:nn { rowcolor~in~detected-commands }
  {
     'rowcolor'~forbidden~in~'detected-commands'.\\
     You~should~put~'rowcolor'~in~'raw-detected-commands'.~
     That~key~will~be~ignored.
  }
\@@_msg_new:nnn { Unknown~key~for~PitonOptions }
  {
    Unknown~key. \\
    The~key~'\l_keys_key_str'~is~unknown~for~\token_to_str:N \PitonOptions.~
    It~will~be~ignored.~
    For~a~list~of~the~available~keys,~type~H~<return>.
  }
  {
    The~available~keys~are~(in~alphabetic~order):~
    annotation,~
    add-to-split-separation,~
    auto-gobble,~
    background-color,~
    begin-range,~
    box,~
    break-lines,~
    break-lines-in-piton,~
    break-lines-in-Piton,~
    break-numbers-anywhere,~
    break-strings-anywhere,~
    continuation-symbol,~
    continuation-symbol-on-indentation,~
    detected-beamer-commands,~
```

```
    detected-beamer-environments,~
    detected-commands,~
    end-of-broken-line,~
    end-range,~
    env-gobble,~
    env-used-by-split,~
    font-command(+),~
    gobble,~
    indent-broken-lines,~
    join,~
    label-as-zlabel,~
    language,~
    left-margin,~
    line-numbers/,~
    marker/,~
    math-comments,~
    no-join,~
    no-write,~
    path,~
    path-write,~
    print,~
    prompt-background-color,~
    raw-detected-commands,~
    resume,~
    right-margin,~
    rounded-corners,~
    show-spaces,~
    show-spaces-in-strings,~
    splittable,~
    splittable-on-empty-lines,~
    split-on-empty-lines,~
    split-separation,~
    tabs-auto-gobble,~
    tab-size,~
    tcolorbox,~
    varwidth,~
    vertical-detected-commands,~
    width~and~write.
  }

\@@_msg_new:nn { label~with~lines~numbers }
  {
    You~can't~use~the~command~\token_to_str:N \label\
    or~\token_to_str:N \zlabel\
    because~the~key~'line-numbers'~
    is~not~active.~If~you~go~on,~that~command~will~ignored.
  }

\@@_msg_new:nn { overlay~without~beamer }
  {
    You~can't~use~an~argument~<...>~for~your~command~
    \token_to_str:N \PitonInputFile\ because~you~are~not~
    in~Beamer.~If~you~go~on,~that~argument~will~be~ignored.
  }

\@@_msg_new:nn { label~as~zlabel~needs~zref~package }
  {
    The~key~'label-as-zlabel'~requires~the~package~'zref'.~
    Please~load~the~package~'zref'~before~setting~the~key.
  }
\hook_gput_code:nnn { begindocument } { . }
```

```
  {
    \bool_if:NT \g_@@_label_as_zlabel_bool
      {
        \IfPackageLoadedF { zref-base }
          { \@@_fatal:n { label~as~zlabel~needs~zref~package } }
      }
  }
```

2.15 The glyphs of the 10 arabic numbers

```
\cs_new_protected:Npn \@@_draw_number:n #1
  { \tl_map_inline:nn { #1 } { \use:c { c_@@_glyph_ ##1 _tl } } }
\cs_generate_variant:Nn \@@_draw_number:n { e }
\cs_set_eq:NN \tlconstcn \tl_const:cn
\ExplSyntaxOff
\tlconstcn{c_@@_glyph_0_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.24 3.05 m
            4.24 4.91 3.22 6.22 2.12 6.22 c
            1.00 6.22 0 4.88 0 3.06 c
            0 1.20 1.02 -0.11 2.12 -0.11 c
            3.24 -0.11 4.24 1.23 4.24 3.05 c
            3.55 3.16 m
            3.55 1.68 2.90 0.50 2.12 0.50 c
            1.34 0.50 0.69 1.68 0.69 3.16 c
            0.69 4.62 1.38 5.61 2.12 5.61 c
            2.85 5.61 3.55 4.63 3.55 3.16 c
            h f
          }%
        \hfill
      }%
  }
\tlconstcn{c_@@_glyph_1_tl}
  {%
    \hbox to 5pt
      {%
        \hfill \kern 1 pt
        \pdfextension literal
          {
            3.37 0.3 m
            3.37 0.61 3.13 0.61 2.97 0.61 c
            2.06 0.61 l
            2.06 5.81 l
            2.06 5.97 2.06 6.22 1.76 6.22 c
            1.57 6.22 1.51 6.1 1.46 5.98 c
            1.08 5.13 0.56 5.02 0.37 5.0 c
            0.21 4.99 0.0 4.97 0.0 4.69 c
            0.0 4.44 0.18 4.39 0.33 4.39 c
            0.52 4.39 0.93 4.45 1.37 4.83 c
            1.37 0.61 l
            0.46 0.61 l
            0.3 0.61 0.06 0.61 0.06 0.3 c
            0.06 0.0 0.31 0.0 0.46 0.0 c
            2.97 0.0 l
            3.12 0.0 3.37 0.0 3.37 0.3 c
            h f
```

```
          }%
        \hfill
      }%
  }
\tlconstcn{c_@@_glyph_2_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.2 0.41 m
            4.2 0.67 l
            4.2 0.86 4.2 1.08 3.86 1.08 c
            3.51 1.08 3.51 0.89 3.51 0.61 c
            1.13 0.61 l
            1.72 1.12 2.68 1.87 3.11 2.27 c
            3.74 2.83 4.2 3.47 4.2 4.27 c
            4.2 5.47 3.19 6.22 1.97 6.22 c
            0.79 6.22 0.0 5.4 0.0 4.55 c
            0.0 4.18 0.28 4.07 0.45 4.07 c
            0.66 4.07 0.89 4.24 0.89 4.52 c
            0.89 4.64 0.84 4.77 0.75 4.84 c
            0.9 5.3 1.37 5.61 1.92 5.61 c
            2.74 5.61 3.51 5.15 3.51 4.27 c
            3.51 3.57 3.02 2.99 2.36 2.44 c
            0.15 0.58 l
            0.06 0.5 0.0 0.45 0.0 0.31 c
            0.0 0.0 0.25 0.0 0.41 0.0 c
            3.8 0.0 l
            4.13 0.0 4.2 0.09 4.2 0.41 c
            h f
          }%
        \hfill
      }%
  }
\tlconstcn{c_@@_glyph_3_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.36 1.74 m
            4.36 2.45 3.89 3.04 3.23 3.34 c
            3.79 3.7 4.07 4.27 4.07 4.81 c
            4.07 5.55 3.34 6.22 2.19 6.22 c
            0.99 6.22 0.29 5.74 0.29 5.05 c
            0.29 4.72 0.54 4.58 0.74 4.58 c
            0.95 4.58 1.18 4.75 1.18 5.03 c
            1.18 5.17 1.12 5.27 1.09 5.3 c
            1.4 5.61 2.11 5.61 2.2 5.61 c
            2.88 5.61 3.38 5.25 3.38 4.8 c
            3.38 4.5 3.23 4.15 2.96 3.93 c
            2.64 3.67 2.39 3.65 2.03 3.63 c
            1.46 3.59 1.31 3.59 1.31 3.3 c
            1.31 2.99 1.55 2.99 1.71 2.99 c
            2.17 2.99 l
            3.16 2.99 3.67 2.32 3.67 1.74 c
            3.67 1.13 3.11 0.5 2.2 0.5 c
            1.8 0.5 1.03 0.61 0.77 1.08 c
            0.82 1.13 0.89 1.19 0.89 1.39 c
            0.89 1.63 0.7 1.83 0.45 1.83 c
```

```
            0.22 1.83 0.0 1.68 0.0 1.36 c
            0.0 0.47 0.97 -0.11 2.2 -0.11 c
            3.51 -0.11 4.36 0.81 4.36 1.74 c
            h f
          }%
        \hfill
      }%
  }
\tlconstcn{c_@@_glyph_4_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.66 1.99 m
            4.66 2.3 4.42 2.3 4.26 2.3 c
            3.48 2.3 l
            3.48 5.82 l
            3.48 6.15 3.41 6.23 3.07 6.23 c
            2.79 6.23 l
            2.55 6.23 2.5 6.22 2.37 6.02 c
            0.09 2.44 l
            0.0 2.31 0.0 2.29 0.0 2.09 c
            0.0 1.76 0.09 1.69 0.4 1.69 c
            2.92 1.69 l
            2.92 0.61 l
            2.3 0.61 l
            2.14 0.61 1.9 0.61 1.9 0.3 c
            1.9 0.0 2.15 0.0 2.3 0.0 c
            4.1 0.0 l
            4.25 0.0 4.5 0.0 4.5 0.3 c
            4.5 0.61 4.26 0.61 4.1 0.61 c
            3.48 0.61 l
            3.48 1.69 l
            4.26 1.69 l
            4.41 1.69 4.66 1.69 4.66 1.99 c
            2.92 2.3 m
            0.7 2.3 l
            2.92 5.79 l
            h f
          }%
        \hfill
     }%
  }
\tlconstcn{c_@@_glyph_5_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.2 1.9 m
            4.2 2.91 3.43 3.89 2.25 3.89 c
            1.9 3.89 1.46 3.82 1.05 3.6 c
            1.05 5.5 l
            3.45 5.5 l
            3.6 5.5 3.85 5.5 3.85 5.8 c
            3.85 6.11 3.61 6.11 3.45 6.11 c
            0.76 6.11 l
            0.43 6.11 0.36 6.02 0.36 5.7 c
            0.36 3.04 l
            0.36 2.86 0.36 2.63 0.68 2.63 c
```

```
            0.86 2.63 0.9 2.68 0.98 2.78 c
            1.25 3.1 1.66 3.28 2.24 3.28 c
            3.06 3.28 3.51 2.55 3.51 1.9 c
            3.51 1.1 2.8 0.5 1.96 0.5 c
            1.68 0.5 1.04 0.58 0.76 1.13 c
            0.81 1.18 0.89 1.25 0.89 1.45 c
            0.89 1.74 0.66 1.9 0.45 1.9 c
            0.3 1.9 0.0 1.81 0.0 1.42 c
            0.0 0.59 0.84 -0.11 1.96 -0.11 c
            3.21 -0.11 4.2 0.79 4.2 1.9 c
            h f
          }%
        \hfill
      }%
  }
\tlconstcn{c_@@_glyph_6_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.18 1.93 m
            4.18 3.07 3.3 3.96 2.2 3.96 c
            1.68 3.96 1.16 3.79 0.71 3.38 c
            0.85 4.79 1.79 5.61 2.67 5.61 c
            3.01 5.61 3.17 5.5 3.22 5.45 c
            3.17 5.4 3.12 5.34 3.12 5.16 c
            3.12 4.92 3.3 4.72 3.56 4.72 c
            3.81 4.72 4.01 4.89 4.01 5.19 c
            4.01 5.68 3.65 6.22 2.68 6.22 c
            1.34 6.22 0.0 5.01 0.0 2.99 c
            0.0 0.62 1.12 -0.11 2.11 -0.11 c
            3.2 -0.11 4.18 0.73 4.18 1.93 c
            3.49 1.93 m
            3.49 1.07 2.83 0.5 2.11 0.5 c
            1.46 0.5 1.07 0.99 0.87 1.6 c
            0.77 1.84 0.79 2.08 0.79 2.22 c
            0.79 2.84 1.39 3.34 2.15 3.34 c
            2.96 3.34 3.49 2.67 3.49 1.93 c
            h f
          }%
        \hfill
      }%
  }
\tlconstcn{c_@@_glyph_7_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.36 5.8 m
            4.36 6.11 4.12 6.11 3.96 6.11 c
            0.66 6.11 l
            0.6 6.27 0.42 6.27 0.34 6.27 c
            0.0 6.27 0.0 6.05 0.0 5.86 c
            0.0 5.44 l
            0.0 5.25 0.0 5.03 0.34 5.03 c
            0.69 5.03 0.69 5.22 0.69 5.5 c
            3.33 5.5 l
            1.6 3.66 1.26 1.46 1.26 0.36 c
            1.26 0.22 1.26 -0.11 1.61 -0.11 c
```

```
            1.78 -0.11 1.95 0.0 1.95 0.29 c
            2.0 3.13 3.53 4.87 4.14 5.46 c
            4.34 5.64 4.36 5.66 4.36 5.8 c
            h f
          }%
        \hfill
      }%
  }
\tlconstcn{c_@@_glyph_8_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.36 1.74 m
            4.36 2.49 3.71 3.08 2.97 3.29 c
            3.77 3.56 4.22 4.05 4.22 4.62 c
            4.22 5.44 3.37 6.22 2.18 6.22 c
            0.98 6.22 0.14 5.43 0.14 4.62 c
            0.14 4.05 0.6 3.55 1.39 3.29 c
            0.64 3.08 0.0 2.49 0.0 1.74 c
            0.0  0.77 0.93 -0.11 2.18 -0.11 c
            3.44 -0.11 4.36 0.77 4.36 1.74 c
            3.53 4.61 m
            3.53 4.04 2.91 3.6 2.18 3.6 c
            1.45 3.6 0.83 4.05 0.83 4.61 c
            0.83 5.13 1.39 5.61 2.18 5.61 c
            2.96 5.61 3.53 5.13 3.53 4.61 c
            3.67 1.75 m
            3.67 1.06 3.01 0.5 2.18 0.5 c
            1.35 0.5 0.69 1.06 0.69 1.75 c
            0.69 2.36 1.27 2.99 2.18 2.99 c
            3.1 2.99 3.67 2.36 3.67 1.75 c
            h f
          }%
        \hfill
      }%
  }
\tlconstcn{c_@@_glyph_9_tl}
  {%
    \hbox to 5pt
      {%
        \hfill
        \pdfextension literal
          {
            4.18 3.12 m
            4.18 5.53 3.07 6.22 2.12 6.22 c
            1.01 6.22 0.0 5.39 0.0 4.18 c
            0.0 3.04 0.88 2.15 1.98 2.15 c
            2.5 2.15 3.02 2.32 3.47 2.73 c
            3.37 1.49 2.59 0.5 1.63 0.5 c
            1.54 0.5 1.18 0.51 0.97 0.67 c
            1.01 0.72 1.06 0.78 1.06 0.95 c
            1.06 1.19 0.88 1.39 0.62 1.39 c
            0.37 1.39 0.17 1.22 0.17 0.92 c
            0.17 0.6 0.35 -0.11 1.63 -0.11 c
            2.95 -0.11 4.18 1.14 4.18 3.12 c
            3.4 3.89 m
            3.4 3.34 2.86 2.77 2.03 2.77 c
            1.22 2.77 0.69 3.44 0.69 4.18 c
            0.69 5.05 1.4 5.61 2.12 5.61 c
            2.55 5.61 2.83 5.38 2.99 5.18 c
```

```
            3.31 4.79 3.4 4.6 3.4 3.89 c
            h f
          }%
        \hfill
      }%
  }
\ExplSyntaxOn
% \end{macrocode}
%
% \bigskip
% \subsection{We load piton.lua}
%
%
% \bigskip
%    \begin{macrocode}
\cs_new_protected:Npn \@@_test_version:n #1
  {
    \str_if_eq:onF \PitonFileVersion { #1 }
      { \@@_error:n { bad~version~of~piton.lua } }
  }


\hook_gput_code:nnn { begindocument } { . }
  {
    \lua_load_module:n { piton }
    \lua_now:n
      {
        tex.sprint ( luatexbase.catcodetables.expl ,
                     [[\@@_test_version:n {]] .. piton_version ..  "}" )
      }
  }
```

</STY>

3 The Lua part of the implementation

The Lua code will be loaded via a `{luacode*}` environment. The environment is by itself a Lua block and the local declarations will be local to that block. All the global functions (used by the L3 parts of the implementation) will be put in a Lua table called `piton`.

```
⟨*LUA⟩
piton.comment_latex = piton.comment_latex or ">"
piton.comment_latex = "#" .. piton.comment_latex
```

The table `piton.write_files` will contain the contents of all the files that we will write on the disk in the `\AtEndDocument` (if the user has used the key `write-file`). The table `piton.join_files` is similar for the key `join`.

```
piton.write_files = { }
piton.join_files = { }


local sprintL3
function sprintL3 ( s )
  tex.sprint ( luatexbase.catcodetables.expl , s )
end
```

3.1 Special functions dealing with LPEG

We will use the Lua library lpeg which is built in LuaTeX. That's why we define first aliases for several functions of that library.

```
local P, S, V, C, Ct, Cc = lpeg.P, lpeg.S, lpeg.V, lpeg.C, lpeg.Ct, lpeg.Cc
local Cg , Cmt , Cb = lpeg.Cg , lpeg.Cmt , lpeg.Cb
local B , R = lpeg.B , lpeg.R
```

The following line is mandatory.

```
lpeg.locale(lpeg)
```

3.2 The functions Q, K, WithStyle, etc.

The function `Q` takes in as argument a pattern and returns a LPEG *which does a capture* of the pattern. That capture will be sent to LaTeX with the catcode "other" for all the characters: it's suitable for elements of the computer listings that piton will typeset verbatim (thanks to the catcode "other").

```
local Q
function Q ( pattern )
  return Ct ( Cc ( luatexbase.catcodetables.other ) * C ( pattern ) )
end
```

The function `L` takes in as argument a pattern and returns a LPEG *which does a capture* of the pattern. That capture will be sent to LaTeX with standard LaTeX catcodes for all the characters: the elements captured will be formatted as normal LaTeX codes. It's suitable for the "LaTeX comments" in the environments `{Piton}` and the elements between `begin-escape` and `end-escape`. That function won't be much used.

```
local L
function L ( pattern ) return
  Ct ( C ( pattern ) )
end
```

The function `Lc` (the c is for *constant*) takes in as argument a string and returns a LPEG *with does a constant capture* which returns that string. The elements captured will be formatted as L3 code. It will be used to send to LaTeX all the formatting LaTeX instructions we have to insert in order to do the syntactic highlighting (that's the main job of piton). That function, unlike the previous one, will be widely used.

```
local Lc
function Lc ( string ) return
  Cc ( { luatexbase.catcodetables.expl , string } )
end
```

The function `K` creates a LPEG which will return as capture the whole LaTeX code corresponding to a Python chunk (that is to say with the LaTeX formatting instructions corresponding to the syntactic nature of that Python chunk). The first argument is a Lua string corresponding to the name of a piton style and the second element is a pattern (that is to say a LPEG without capture)

```
local K
function K ( style , pattern ) return
  Lc ( [[ {\PitonStyle{ ]] .. style .. "}{" )
  * Q ( pattern )
  * Lc "}}"
end
```

The formatting commands in a given piton style (eg. the style `Keyword`) may be semi-global declarations (such as `\bfseries` or `\slshape`) or LaTeX macros with an argument (such as `\fbox` or `\colorbox{yellow}`). In order to deal with both syntaxes, we have used two pairs of braces: `{\PitonStyle{Keyword}{`*`text to format`*`}}`.

The following function `WithStyle` is similar to the function `K` but should be used for multi-lines elements.

```
local WithStyle
function WithStyle ( style , pattern ) return
    Ct ( Cc "Open" * Cc ( [[{\PitonStyle{]] .. style .. "}{" ) * Cc "}}" )
  * pattern
  * Ct ( Cc "Close" )
end
```

The following LPEG catches the Python chunks which are in LaTeX escapes (and that chunks will be considered as normal LaTeX constructions).

```
Escape = P ( false )
EscapeClean = P ( false )
if piton.begin_escape then
  Escape =
    P ( piton.begin_escape )
    * L ( ( 1 - P ( piton.end_escape ) ) ^ 1 )
    * P ( piton.end_escape )
```

The LPEG `EscapeClean` will be used in the LPEG Clean (and that LPEG is used to "clean" the code by removing the formatting elements).

```
  EscapeClean =
    P ( piton.begin_escape )
    * ( 1 - P ( piton.end_escape ) ) ^ 1
    * P ( piton.end_escape )
end
EscapeMath = P ( false )
if piton.begin_escape_math then
  EscapeMath =
    P ( piton.begin_escape_math )
    * Lc "$"
    * L ( ( 1 - P(piton.end_escape_math) ) ^ 1 )
    * Lc "$"
    * P ( piton.end_escape_math )
end
```

The basic syntactic LPEG

```
local alpha , digit = lpeg.alpha , lpeg.digit
local space = P " "
```

Remember that, for LPEG, the Unicode characters such as à, â, ç, etc. are in fact strings of length 2 (2 bytes) because lpeg is not Unicode-aware.

```
local letter = alpha + "_" + "â" + "à" + "ç" + "é" + "è" + "ê" + "ë" + "ï" + "î"
                     + "ô" + "û" + "ü" + "Â" + "À" + "Ç" + "É" + "È" + "Ê" + "Ë"
                     + "Ï" + "Î" + "Ô" + "Û" + "Ü"

local alphanum = letter + digit
```

The following LPEG `identifier` is a mere pattern (that is to say more or less a regular expression) which matches the Python identifiers (hence the name).

```
local identifier = letter * alphanum ^ 0
```

On the other hand, the LPEG `Identifier` (with a capital) also returns a *capture*.

```
local Identifier = K ( 'Identifier.Internal' , identifier )
```

By convention, we will use names with an initial capital for LPEG which return captures.

The following functions allow to recognize numbers that contains _ among their digits, for example 1_000_000, but also floating point numbers, numbers with exponents and numbers with different bases.[3]

```
local allow_underscores_except_first
function allow_underscores_except_first ( p )
    return p * (P "_" + p)^0
end
local allow_underscores
function allow_underscores ( p )
    return (P "_" + p)^0
end
local digits_to_number
function digits_to_number(prefix, digits)
    -- The edge cases of what is allowed in number litterals is modelled after
    -- OCaml numbers, which seems to be the most permissive language
    -- in this regard (among C, OCaml, Python & SQL).
    return prefix
        * allow_underscores_except_first(digits^1)
        * (P "." * #(1 - P ".") * allow_underscores(digits))^-1
        * (S "eE" * S "+-"^-1 * allow_underscores_except_first(digits^1))^-1
end
```

Here is the first use of our function K. That function will be used to construct LPEG which capture Python chunks for which we have a dedicated piton style. For example, for the numbers, piton provides a style which is called Number. The name of the style is provided as a Lua string in the second argument of the function K. By convention, we use single quotes for delimiting the Lua strings which are names of piton styles (but this is only a convention).

```
local Number =
  K ( 'Number.Internal' ,
      digits_to_number (P "0x" + P "0X", R "af" + R "AF" + digit)
      + digits_to_number (P "0o" + P "0O", R "07")
      + digits_to_number (P "0b" + P "0B", R "01")
      + digits_to_number ( "" , digit )
    )
```

We will now define the LPEG Word.
We have a problem in the following LPEG because, obviously, we should adjust the list of symbols with the delimiters of the current language (no?).

```
local lpeg_central = 1 - S " '\"\r[({})]" - digit
```

We recall that piton.begin_escape and piton_end_escape are Lua strings corresponding to the keys begin-escape and end-escape.

```
if piton.begin_escape then
  lpeg_central = lpeg_central - piton.begin_escape
end
if piton.begin_escape_math then
  lpeg_central = lpeg_central - piton.begin_escape_math
end
local Word = Q ( lpeg_central ^ 1 )


local Space = Q " " ^ 1
local SkipSpace = Q " " ^ 0

local Punct = Q ( S ".,:;!" )

local Tab = "\t" * Lc [[ \@@_tab: ]]
```

[3]The edge cases such as

```
local LeadingSpace = Lc [[ \@@_leading_space: ]] * P " "
```

```
local Delim = Q ( S "[({})]" )
```

The following LPEG catches a space (U+0020) and replaces it by `\l_@@_space_in_string_tl`. It will be used in the strings. Usually, `\l_@@_space_in_string_tl` will contain a space and therefore there won't be any difference. However, when the key `show-spaces-in-strings` is in force, `\\l_@@_space_in_string_tl` will contain ␣ (U+2423) in order to visualize the spaces.

```
local SpaceInString = space * Lc [[ \l_@@_space_in_string_tl ]]
```

3.3 The option 'detected-commands' and al.

We create four Lua tables called `detected_commands`, `raw_detected_commands`, `beamer_commands` and `beamer_environments`.
On the TeX side, the corresponding data have first been stored as clists.
Then, in a `\AtBeginDocument`, they have been converted in "toks registers" of TeX.
Now, on the Lua side, we are able to access to those "toks registers" with the special pseudo-table `tex.toks` of LuaTeX.
Remark that we can safely use `explode(',')` to convert such "toks registers" in Lua tables since, in a clist of L3, there is no empty component and, for each component, there is no space on both sides (the `explode` of the Lua of LuaTeX is unable to do itself such purification of the components).

```
local detected_commands = tex.toks.PitonDetectedCommands : explode ( ',' )
local raw_detected_commands = tex.toks.PitonRawDetectedCommands : explode ( ',' )
local beamer_commands = tex.toks.PitonBeamerCommands : explode ( ',' )
local beamer_environments = tex.toks.PitonBeamerEnvironments : explode ( ',' )
```

We will also create some LPEG.
According to our conventions, a LPEG with a name in camelCase is a LPEG which doesn't do any capture.

```
local detectedCommands = P ( false )
for _ , x in ipairs ( detected_commands ) do
  detectedCommands = detectedCommands + P ( "\\" .. x )
end
```

Further, we will have a LPEG called `DetectedCommands` (in PascalCase) which will be a LPEG *with* captures.

```
local rawDetectedCommands = P ( false )
for _ , x in ipairs ( raw_detected_commands ) do
  rawDetectedCommands = rawDetectedCommands + P ( "\\" .. x )
end

local beamerCommands = P ( false )
for _ , x in ipairs ( beamer_commands ) do
  beamerCommands = beamerCommands + P ( "\\" .. x )
end

local beamerEnvironments = P ( false )
for _ , x in ipairs ( beamer_environments ) do
  beamerEnvironments = beamerEnvironments + P ( x )
end
```

Several tools for the construction of the main LPEG

```
local LPEG0 = { }
local LPEG1 = { }
local LPEG2 = { }
local LPEG_cleaner = { }
```

For each language, we will need a pattern to match expressions with balanced braces. Those balanced braces must *not* take into account the braces present in strings of the language. However, the syntax for the strings is language-dependent. That's why we write a Lua function `Compute_braces` which will compute the pattern by taking in as argument a pattern for the strings of the language (at least the shorts strings). The argument of `Compute_braces` must be a pattern *which does no captures*.

```
local Compute_braces
function Compute_braces ( lpeg_string ) return
  P { "E" ,
      E =
          (
            "{" * V "E" * "}"
            +
            lpeg_string
            +
            ( 1 - S "{}" )
          ) ^ 0
    }
end
```

The following Lua function will compute the lpeg `DetectedCommands` which is a LPEG with captures.

```
local Compute_DetectedCommands
function Compute_DetectedCommands ( lang , braces ) return
  Ct (
      Cc "Open"
       * C ( detectedCommands * space ^ 0 * P "{" )
       * Cc "}"
    )
   * ( braces
      / ( function ( s )
            if s ~= '' then return
              LPEG1[lang] : match ( s )
            end
          end )
    )
   * P "}"
   * Ct ( Cc "Close" )
end
```

```
local Compute_RawDetectedCommands
function Compute_RawDetectedCommands ( lang , braces ) return
  Ct ( C ( rawDetectedCommands * space ^ 0 * P "{" * braces * P "}" ) )
end
```

```
local Compute_LPEG_cleaner
function Compute_LPEG_cleaner ( lang , braces ) return
  Ct ( ( ( detectedCommands + rawDetectedCommands ) * "{"
         * ( braces
             / ( function ( s )
                   if s ~= '' then return
                     LPEG_cleaner[lang] : match ( s )
                   end
                 end )
           )
         * "}"
       + EscapeClean
```

```
          +  C ( P ( 1 ) )
        ) ^ 0 ) / table.concat
end
```

The following function `ParseAgain` will be used in the definitions of the LPEG of the different computer languages when we will need to *parse again* a small chunk of code. It's a way to avoid the use of a actual *grammar* of LPEG (in a sens, a recursive regular expression).
Remark that there is no piton style associated to a chunk of code which is analyzed by `ParseAgain`. If we wish a piton style available to the end user (if he wish to format that element with a uniform font instead of an analyze by `ParseAgain`), we have to use `\@@_piton:n`.

```
local ParseAgain
function ParseAgain ( code )
  if code ~= '' then return
```

The variable `piton.language` is set in the function `piton.Parse`.

```
    LPEG1[piton.language] : match ( code )
  end
end
```

Constructions for Beamer If the class Beamer is used, some environments and commands of Beamer are automatically detected in the listings of piton.

```
local Beamer = P ( false )
```

The following Lua function will be used to compute the LPEG `Beamer` for each computer language. According to our conventions, the LPEG `Beamer`, with its name in PascalCase does captures.

```
local Compute_Beamer
function Compute_Beamer ( lang , braces )
```

We will compute in `lpeg` the LPEG that we will return.

```
  local lpeg = L ( P [[\pause]] * ( "[" * ( 1 - P "]" ) ^ 0 * "]" ) ^ -1 )
  lpeg = lpeg +
      Ct ( Cc "Open"
            * C ( beamerCommands
                  * ( "<" * ( 1 - P ">" ) ^ 0 * ">" ) ^ -1
                  * P "{"
                )
            * Cc "}"
          )
       * ( braces /
           ( function ( s ) if s ~= '' then return LPEG1[lang] : match ( s ) end end ) )
       * "}"
       * Ct ( Cc "Close" )
```

For the command `\alt`, the specification of the overlays (between angular brackets) is mandatory.

```
  lpeg = lpeg +
    L ( P [[\alt]] * "<" * ( 1 - P ">" ) ^ 0 * ">{" )
     * ( braces /
         ( function ( s ) if s ~= '' then return LPEG1[lang] : match ( s ) end end ) )
     * L ( P "}{" )
     * ( braces /
         ( function ( s ) if s ~= '' then return LPEG1[lang] : match ( s ) end end ) )
     * L ( P "}" )
```

For `\temporal`, the specification of the overlays (between angular brackets) is mandatory.

```
  lpeg = lpeg +
      L ( P [[\temporal]] * "<" * ( 1 - P ">" ) ^ 0 * ">{" )
      * ( braces
          / ( function ( s )
              if s ~= '' then return LPEG1[lang] : match ( s ) end end ) )
      * L ( P "}{" )
      * ( braces
          / ( function ( s )
              if s ~= '' then return LPEG1[lang] : match ( s ) end end ) )
      * L ( P "}{" )
      * ( braces
          / ( function ( s )
              if s ~= '' then return LPEG1[lang] : match ( s ) end end ) )
      * L ( P "}" )
```

Now, the environments of Beamer.

```
  for _ , x in ipairs ( beamer_environments ) do
    lpeg = lpeg +
          Ct ( Cc "Open"
               * C (
                     P ( [[\begin{]] .. x .. "}" )
                        * ( "<" * ( 1 - P ">") ^ 0 * ">" ) ^ -1
                   )
               * space ^ 0 * ( P "\r" ) ^ 1 -- added 25/08/23
              * Cc ( [[\end{]] .. x ..  "}" )
              )
          * (
```

We catch all the content of the Beamer environment which a LPEG which is a grammar because t here may be nested environments of the same type (added 2025/11/14).

```
                (
                  P { "E" ,
                       E = (
                             P ( [[\begin{]] .. x .. "}" )
                              * V "E"
                              * P ( [[\end{]] .. x .. "}" )
                             +
                              (
                               1
                               - P ( [[\begin{]] .. x .. "}" )
                               - P ( [[\end{]] .. x .. "}" )
                              )
                            ) ^ 0
                    }
                )
                   / ( function ( s )
                         if s ~= '' then return
                           LPEG1[lang] : match ( s )
                         end
                       end )
            )
          * P ( [[\end{]] .. x .. "}" )
          * Ct ( Cc "Close" )
  end
```

Now, you can return the value we have computed.

```
  return lpeg
end
```

The following LPEG is in relation with the key `math-comments`. It will be used in all the languages.

```
local CommentMath =
  P "$" * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1  ) * P "$" -- $
```

EOL There may be empty lines in the transcription of the prompt, *id est* lines of the form `...` without space after and that's why we need `P " " ^ -1` with the `^ -1`.

```
local Prompt =
  K ( 'Prompt' , ( P ">>>" + "..." ) * P " " ^ -1 )
  *  Lc [[ \rowcolor { \l_@@_prompt_bg_color_tl } ]]
```

The following LPEG `EOL` is for the end of lines.

```
local EOL =
  P "\r"
  *
  (
    space ^ 0 * -1
    +
    Cc "EOL"
  )
  * ( LeadingSpace ^ 0 * # ( 1 - S " \r" ) ) ^ -1
```

The following LPEG `CommentLaTeX` is for what is called in that document the "LaTeX comments".

```
local CommentLaTeX =
  P ( piton.comment_latex )
  * Lc [[{\PitonStyle{Comment.LaTeX}{\ignorespaces]]
  * L ( ( 1 - P "\r" ) ^ 0 )
  * Lc "}}"
  * ( EOL + -1 )
```

3.4 The language Python

We open a Lua local scope for the language Python (of course, there will be also global definitions).

```
--python Python
do
```

Some strings of length 2 are explicit because we want the corresponding ligatures available in some fonts such as *Fira Code* to be active.

```
  local Operator =
    K ( 'Operator' ,
        P "!=" + "<>" + "==" + "<<" + ">>" + "<=" + ">=" + ":=" + "//" + "**"
        + S "-~+/*%=<>&.@|" )

  local OperatorWord =
    K ( 'Operator.Word' , P "in" + "is" + "and" + "or" + "not" )
```

The keyword `in` in a construction such as "`for i in range(n)`" must be formatted as a keyword and not as an `Operator.Word` and that's why we write the following LPEG `For`.

```
  local For = K ( 'Keyword' , P "for" )
              * Space
              * Identifier
              * Space
              * K ( 'Keyword' , P "in" )

  local Keyword =
    K ( 'Keyword' ,
        P  "assert" + "as" + "break" + "case" + "class" + "continue" + "def" +
        "del" + "elif" + "else" + "except" + "exec" + "finally" + "for" + "from" +
        "global" + "if" + "import" + "lambda" + "non local" + "pass" + "return" +
        "try" + "while" + "with" + "yield" + "yield from" )
    + K ( 'Keyword.Constant' , P "True" + "False" + "None" )

  local Builtin =
    K ( 'Name.Builtin' ,
```

```
        P "__import__" + "abs" + "all" + "any" + "bin" + "bool" + "bytearray" +
        "bytes" + "chr" + "classmethod" + "compile" + "complex" + "delattr" +
        "dict" + "dir" + "divmod" + "enumerate" + "eval" + "filter" + "float" +
        "format" + "frozenset" + "getattr" + "globals" + "hasattr" + "hash" +
        "hex" + "id" + "input" + "int" + "isinstance" + "issubclass" + "iter" +
        "len" + "list" + "locals" + "map" + "max" + "memoryview" + "min" + "next"
        + "object" + "oct" + "open" + "ord" + "pow" + "print" + "property" +
        "range" + "repr" + "reversed" + "round" + "set" + "setattr" + "slice" +
        "sorted" + "staticmethod" + "str" + "sum" + "super" + "tuple" + "type" +
        "vars" + "zip" )

  local Exception =
    K ( 'Exception' ,
        P "ArithmeticError" + "AssertionError" + "AttributeError" +
        "BaseException" + "BufferError" + "BytesWarning" + "DeprecationWarning" +
        "EOFError" + "EnvironmentError" + "Exception" + "FloatingPointError" +
        "FutureWarning" + "GeneratorExit" + "IOError" + "ImportError" +
        "ImportWarning" + "IndentationError" + "IndexError" + "KeyError" +
        "KeyboardInterrupt" + "LookupError" + "MemoryError" + "NameError" +
        "NotImplementedError" + "OSError" + "OverflowError" +
        "PendingDeprecationWarning" + "ReferenceError" + "ResourceWarning" +
        "RuntimeError" + "RuntimeWarning" + "StopIteration" + "SyntaxError" +
        "SyntaxWarning" + "SystemError" + "SystemExit" + "TabError" + "TypeError"
        + "UnboundLocalError" + "UnicodeDecodeError" + "UnicodeEncodeError" +
        "UnicodeError" + "UnicodeTranslateError" + "UnicodeWarning" +
        "UserWarning" + "ValueError" + "VMSError" + "Warning" + "WindowsError" +
        "ZeroDivisionError" + "BlockingIOError" + "ChildProcessError" +
        "ConnectionError" + "BrokenPipeError" + "ConnectionAbortedError" +
        "ConnectionRefusedError" + "ConnectionResetError" + "FileExistsError" +
        "FileNotFoundError" + "InterruptedError" + "IsADirectoryError" +
        "NotADirectoryError" + "PermissionError" + "ProcessLookupError" +
        "TimeoutError" + "StopAsyncIteration" + "ModuleNotFoundError" +
        "RecursionError" )

  local RaiseException = K ( 'Keyword' , P "raise" ) * SkipSpace * Exception * Q "("
```

In Python, a "decorator" is a statement whose begins by `@` which patches the function defined in the following statement.

```
  local Decorator = K ( 'Name.Decorator' , P "@" * letter ^ 1  )
```

The following LPEG `DefClass` will be used to detect the definition of a new class (the name of that new class will be formatted with the piton style `Name.Class`).

Example: `class myclass:`

```
  local DefClass =
    K ( 'Keyword' , "class" ) * Space * K ( 'Name.Class' , identifier )
```

If the word `class` is not followed by a identifier, it will be caught as keyword by the LPEG `Keyword` (useful if we want to type a list of keywords).

The following LPEG `ImportAs` is used for the lines beginning by `import`. We have to detect the potential keyword `as` because both the name of the module and its alias must be formatted with the piton style `Name.Namespace`.

Example: `import numpy as np`

Moreover, after the keyword `import`, it's possible to have a comma-separated list of modules (if the keyword `as` is not used).

Example: `import math, numpy`

```
  local ImportAs =
    K ( 'Keyword' , "import" )
     * Space
     * K ( 'Name.Namespace' , identifier * ( "." * identifier ) ^ 0 )
     * (
```

```
        ( Space * K ( 'Keyword' , "as" ) * Space
           * K ( 'Name.Namespace' , identifier ) )
        +
        ( SkipSpace * Q "," * SkipSpace
           * K ( 'Name.Namespace' , identifier ) ) ^ 0
      )
```

Be careful: there is no commutativity of + in the previous expression.

The LPEG `FromImport` is used for the lines beginning by `from`. We need a special treatment because the identifier following the keyword `from` must be formatted with the piton style `Name.Namespace` and the following keyword `import` must be formatted with the piton style `Keyword` and must *not* be caught by the LPEG `ImportAs`.

Example: `from math import pi`

```
local FromImport =
  K ( 'Keyword' , "from" )
    * Space * K ( 'Name.Namespace' , identifier )
    * Space * K ( 'Keyword' , "import" )
```

The strings of Python For the strings in Python, there are four categories of delimiters (without counting the prefixes for f-strings and raw strings). We will use, in the names of our LPEG, prefixes to distinguish the LPEG dealing with that categories of strings, as presented in the following tabular.

	Single	Double
Short	`'text'`	`"text"`
Long	`'''test'''`	`"""text"""`

We have also to deal with the interpolations in the f-strings. Here is an example of a f-string with an interpolation and a format instruction[4] in that interpolation:
`\piton{f'Total price: {total+1:.2f} €'}`

The interpolations beginning by % (even though there is more modern techniques now in Python).

```
local PercentInterpol =
  K ( 'String.Interpol' ,
      P "%"
      * ( "(" * alphanum ^ 1 * ")" ) ^ -1
      * ( S "-#0 +" ) ^ 0
      * ( digit ^ 1 + "*" ) ^ -1
      * ( "." * ( digit ^ 1 + "*" ) ) ^ -1
      * ( S "HlL" ) ^ -1
      * S "sdfFeExXorgiGauc%"
    )
```

We can now define the LPEG for the four kinds of strings. It's not possible to use our function `K` because of the interpolations which must be formatted with another piton style that the rest of the string.[5]

```
local SingleShortString =
  WithStyle ( 'String.Short.Internal' ,
```

[4] There is no special piton style for the formatting instruction (after the colon): the style which will be applied will be the style of the encompassing string, that is to say `String.Short` or `String.Long`.

[5] The interpolations are formatted with the piton style `Interpol.Inside`. The initial value of that style is `\@@_piton:n` which means that the interpolations are parsed once again by piton.

First, we deal with the f-strings of Python, which are prefixed by `f` or `F`.

```
        Q ( P "f'" + "F'" )
        * (
            K ( 'String.Interpol' , "{" )
             * K ( 'Interpol.Inside' , ( 1 - S "}':" ) ^ 0  )
             * Q ( P ":" * ( 1 - S "}:'" ) ^ 0 ) ^ -1
             * K ( 'String.Interpol' , "}" )
            +
            SpaceInString
            +
            Q ( ( P "\\'" + "\\\\" + "{{" + "}}" + 1 - S " {}'" ) ^ 1 )
          ) ^ 0
        * Q "'"
      +
```

Now, we deal with the standard strings of Python, but also the "raw strings".

```
        Q ( P "'" + "r'" + "R'" )
        * ( Q ( ( P "\\'" + "\\\\" + 1 - S " '\r%" ) ^ 1 )
            + SpaceInString
            + PercentInterpol
            + Q "%"
          ) ^ 0
        * Q "'" )
local DoubleShortString =
  WithStyle ( 'String.Short.Internal' ,
        Q ( P "f\"" + "F\"" )
        * (
            K ( 'String.Interpol' , "{" )
              * K ( 'Interpol.Inside' , ( 1 - S "}\":" ) ^ 0 )
              * ( K ( 'String.Interpol' , ":" ) * Q ( (1 - S "}:\"") ^ 0 ) ) ^ -1
              * K ( 'String.Interpol' , "}" )
            +
            SpaceInString
            +
            Q ( ( P "\\\"" + "\\\\" + "{{" + "}}" + 1 - S " {}\"" ) ^ 1 )
           ) ^ 0
        * Q "\""
      +
        Q ( P "\"" + "r\"" + "R\"" )
        * ( Q ( ( P "\\\"" + "\\\\" + 1 - S " \"\r%" ) ^ 1 )
            + SpaceInString
            + PercentInterpol
            + Q "%"
          ) ^ 0
        * Q "\""  )

local ShortString = SingleShortString + DoubleShortString
```

Beamer The argument of `Compute_braces` must be a pattern *which does no catching* corresponding to the strings of the language.

```
local braces =
  Compute_braces
   (
       ( P "\"" + "r\"" + "R\"" + "f\"" + "F\"" )
          * ( P '\\\"' + 1 - S "\"" ) ^ 0 * "\""
     +
       ( P '\'' + 'r\'' + 'R\'' + 'f\'' + 'F\'' )
          * ( P '\\\'' + 1 - S '\'' ) ^ 0 * '\''
   )

if piton.beamer then Beamer = Compute_Beamer ( 'python' , braces ) end
```

Detected commands

```
DetectedCommands = Compute_DetectedCommands ( 'python' , braces )
    + Compute_RawDetectedCommands ( 'python' , braces )
```

LPEG_cleaner

```
LPEG_cleaner.python = Compute_LPEG_cleaner ( 'python' , braces )
```

The long strings

```
local SingleLongString =
  WithStyle ( 'String.Long.Internal' ,
     ( Q ( S "fF" * P "'''" )
         * (
             K ( 'String.Interpol' , "{" )
               * K ( 'Interpol.Inside' , ( 1 - S "}:\r" - "'''" ) ^ 0  )
               * Q ( P ":" * (1 - S "}:\r" - "'''" ) ^ 0 ) ^ -1
               * K ( 'String.Interpol' , "}"  )
             +
             Q ( ( 1 - P "'''" - S "{}'\r" ) ^ 1 )
             +
             EOL
           ) ^ 0
       +
         Q ( ( S "rR" ) ^ -1  * "'''" )
         * (
             Q ( ( 1 - P "'''" - S "\r%" ) ^ 1 )
             +
             PercentInterpol
             +
             P "%"
             +
             EOL
           ) ^ 0
      )
      * Q "'''"  )
local DoubleLongString =
  WithStyle ( 'String.Long.Internal' ,
     (
       Q ( S "fF" * "\"\"\"" )
       * (
           K ( 'String.Interpol', "{"  )
             * K ( 'Interpol.Inside' , ( 1 - S "}:\r" - "\"\"\"" ) ^ 0 )
             * Q ( ":" * (1 - S "}:\r" - "\"\"\"" ) ^ 0 ) ^ -1
             * K ( 'String.Interpol' , "}"  )
           +
           Q ( ( 1 - S "{}\"\r" - "\"\"\"" ) ^ 1 )
           +
           EOL
         ) ^ 0
     +
       Q ( S "rR" ^ -1  * "\"\"\"" )
       * (
           Q ( ( 1 - P "\"\"\"" - S "%\r" ) ^ 1 )
           +
           PercentInterpol
           +
           P "%"
           +
           EOL
         ) ^ 0
```

```
      )
      * Q "\"\"\""
  )
local LongString = SingleLongString + DoubleLongString
```

We have a LPEG for the Python docstrings. That LPEG will be used in the LPEG `DefFunction` which deals with the whole preamble of a function definition (which begins with `def`).

```
local StringDoc =
    K ( 'String.Doc.Internal' , P "r" ^ -1 * "\"\"\"" )
      * ( K ( 'String.Doc.Internal' , (1 - P "\"\"\"" - "\r" ) ^ 0  ) * EOL
          * Tab ^ 0
        ) ^ 0
      * K ( 'String.Doc.Internal' , ( 1 - P "\"\"\"" - "\r" ) ^ 0 * "\"\"\"" )
```

The comments in the Python listings We define different LPEG dealing with comments in the Python listings.

```
local Comment =
  WithStyle
   ( 'Comment.Internal' ,
     Q "#" * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0  -- $
   )
  * ( EOL + -1 )
```

DefFunction The following LPEG `expression` will be used for the parameters in the *argspec* of a Python function. It's necessary to use a *grammar* because that pattern mainly checks the correct nesting of the delimiters (and it's known in the theory of formal languages that this can't be done with regular expressions *stricto sensu* only).

```
local expression =
  P { "E" ,
      E = ( "'" * ( P "\\'" + 1 - S "'\r" ) ^ 0 * "'"
            + "\"" * ( P "\\\"" + 1 - S "\"\r" ) ^ 0 * "\""
            + "{" * V "F" * "}"
            + "(" * V "F" * ")"
            + "[" * V "F" * "]"
            + ( 1 - S "{}()[]\r," ) ) ^ 0 ,
      F = (   "{" * V "F" * "}"
            + "(" * V "F" * ")"
            + "[" * V "F" * "]"
            + ( 1 - S "{}()[]\r\"'" ) ) ^ 0
    }
```

We will now define a LPEG `Params` that will catch the list of parameters (that is to say the *argspec*) in the definition of a Python function. For example, in the line of code

```
def MyFunction(a,b,x=10,n:int): return n
```

the LPEG `Params` will be used to catch the chunk `a,b,x=10,n:int`.

```
local Params =
  P { "E" ,
      E = ( V "F" * ( Q "," * V "F" ) ^ 0 ) ^ -1 ,
      F = SkipSpace * ( Identifier + Q "*args" + Q "**kwargs" ) * SkipSpace
          * ( Q ":" * SkipSpace * K ( 'Name.Type' , identifier ) ) ^ -1
          * ( SkipSpace * K ( 'InitialValues' , "=" * SkipSpace * expression ) ) ^ -1
    }
```

The following LPEG `DefFunction` catches a keyword `def` and the following name of function *but also everything else until a potential docstring.* That's why this definition of LPEG must occur (in the file `piton.sty`) after the definition of several other LPEG such as `Comment`, `CommentLaTeX`, `Params`, `StringDoc`...

```
local DefFunction =
  K ( 'Keyword' , "def" )
  * Space
  * K ( 'Name.Function.Internal' , identifier )
  * SkipSpace
  * Q "("  * Params * Q ")"
  * SkipSpace
  * ( Q "->" * SkipSpace * K ( 'Name.Type' , identifier ) ) ^ -1
  * ( C ( ( 1 - S ":\r" ) ^ 0 ) / ParseAgain )
  * Q ":"
  * ( SkipSpace
      * ( EOL + CommentLaTeX + Comment ) -- in all cases, that contains an EOL
      * Tab ^ 0
      * SkipSpace
      * StringDoc ^ 0 -- there may be additional docstrings
    ) ^ -1
```

Remark that, in the previous code, `CommentLaTeX` *must* appear before `Comment`: there is no commutativity of the addition for the *parsing expression grammars* (PEG).

If the word `def` is not followed by an identifier and parenthesis, it will be caught as keyword by the LPEG `Keyword` (useful if, for example, the end user wants to speak of the keyword **def**).

Miscellaneous

```
local ExceptionInConsole = Exception *  Q ( ( 1 - P "\r" ) ^ 0 ) * EOL
```

The main LPEG for the language Python

```
local EndKeyword
  = Space + Punct + Delim + EOL + Beamer + DetectedCommands + Escape +
  EscapeMath + -1
```

First, the main loop :

```
local Main =
     space ^ 0 * EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + Beamer
     + CommentLaTeX
     + DetectedCommands
     + Prompt
     + LongString
     + Comment
     + ExceptionInConsole
     + Delim
     + Operator
     + OperatorWord * EndKeyword
     + ShortString
     + Punct
     + FromImport
     + RaiseException
     + DefFunction
     + DefClass
     + For
     + Keyword * EndKeyword
     + Decorator
     + Builtin * EndKeyword
```

```
        + Identifier
        + Number
        + Word
```

Here, we must not put `local`, of course.

```
  LPEG1.python = Main ^ 0
```

We recall that each line in the Python code to parse will be sent back to LaTeX between a pair `\@@_begin_line:` – `\@@_end_line:`[6].

```
  LPEG2.python =
    Ct (
         ( space ^ 0 * "\r" ) ^ -1
         * Lc [[ \@@_begin_line: ]]
         * LeadingSpace ^ 0
         * ( space ^ 1 * -1 + Main ) ^ 0
         * -1
         * Lc [[ \@@_end_line: ]]
       )
```

End of the Lua scope for the language Python.

```
end
```

3.5 The language OCaml

We open a Lua local scope for the language OCaml (of course, there will be also global definitions).

```
--ocaml Ocaml OCaml
do


  local SkipSpace = ( Q " " + EOL ) ^ 0
  local Space = ( Q " " + EOL ) ^ 1


  local braces = Compute_braces ( '\"' * ( 1 - S "\"" ) ^ 0 * '\"' )


  if piton.beamer then Beamer = Compute_Beamer ( 'ocaml' , braces ) end
  DetectedCommands =
    Compute_DetectedCommands ( 'ocaml' , braces )
    + Compute_RawDetectedCommands ( 'ocaml' , braces )
  local Q
```

Usually, the following version of the function `Q` will be used without the second arguemnt (`strict`), that is to say in a loosy way. However, in some circunstancies, we will a need the "strict" version, for instance in `DefFunction`.

```
  function Q ( pattern, strict )
    if strict ~= nil then
      return Ct ( Cc ( luatexbase.catcodetables.CatcodeTableOther ) * C ( pattern ) )
    else
      return Ct ( Cc ( luatexbase.catcodetables.CatcodeTableOther ) * C ( pattern ) )
          + Beamer + DetectedCommands + EscapeMath + Escape
    end
  end
```

[6] Remember that the `\@@_end_line:` must be explicit because it will be used as marker in order to delimit the argument of the command `\@@_begin_line:`

```
local K
function K ( style , pattern, strict ) return
  Lc ( [[ {\PitonStyle{ ]] .. style .. "}{" )
  * Q ( pattern, strict )
  * Lc "}}"
end


local WithStyle
function WithStyle ( style , pattern ) return
    Ct ( Cc "Open" * Cc ( [[{\PitonStyle{]] .. style .. "}{" ) * Cc "}}" )
  * (pattern + Beamer + DetectedCommands + EscapeMath + Escape)
  * Ct ( Cc "Close" )
end
```

The following LPEG corresponds to the balanced expressions (balanced according to the parenthesis). Of course, we must write `(1 - S "()")` with outer parenthesis.

```
local balanced_parens =
  P { "E" , E = ( "(" * V "E" * ")" + ( 1 - S "()" ) ) ^ 0 }
```

The strings of OCaml

```
local ocaml_string =
  P "\""
* (
    P " "
    +
    P ( ( P '\\\"' + 1 - S " \"\r" ) ^ 1 )
    +
    EOL -- ?
  ) ^ 0
* P "\""
```

```
local String =
  WithStyle
    ( 'String.Long.Internal' ,
        Q "\""
      * (
          SpaceInString
          +
          Q ( ( P '\\\"' +  1 - S " \"\r" ) ^ 1 )
          +
          EOL
        ) ^ 0
      * Q "\""
    )
```

Now, the "quoted strings" of OCaml (for example `{ext|Essai|ext}`).
For those strings, we will do two consecutive analysis. First an analysis to determine the whole string and, then, an analysis for the potential visual spaces and the EOL in the string.
The first analysis require a match-time capture. For explanations about that programmation, see the paragraphe *Lua's long strings* in `www.inf.puc-rio.br/~roberto/lpeg`.

```
local ext = ( R "az" + "_" ) ^ 0
local open = "{" * Cg ( ext , 'init' ) * "|"
local close = "|" * C ( ext ) * "}"
local closeeq =
  Cmt ( close * Cb ( 'init' ) ,
        function ( s , i , a , b ) return a == b end )
```

The LPEG `QuotedStringBis` will do the second analysis.

```
local QuotedStringBis =
  WithStyle ( 'String.Long.Internal' ,
      (
        Space
        +
        Q ( ( 1 - S " \r" ) ^ 1 )
        +
        EOL
      ) ^ 0  )
```

We use a "function capture" (as called in the official documentation of the LPEG) in order to do the second analysis on the result of the first one.

```
local QuotedString =
  C ( open * ( 1 - closeeq ) ^ 0  * close ) /
  ( function ( s ) return QuotedStringBis : match ( s ) end )
```

In OCaml, the delimiters for the comments are `(*` and `*)`. There are unsymmetrical and OCaml allows those comments to be nested. That's why we need a grammar.
In these comments, we embed the math comments (between `$` and `$`) and we embed also a treatment for the end of lines (since the comments may be multi-lines).

```
local comment =
    P {
        "A" ,
        A = Q "(*"
            * ( V "A"
                + Q ( ( 1 - S "\r$\"" - "(*" - "*)" ) ^ 1 ) -- $
                + Q ( ocaml_string )
                + "$" * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1 ) * "$" -- $
                + EOL
              ) ^ 0
            * Q "*)"
      }
local Comment = WithStyle ( 'Comment.Internal' , comment )
```

Some standard LPEG

```
local Delim = K ( 'Delim' , P "[|" + "|]" + S "[()]" )
local Punct = K ( 'Punct' , S ",:;!" )
```

The identifiers caught by `cap_identifier` begin with a capital. In OCaml, it's used for the constructors of types and for the names of the modules.

```
local cap_identifier = R "AZ" * ( R "az" + R "AZ" + S "_'" + digit ) ^ 0
```

We consider `::` and `[]` as constructors (of the lists) as does the Tuareg mode of Emacs.

```
local Constructor =
  P "::"
```

Don't use `\hspace` instead of `\kern`

```
    * Lc [[{\PitonStyle{Name.Constructor}{\kern0.1em:\kern-0.2em:\kern0.1em}}]]
     +
    P "[]"
    * Lc ([[{\PitonStyle{Name.Constructor}{\kern-0.1em[\kern0.1em]}}]])
    K ( 'Name.Constructor' ,
        Q "`" ^ -1 * cap_identifier
        + Q ( "[" , true ) * SkipSpace * Q ( "]" , true) )


local ModuleType = K ( 'Name.Type' , cap_identifier )
```

```
local OperatorWord =
  K ( 'Operator.Word' ,
      P "asr" + "land" + "lor" + "lsl" + "lxor" + "mod" + "or" + "not" )
```

In OCaml, some keywords are considered as *governing keywords* with some special syntactic characteristics.

```
local governing_keyword = P "and" + "begin" + "class" + "constraint" +
      "end" + "external" + "functor" + "include" + "inherit" + "initializer" +
      "in" + "let" + "method" + "module" + "object" + "open" + "rec" + "sig" +
      "struct" + "type" + "val"


local Keyword =
  K ( 'Keyword' ,
      P "assert" + "as" + "done" + "downto" + "do" + "else" + "exception"
      + "for" + "function"  + "fun" + "if" + "lazy" + "match" + "mutable"
      + "new" + "of" + "private" + "raise" + "then" + "to" + "try"
      + "virtual" + "when" + "while" + "with" )
  + K ( 'Keyword.Constant' , P "true" + "false" )
  + K ( 'Keyword.Governing', governing_keyword )


local EndKeyword
  = Space + Punct + Delim + EOL + Beamer + DetectedCommands + Escape
     + EscapeMath + -1
```

Now, the identifier. Recall that we have also a LPEG `cap_identifier` for the indentifiers beginning with a capital letter.

```
local identifier = ( R "az" + "_" ) * ( R "az" + R "AZ" + S "_'" + digit ) ^ 0
                   - ( OperatorWord + Keyword ) * EndKeyword
```

We have the internal style `Identifier.Internal` in order to be able to implement the mechanism `\SetPitonIdentifier`. The final user has access to a style called `Identifier`.

```
local Identifier = K ( 'Identifier.Internal' , identifier )
```

In OCmal, *character* is a type different of the type `string`.

```
local ocaml_char =
    P "'" *
    (
      ( 1 - S "'\\" )
      + "\\"
        * ( S "\\'ntbr \""
            + digit * digit * digit
            + P "x" * ( digit + R "af" + R "AF" )
                    * ( digit + R "af" + R "AF" )
                    * ( digit + R "af" + R "AF" )
            + P "o" * R "03" * R "07" * R "07" )
    )
    * "'"
local Char =
  K ( 'String.Short.Internal', ocaml_char )
```

For the parameter of the types (for example : `` `\a `` as in `` `a list ``).

```
local TypeParameter =
  K ( 'TypeParameter' ,
      "'" * Q "_" ^ -1 * alpha ^ 1 * digit ^ 0 * ( # ( 1 - P "'" ) + -1 ) )
```

DotNotation Now, we deal with the notations with points (eg: `List.length`). In OCaml, such notation is used for the fields of the records and for the modules.

```
local DotNotation =
    (
        K ( 'Name.Module' , cap_identifier )
          * Q "."
          * ( Identifier + Constructor + Q "(" + Q "[" + Q "{" ) ^ -1
        +
         Identifier
          * Q "."
          * K ( 'Name.Field' , identifier )
    )
    * ( Q "." * K ( 'Name.Field' , identifier ) ) ^ 0
```

The records

```
local expression_for_fields_type =
  P { "E" ,
      E =  (  "{" * V "F" * "}"
            + "(" * V "F" * ")"
            + TypeParameter
            + ( 1 - S "{}()[]\r;" ) ) ^ 0 ,
      F = (    "{" * V "F" * "}"
            + "(" * V "F" * ")"
            + ( 1 - S "{}()[]\r\"'" ) + TypeParameter ) ^ 0
    }


local expression_for_fields_value =
  P { "E" ,
      E =  (   "{" * V "F" * "}"
            + "(" * V "F" * ")"
            + "[" * V "F" * "]"
            + ocaml_string + ocaml_char
            + ( 1 - S "{}()[];" ) ) ^ 0 ,
      F = (    "{" * V "F" * "}"
            + "(" * V "F" * ")"
            + "[" * V "F" * "]"
            + ocaml_string + ocaml_char
            + ( 1 - S "{}()[]\"'" )) ^ 0
    }


local OneFieldDefinition =
    ( K ( 'Keyword' , "mutable" ) * SkipSpace ) ^ -1
  * K ( 'Name.Field' , identifier ) * SkipSpace
  * Q ":" * SkipSpace
  * K ( 'TypeExpression' , expression_for_fields_type )
  * SkipSpace


local OneField =
    K ( 'Name.Field' , identifier ) * SkipSpace
  * Q "=" * SkipSpace
```

Don't forget the parentheses!

```
  * ( C ( expression_for_fields_value ) / ParseAgain )
  * SkipSpace
```

The *records*.

```
local RecordVal =
  Q "{" * SkipSpace
  *
    (
```

```
        (Identifier + DotNotation) * Space * K('Keyword', "with") * Space
      ) ^-1
    *
      (
        OneField * ( Q ";" * SkipSpace * ( Comment * SkipSpace ) ^ 0 * OneField ) ^ 0
      )
    * SkipSpace
    * Q ";" ^ -1
    * SkipSpace
    * Comment ^ -1
    * SkipSpace
    * Q "}"
  local RecordType =
    Q "{" * SkipSpace
    *
      (
        OneFieldDefinition
        * ( Q ";" * SkipSpace * ( Comment * SkipSpace ) ^ 0 * OneFieldDefinition ) ^ 0
      )
    * SkipSpace
    * Q ";" ^ -1
    * SkipSpace
    * Comment ^ -1
    * SkipSpace
    * Q "}"
  local Record = RecordType + RecordVal


  local Operator =
    P "||" *
```

Don't use `\hspace` instead of `\kern`!

```
    Lc([[{\PitonStyle{Operator}{\kern0.1em|\kern-0.2em|\kern0.1em}}]])
     +
    K ( 'Operator' ,
        P "!=" + "<>" + "==" + "<<" + ">>" + "<=" + ">=" + ":=" + "&&" +
        "//" + "**" + ";;" + "->" + "+." + "-." + "*." + "/."
        + S "-~+/*%=<>&@|" )


  local Builtin =
    K ( 'Name.Builtin' , P "incr" + "decr" + "fst" + "snd" + "ref" )


  local Exception =
    K (   'Exception' ,
        P "Division_by_zero" + "End_of_File" + "Failure" + "Invalid_argument" +
        "Match_failure" + "Not_found" + "Out_of_memory" + "Stack_overflow" +
        "Sys_blocked_io" + "Sys_error" + "Undefined_recursive_module" )


  LPEG_cleaner.ocaml = Compute_LPEG_cleaner ( 'ocaml' , braces )
```

An argument in the definition of a OCaml function may be of the form `(pattern:type)`. `pattern` may be a single identifier but it's not mandatory. First instance, it's possible to write in OCaml:
`let head (a::q) = a`
First, we write a pattern (in the LPEG sens!) to match what will be the pattern (in the OCaml sens).

```
  local pattern_part =
    ( P "(" * balanced_parens * ")" + ( 1 - S ":()" ) + P "::" ) ^ 0
```

For the "type" part, the LPEG-pattern will merely be `balanced_parens`.

We can now write a LPEG `Argument` which catches a argument of function (in the definition of the function).

```
  local Argument =
```

The following line is for the labels of the labeled arguments. Maybe we will, in the future, create a style for those elements.

```
    (  Q "~" * Identifier * Q ":" * SkipSpace ) ^ -1
    *
```

Now, the argument itself, either a single identifier, or a construction between parentheses

```
    (
        K ( 'Identifier.Internal' , identifier )
      +
        Q "(" * SkipSpace
        * ( C ( pattern_part ) / ParseAgain )
        * SkipSpace
```

Of course, the specification of type is optional.

```
       * ( Q ":" * #(1- P"=")
           * K ( 'TypeExpression' , balanced_parens ) * SkipSpace
         ) ^ -1
        * Q ")"
    )
```

Despite its name, the LPEG `DefFunction` deals also with `let open` which opens locally a module.

```
  local DefFunction =
    K ( 'Keyword.Governing' , "let open" )
    * Space
    * K ( 'Name.Module' , cap_identifier )
    +
    K ( 'Keyword.Governing' , P "let rec" + "let" + "and" )
      * Space
      * K ( 'Name.Function.Internal' , identifier )
      * Space
      * (
```

We use here the argument `strict` in order to allow a correct analyse of `let x = \uncover<2->{y}` (elsewhere, it's interpreted as a definition of a OCaml function).

```
          Q "=" * SkipSpace * K ( 'Keyword' , "function" , true )
          +
          Argument * ( SkipSpace * Argument ) ^ 0
          * (
              SkipSpace
              * Q ":" * # ( 1 - P "=" )
              * K ( 'TypeExpression' , ( 1 - P "=" ) ^ 0 )
            ) ^ -1
        )
```

DefModule

```
  local DefModule =
    K ( 'Keyword.Governing' , "module" ) * Space
    *
      (
            K ( 'Keyword.Governing' , "type" ) * Space
          * K ( 'Name.Type' , cap_identifier )
        +
          K ( 'Name.Module' , cap_identifier ) * SkipSpace
          *
            (
              Q "(" * SkipSpace
                * K ( 'Name.Module' , cap_identifier ) * SkipSpace
                * Q ":" * # ( 1 - P "=" ) * SkipSpace
                * K ( 'Name.Type' , cap_identifier ) * SkipSpace
                *
                  (
                    Q "," * SkipSpace
                      * K ( 'Name.Module' , cap_identifier ) * SkipSpace
```

```
                    * Q ":" * # ( 1 - P "=" ) * SkipSpace
                    * K ( 'Name.Type' , cap_identifier ) * SkipSpace
                ) ^ 0
              * Q ")"
            ) ^ -1
          *
            (
              Q "=" * SkipSpace
              * K ( 'Name.Module' , cap_identifier )  * SkipSpace
              * Q "("
              * K ( 'Name.Module' , cap_identifier ) * SkipSpace
                *
                (
                  Q ","
                  *
                  K ( 'Name.Module' , cap_identifier ) * SkipSpace
                ) ^ 0
              * Q ")"
            ) ^ -1
      )
    +
    K ( 'Keyword.Governing' , P "include" + "open" )
    * Space
    * K ( 'Name.Module' , cap_identifier )
```

DefType

```
  local DefType =
    K ( 'Keyword.Governing' , "type" )
    * Space
    * K ( 'TypeExpression' , Q ( 1 - P "=" - P "+=" ) ^ 1 )
    * SkipSpace
    * ( Q "+=" + Q "=" )
    * SkipSpace
    * (
        RecordType
        +
```

The following lines are a suggestion of Y. Salmon.

```
        WithStyle
         (
           'TypeExpression' ,
           (
             (
               EOL
               + comment
               +  Q ( 1
                      - P ";;"
                      - P "type"
                      - ( ( Space + EOL ) * governing_keyword * EndKeyword )
                    )
             ) ^ 0
             *
             (
               # ( P "type" + ( Space + EOL ) * governing_keyword * EndKeyword )
               + Q ";;"
               + -1
             )
           )
         )
      )


  local prompt =
    Q "utop[" * digit^1 * Q "]> "
```

```
  local start_of_line = P(function(subject, position)
  if position == 1 or subject:sub(position - 1, position - 1) == "\r" then
    return position
  end
  return nil
end)
  local Prompt = #start_of_line * K( 'Prompt', prompt )
  local Answer = #start_of_line * (Q "-" + Q "val" * Space * Identifier )
                 * SkipSpace * Q ":" * #(1- P"=") * SkipSpace
                 * (K ( 'TypeExpression' , Q ( 1 - P "=") ^ 1 ) ) * SkipSpace * Q "="
```

The main LPEG for the language OCaml

```
  local Main =
      space ^ 0 * EOL
      + Space
      + Tab
      + Escape + EscapeMath
      + Beamer
      + DetectedCommands
      + TypeParameter
      + String + QuotedString + Char
      + Comment
      + Prompt + Answer
```

For the labels (maybe we will write in the future a dedicated LPEG pour those tokens).

```
      + Q "~" * Identifier * ( Q ":" ) ^ -1
      + Q ":" * # (1 - P ":") * SkipSpace
          * K ( 'TypeExpression' , balanced_parens ) * SkipSpace * Q ")"
      + Exception
      + DefType
      + DefFunction
      + DefModule
      + Record
      + Keyword * EndKeyword
      + OperatorWord * EndKeyword
      + Builtin * EndKeyword
      + DotNotation * EndKeyword
      + Constructor
      + Identifier
      + Punct
      + Delim -- Delim is before Operator for a correct analysis of [| et |]
      + Operator
      + Number
      + Word
```

Here, we must not put `local`, of course.

```
  LPEG1.ocaml = Main ^ 0
```

```
  LPEG2.ocaml =
    Ct (
```

The following lines are in order to allow, in `\piton` (and not in `{Piton}`), judgments of type (such as `f : my_type -> 'a list`) or single expressions of type such as `my_type -> 'a list` (in that case, the argument of `\piton` *must* begin by a colon).

```
          (
            (
               P ":"
               +
               (
                 ( K ( 'Name.Module' , cap_identifier ) * Q "." ) ^ -1
                 * Identifier
```

```
                * SkipSpace
                * Q ":"
              )
            )
              * # ( 1 - S ":=" )
              * SkipSpace
              * K ( 'TypeExpression' , ( 1 - P "\r" ) ^ 0 ) * -1
          )
        +
        (
          ( space ^ 0 * "\r" ) ^ -1
          * Lc [[ \@@_begin_line: ]]
          * LeadingSpace ^ 0
          * ( ( space * Lc [[ \@@_trailing_space: ]] ) ^ 1 * -1
                + space ^ 0 * EOL
                + Main
            ) ^ 0
          * -1
          * Lc [[ \@@_end_line: ]]
        )
      )
```

End of the Lua scope for the language OCaml.

```
end
```

3.6 The language C

We open a Lua local scope for the language C (of course, there will be also global definitions).

```
--c C c++ C++
do
```

```
  local Delim = Q ( S "{[()]}" )
  local Punct = Q ( S ",:;!" )
```

Some strings of length 2 are explicit because we want the corresponding ligatures available in some fonts such as *Fira Code* to be active.

```
  local identifier = letter * alphanum ^ 0

  local Operator =
    K ( 'Operator' ,
        P "!=" + "==" + "<<" + ">>" + "<=" + ">=" + "||" + "&&"
          + S "-~+/*%=<>&.@|!" )

  local Keyword =
    K ( 'Keyword' ,
        P "alignas" + "asm" + "auto" + "break" + "case" + "catch" + "class" +
        "const" + "constexpr" + "continue" + "decltype" + "do" + "else" + "enum" +
        "extern" + "for" + "goto" + "if" + "nexcept" + "private" + "public" +
        "register" + "restricted" + "return" + "static" + "static_assert" +
        "struct" + "switch" + "thread_local" + "throw" + "try" + "typedef" +
        "union" + "using" + "virtual" + "volatile" + "while"
      )
    + K ( 'Keyword.Constant' , P "default" + "false" + "NULL" + "nullptr" + "true" )

  local Builtin =
    K ( 'Name.Builtin' ,
        P "alignof" + "malloc" + "printf" + "scanf" + "sizeof" )

  local Type =
```

```
    K ( 'Name.Type' ,
        P "bool" + "char" + "char16_t" + "char32_t" + "double" + "float" +
        "int8_t" + "int16_t" + "int32_t" + "int64_t" + "uint8_t" + "uint16_t" +
        "uint32_t" + "uint64_t" + "int" + "long" + "short" + "signed" + "unsigned" +
        "void" + "wchar_t" ) * Q "*" ^ 0

  local DefFunction =
    Type
    * Space
    * Q "*" ^ -1
    * K ( 'Name.Function.Internal' , identifier )
    * SkipSpace
    * # P "("
```

We remind that the marker `#` of LPEG specifies that the pattern will be detected but won't consume any character.

The following LPEG `DefClass` will be used to detect the definition of a new class (the name of that new class will be formatted with the piton style `Name.Class`).

Example: `class myclass:`

```
  local DefClass =
    K ( 'Keyword' , "class" ) * Space * K ( 'Name.Class' , identifier )
```

If the word `class` is not followed by a identifier, it will be caught as keyword by the LPEG `Keyword` (useful if we want to type a list of keywords).

```
  local Character =
    K ( 'String.Short' ,
        P [['\'']] + P "'" * ( 1 - P "'" ) ^ 0 * P "'" )
```

The strings of C

```
  String =
    WithStyle ( 'String.Long.Internal' ,
        Q "\""
        * ( SpaceInString
            + K ( 'String.Interpol' ,
                  "%" * ( S "difcspxXou" + "ld" + "li" + "hd" + "hi" )
                )
            + Q ( ( P "\\\"" + 1 - S " \"" ) ^ 1 )
          ) ^ 0
        * Q "\""
      )
```

Beamer The argument of `Compute_braces` must be a pattern *which does no catching* corresponding to the strings of the language.

```
  local braces = Compute_braces ( "\"" * ( 1 - S "\"" ) ^ 0 * "\"" )
  if piton.beamer then Beamer = Compute_Beamer ( 'c' , braces ) end

  DetectedCommands =
    Compute_DetectedCommands ( 'c' , braces )
    + Compute_RawDetectedCommands ( 'c' , braces )

  LPEG_cleaner.c = Compute_LPEG_cleaner ( 'c' , braces )
```

The directives of the preprocessor

```
  local Preproc = K ( 'Preproc' , "#" * ( 1 - P "\r" ) ^ 0  ) * ( EOL + -1 )
```

The comments in the C listings We define different LPEG dealing with comments in the C listings.

```
local Comment =
  WithStyle ( 'Comment.Internal' ,
     Q "//" * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0 ) -- $
            * ( EOL + -1 )

local LongComment =
  WithStyle ( 'Comment.Internal' ,
               Q "/*"
               * ( CommentMath + Q ( ( 1 - P "*/" - S "$\r" ) ^ 1 ) + EOL ) ^ 0
               * Q "*/"
             ) -- $
```

The main LPEG for the language C

```
local EndKeyword
  = Space + Punct + Delim + EOL + Beamer + DetectedCommands + Escape +
  EscapeMath  + -1
```

First, the main loop :

```
local Main =
     space ^ 0 * EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + CommentLaTeX
     + Beamer
     + DetectedCommands
     + Preproc
     + Comment + LongComment
     + Delim
     + Operator
     + Character
     + String
     + Punct
     + DefFunction
     + DefClass
     + Type * ( Q "*" ^ -1 + EndKeyword )
     + Keyword * EndKeyword
     + Builtin * EndKeyword
     + Identifier
     + Number
     + Word
```

Here, we must not put `local`, of course.

```
LPEG1.c = Main ^ 0
```

We recall that each line in the C code to parse will be sent back to LaTeX between a pair `\@@_begin_line:` – `\@@_end_line:`[7].

```
LPEG2.c =
  Ct (
       ( space ^ 0 * P "\r" ) ^ -1
       * Lc [[ \@@_begin_line: ]]
       * LeadingSpace ^ 0
       * ( space ^ 1 * -1 + Main ) ^ 0
       * -1
       * Lc [[ \@@_end_line: ]]
     )
```

[7] Remember that the `\@@_end_line:` must be explicit because it will be used as marker in order to delimit the argument of the command `\@@_begin_line:`

End of the Lua scope for the language C.

```
end
```

3.7 The language SQL

We open a Lua local scope for the language SQL (of course, there will be also global definitions).

```
--sql SQL
do
```

```
  local LuaKeyword
  function LuaKeyword ( name ) return
    Lc [[ {\PitonStyle{Keyword}{ ]]
    * Q ( Cmt (
                C ( letter * alphanum ^ 0 ) ,
                function ( _ , _ , a ) return a : upper ( ) == name end
              )
        )
    * Lc "}}"
  end
```

In the identifiers, we will be able to catch those contening spaces, that is to say like `"last name"`.

```
  local identifier =
    letter * ( alphanum + "-" ) ^ 0
    + P '"' * ( ( 1 - P '"' ) ^ 1 ) * '"'
```

```
  local Operator =
    K ( 'Operator' , P "=" + "!=" + "<>" + ">=" + ">" + "<=" + "<"  + S "*+/" )
```

In SQL, the keywords are case-insensitive. That's why we have a little complication. We will catch the keywords with the identifiers and, then, distinguish the keywords with a Lua function. However, some keywords will be caught in special LPEG because we want to detect the names of the SQL tables.

The following function converts a comma-separated list in a "set", that is to say a Lua table with a fast way to test whether a string belongs to that set (eventually, the indexation of the components of the table is no longer done by integers but by the strings themselves).

```
  local Set
  function Set ( list )
    local set = { }
    for _ , l in ipairs ( list ) do set[l] = true end
    return set
  end
```

We now use the previous function `Set` to creates the "sets" `set_keywords` and `set_builtin`. That list of keywords comes from https://sqlite.org/lang_keywords.html.

```
  local set_keywords = Set
   {
     "ABORT", "ACTION", "ADD", "AFTER", "ALL", "ALTER", "ALWAYS", "ANALYZE",
     "AND", "AS", "ASC", "ATTACH", "AUTOINCREMENT", "BEFORE", "BEGIN", "BETWEEN",
     "BY", "CASCADE", "CASE", "CAST", "CHECK", "COLLATE", "COLUMN", "COMMIT",
     "CONFLICT", "CONSTRAINT", "CREATE", "CROSS", "CURRENT", "CURRENT_DATE",
     "CURRENT_TIME", "CURRENT_TIMESTAMP", "DATABASE", "DEFAULT", "DEFERRABLE",
     "DEFERRED", "DELETE", "DESC", "DETACH", "DISTINCT", "DO", "DROP", "EACH",
     "ELSE", "END", "ESCAPE", "EXCEPT", "EXCLUDE", "EXCLUSIVE", "EXISTS",
     "EXPLAIN", "FAIL", "FILTER", "FIRST", "FOLLOWING", "FOR", "FOREIGN", "FROM",
     "FULL", "GENERATED", "GLOB", "GROUP", "GROUPS", "HAVING", "IF", "IGNORE",
     "IMMEDIATE", "IN", "INDEX", "INDEXED", "INITIALLY", "INNER", "INSERT",
     "INSTEAD", "INTERSECT", "INTO", "IS", "ISNULL", "JOIN", "KEY", "LAST",
     "LEFT", "LIKE", "LIMIT", "MATCH", "MATERIALIZED", "NATURAL", "NO", "NOT",
```

```
    "NOTHING", "NOTNULL", "NULL", "NULLS", "OF", "OFFSET", "ON", "OR", "ORDER",
    "OTHERS", "OUTER", "OVER", "PARTITION", "PLAN", "PRAGMA", "PRECEDING",
    "PRIMARY", "QUERY", "RAISE", "RANGE", "RECURSIVE", "REFERENCES", "REGEXP",
    "REINDEX", "RELEASE", "RENAME", "REPLACE", "RESTRICT", "RETURNING", "RIGHT",
    "ROLLBACK", "ROW", "ROWS", "SAVEPOINT", "SELECT", "SET", "TABLE", "TEMP",
    "TEMPORARY", "THEN", "TIES", "TO", "TRANSACTION", "TRIGGER", "UNBOUNDED",
    "UNION", "UNIQUE", "UPDATE", "USING", "VACUUM", "VALUES", "VIEW", "VIRTUAL",
    "WHEN", "WHERE", "WINDOW", "WITH", "WITHOUT"
  }
local set_builtins = Set
  {
    "AVG" , "COUNT" , "CHAR_LENGTH" , "CONCAT" , "CURDATE" , "CURRENT_DATE" ,
    "DATE_FORMAT" , "DAY" , "LOWER" , "LTRIM" , "MAX" , "MIN" , "MONTH" , "NOW" ,
    "RANK" , "ROUND" , "RTRIM" , "SUBSTRING" , "SUM" , "UPPER" , "YEAR"
  }
```

The LPEG `Identifier` will catch the identifiers of the fields but also the keywords and the built-in functions of SQL. If will *not* catch the names of the SQL tables.

```
local Identifier =
  C ( identifier ) /
  (
    function ( s )
        if set_keywords [ s : upper ( ) ] then return
```

Remind that, in Lua, it's possible to return *several* values.

```
          { [[{\PitonStyle{Keyword}{]] } ,
          { luatexbase.catcodetables.other , s } ,
          { "}}" }
        else
          if set_builtins [ s : upper ( ) ] then return
            { [[{\PitonStyle{Name.Builtin}{]] } ,
            { luatexbase.catcodetables.other , s } ,
            { "}}" }
          else return
            { [[{\PitonStyle{Name.Field}{]] } ,
            { luatexbase.catcodetables.other , s } ,
            { "}}" }
          end
        end
    end
  )
```

The strings of SQL

```
local String = K ( 'String.Long.Internal' , "'" * ( 1 - P "'" ) ^ 1 * "'" )
```

Beamer The argument of `Compute_braces` must be a pattern *which does no catching* corresponding to the strings of the language.

```
local braces = Compute_braces ( "'" * ( 1 - P "'" ) ^ 1 * "'" )
if piton.beamer then Beamer = Compute_Beamer ( 'sql' , braces ) end
DetectedCommands =
  Compute_DetectedCommands ( 'sql' , braces )
  + Compute_RawDetectedCommands ( 'sql' , braces )
LPEG_cleaner.sql = Compute_LPEG_cleaner ( 'sql' , braces )
```

The comments in the SQL listings We define different LPEG dealing with comments in the SQL listings.

```
local Comment =
  WithStyle ( 'Comment.Internal' ,
     Q "--"   -- syntax of SQL92
     * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0 ) -- $
  * ( EOL + -1 )

local LongComment =
  WithStyle ( 'Comment.Internal' ,
               Q "/*"
               * ( CommentMath + Q ( ( 1 - P "*/" - S "$\r" ) ^ 1 ) + EOL ) ^ 0
               * Q "*/"
             ) -- $
```

The main LPEG for the language SQL

```
local EndKeyword
  = Space + Punct + Delim + EOL + Beamer + DetectedCommands + Escape +
    EscapeMath + -1

local TableField =
       K ( 'Name.Table' , identifier )
     * Q "."
     * ( DetectedCommands + ( K ( 'Name.Field' , identifier ) ) ^ 0 )

local OneField =
  (
    Q ( "(" * ( 1 - P ")" ) ^ 0 * ")" )
    +
        K ( 'Name.Table' , identifier )
      * Q "."
      * K ( 'Name.Field' , identifier )
    +
    K ( 'Name.Field' , identifier )
  )
  * (
      Space * LuaKeyword "AS" * Space * K ( 'Name.Field' , identifier )
    ) ^ -1
  * ( Space * ( LuaKeyword "ASC" + LuaKeyword "DESC" ) ) ^ -1

local OneTable =
     K ( 'Name.Table' , identifier )
   * (
       Space
       * LuaKeyword "AS"
       * Space
       * K ( 'Name.Table' , identifier )
     ) ^ -1

local WeCatchTableNames =
     LuaKeyword "FROM"
   * ( Space + EOL )
   * OneTable * ( SkipSpace * Q "," * SkipSpace * OneTable ) ^ 0
  + (
      LuaKeyword "JOIN" + LuaKeyword "INTO" + LuaKeyword "UPDATE"
      + LuaKeyword "TABLE"
    )
    * ( Space + EOL ) * OneTable

local EndKeyword
  = Space + Punct + Delim + EOL + Beamer
      + DetectedCommands + Escape + EscapeMath + -1
```

First, the main loop :

```
local Main =
    space ^ 0 * EOL
    + Space
    + Tab
    + Escape + EscapeMath
    + CommentLaTeX
    + Beamer
    + DetectedCommands
    + Comment + LongComment
    + Delim
    + Operator
    + String
    + Punct
    + WeCatchTableNames
    + ( TableField + Identifier ) * ( Space + Operator + Punct + Delim + EOL + -1 )
    + Number
    + Word
```

Here, we must not put `local`, of course.

```
LPEG1.sql = Main ^ 0
```

We recall that each line in the code to parse will be sent back to LaTeX between a pair `\@@_begin_line:` – `\@@_end_line:`[8].

```
LPEG2.sql =
  Ct (
      ( space ^ 0 * "\r" ) ^ -1
      * Lc [[ \@@_begin_line: ]]
      * LeadingSpace ^ 0
      * ( space ^ 1 * -1 + Main ) ^ 0
      * -1
      * Lc [[ \@@_end_line: ]]
    )
```

End of the Lua scope for the language SQL.

```
end
```

3.8 The language “Minimal”

We open a Lua local scope for the language “Minimal” (of course, there will be also global definitions).

```
--minimal Minimal
do
  local Punct = Q ( S ",;:!\\" )

  local Comment =
    WithStyle ( 'Comment.Internal' ,
                Q "#"
                * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0 -- $
              )
       * ( EOL + -1 )

  local String =
    WithStyle ( 'String.Short.Internal' ,
                Q "\""
                * ( SpaceInString
                    + Q ( ( P [[\"]] + 1 - S " \"" ) ^ 1 )
```

[8] Remember that the `\@@_end_line:` must be explicit because it will be used as marker in order to delimit the argument of the command `\@@_begin_line:`

```
                  ) ^ 0
                * Q "\""
              )
```

The argument of `Compute_braces` must be a pattern *which does no catching* corresponding to the strings of the language.

```
local braces = Compute_braces ( P "\"" * ( P "\\\"" + 1 - P "\"" ) ^ 1 * "\"" )

if piton.beamer then Beamer = Compute_Beamer ( 'minimal' , braces ) end

DetectedCommands =
  Compute_DetectedCommands ( 'minimal' , braces )
  + Compute_RawDetectedCommands ( 'minimal' , braces )

LPEG_cleaner.minimal = Compute_LPEG_cleaner ( 'minimal' , braces )

local identifier = letter * alphanum ^ 0

local Identifier = K ( 'Identifier.Internal' , identifier )

local Delim = Q ( S "{[()]}" )

local Main =
     space ^ 0 * EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + CommentLaTeX
     + Beamer
     + DetectedCommands
     + Comment
     + Delim
     + String
     + Punct
     + Identifier
     + Number
     + Word
```

Here, we must not put `local`, of course.

```
LPEG1.minimal = Main ^ 0

LPEG2.minimal =
  Ct (
       ( space ^ 0 * "\r" ) ^ -1
       * Lc [[ \@@_begin_line: ]]
       * LeadingSpace ^ 0
       * ( space ^ 1 * -1 + Main ) ^ 0
       * -1
       * Lc [[ \@@_end_line: ]]
     )
```

End of the Lua scope for the language “Minimal”.

```
end
```

3.9 The language “Verbatim”

We open a Lua local scope for the language “Verbatim” (of course, there will be also global definitions).

```
--verbatim Verbatim
do
```

Here, we don't use `braces` as done with the other languages because we don't have have to take into account the strings (there is no string in the langage "Verbatim").

```
local braces =
    P { "E" ,
        E = ( "{" * V "E" * "}" + ( 1 - S "{}" ) ) ^ 0
      }

if piton.beamer then Beamer = Compute_Beamer ( 'verbatim' , braces ) end

DetectedCommands =
  Compute_DetectedCommands ( 'verbatim' , braces )
  + Compute_RawDetectedCommands ( 'verbatim' , braces )

LPEG_cleaner.verbatim = Compute_LPEG_cleaner ( 'verbatim' , braces )
```

Now, you will construct the LPEG Word.

```
local lpeg_central = 1 - S " \\\r"
if piton.begin_escape then
  lpeg_central = lpeg_central - piton.begin_escape
end
if piton.begin_escape_math then
  lpeg_central = lpeg_central - piton.begin_escape_math
end
local Word = Q ( lpeg_central ^ 1 )

local Main =
     space ^ 0 * EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + Beamer
     + DetectedCommands
     + Q [[\]]
     + Word
```

Here, we must not put `local`, of course.

```
LPEG1.verbatim = Main ^ 0

LPEG2.verbatim =
  Ct (
       ( space ^ 0 * "\r" ) ^ -1
       * Lc [[ \@@_begin_line: ]]
       * LeadingSpace ^ 0
       * ( space ^ 1 * -1 + Main ) ^ 0
       * -1
       * Lc [[ \@@_end_line: ]]
     )
```

End of the Lua scope for the language "`verbatim`".

```
end
```

3.10 The language expl

We open a Lua local scope for the language `expl` of LaTeX3 (of course, there will be also global definitions).

```
--EXPL expl
do
  local Comment =
    WithStyle
     ( 'Comment.Internal' ,
       Q "%" * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0  -- $
```

```
    )
  * ( EOL + -1 )
```

First, we begin with a special function to analyse the "keywords", that is to say the control sequences beginning by "\".

```
local analyze_cs
function analyze_cs ( s )
  local i = s : find ( ":" )
  if i then
```

First, the case of what might be called a "function" in `expl`, for instance, `\tl_set:Nn` or `\int_compare:nNnTF`.

```
    local name = s : sub ( 2 , i - 1 )
    local parts = name : explode ( "_" )
    local module = parts[1]
    if module == "" then module = parts[3] end
```

Remind that, in Lua, we can return *several* values.

```
    return
     { [[{\OptionalLocalPitonStyle{Module.]] .. module .. "}{" } ,
     { luatexbase.catcodetables.other , s } ,
     { "}}" }
  else
```

```
    local p = s : sub ( 1 , 3 )
    if p == [[\l_]] or p == [[\g_]] or p == [[\c_]] then
```

The case of what might be called a "variable", for instance, `\l_tmpa_int` or `\g__module_text_tl`.

```
      local scope = s : sub(2,2)
      local parts = s : explode ( "_" )
      local module = parts[2]
      if module == "" then module = parts[3] end
      local type = parts[#parts]
      return
        { [[{\OptionalLocalPitonStyle{Scope.]] .. scope .. "}{" } ,
        { [[{\OptionalLocalPitonStyle{Module.]] .. module .. "}{" } ,
        { [[{\OptionalLocalPitonStyle{Type.]] .. type .. "}{" } ,
        { luatexbase.catcodetables.other , s } ,
        { "}}}}}}" }
    else
```

We have a control sequence which is neither a "function" neither a "variable" of `expl`. It's a control sequence of standard LaTeX and we don't format it.

```
      return { luatexbase.catcodetables.other , s }
    end
  end
end
```

Here, we don't use `braces` as done with the other languages because we don't have have to take into account the strings (there is no string in the langage `expl`).

```
local braces =
    P { "E" ,
        E = ( "{" * V "E" * "}" + ( 1 - S "{}" ) ) ^ 0
      }

if piton.beamer then Beamer = Compute_Beamer ( 'expl' , braces ) end

DetectedCommands =
  Compute_DetectedCommands ( 'expl' , braces )
  + Compute_RawDetectedCommands ( 'expl' , braces )

LPEG_cleaner.expl = Compute_LPEG_cleaner ( 'expl' , braces )

local control_sequence = P "\\" * ( R "Az" + "_" + ":" + "@" ) ^ 1
local ControlSequence = C ( control_sequence ) / analyze_cs
```

```
local def_function
 = P [[\cs_]]
   * ( P "set" + "new")
   * ( P "_protected" ) ^ -1
   * P ":N"  * ( P "p" ) ^ -1 * "n"
local DefFunction =
  C ( def_function ) / analyze_cs
  * Space
  * Lc ( [[ {\PitonStyle{Name.Function}{ ]] )
  * ControlSequence -- Q ( ControlSequence ) ?
  * Lc "}}"
local Word = Q ( ( 1 - S " \r" ) ^ 1 )

local Main =
     space ^ 0 * EOL
     + Space
     + Tab
     + Escape + EscapeMath
     + Beamer
     + Comment
     + DetectedCommands
     + DefFunction
     + ControlSequence
     + Word
```

Here, we must not put `local`, of course.

```
LPEG1.expl = Main ^ 0

LPEG2.expl =
  Ct (
       ( space ^ 0 * "\r" ) ^ -1
       * Lc [[ \@@_begin_line: ]]
       * LeadingSpace ^ 0
       * ( space ^ 1 * -1 + Main ) ^ 0
       * -1
       * Lc [[ \@@_end_line: ]]
     )
```

End of the Lua scope for the language `expl` of LaTeX3.

```
end
```

3.11 The function Parse

The function `Parse` is the main function of the package piton. It parses its argument and sends back to LaTeX the code with interlaced formatting LaTeX instructions. In fact, everything is done by the LPEG corresponding to the considered language (`LPEG2[language]`) which returns as capture a Lua table containing data to send to LaTeX.

```
function piton.Parse ( language , code )
```

The variable `piton.language` will be used by the function `ParseAgain`.

```
  piton.language = language
  local t = LPEG2[language] : match ( code )
  if not t then
    sprintL3 [[ \@@_error_or_warning:n { SyntaxError } ]]
    return -- to exit in force the function
  end
  local left_stack = {}
  local right_stack = {}
```

```
  for _ , one_item in ipairs ( t ) do
    if one_item == "EOL" then
      for i = #right_stack, 1, -1 do
        tex.sprint ( right_stack[i] )
      end
```

We remind that the `\@@_end_line:` must be explicit since it's the marker of end of the command `\@@_begin_line:`.

```
      sprintL3 ( [[ \@@_end_line: \@@_par: \@@_begin_line: ]] )
      tex.sprint ( table.concat ( left_stack ) )
    else
```

Here is an example of an item beginning with `"Open"`.
`{ "Open" , "\begin{uncoverenv}<2>" , "\end{uncoverenv}" }`
In order to deal with the ends of lines, we have to close the environment (`{uncoverenv}` in this example) at the end of each line and reopen it at the beginning of the new line. That's why we use two Lua stacks, called `left_stack` and `right_stack`. `left_stack` will be for the elements like `\begin{uncoverenv}<2>` and `right_stack` will be for the elements like `\end{uncoverenv}`.

```
      if one_item[1] == "Open" then
        tex.sprint ( one_item[2] )
        table.insert ( left_stack , one_item[2] )
        table.insert ( right_stack , one_item[3] )
      else
        if one_item[1] == "Close" then
          tex.sprint ( right_stack[#right_stack] )
          left_stack[#left_stack] = nil
          right_stack[#right_stack] = nil
        else
          tex.tprint ( one_item )
        end
      end
    end
  end
end
```

There is the problem of the conventions of end of lines (`\n` in Unix and Linux but `\r\n` in Windows). The function `my_file_lines` will read a file line by line after replacement of the potential `\r\n` by `\n` (that means that we go the convention UNIX).

```
local my_file_lines
function my_file_lines ( filename )
    local f = io.open ( filename , 'rb' )
    local s = f : read ( '*a' )
    f : close ( )
```

À la fin, on doit bien mettre `(.-)` et pas `(.*)`.

```
    return ( s .. '\n' ) : gsub( '\r\n?' , '\n') : gmatch ( '(.-)\n' )
end
```

Recall that, in Lua, `gmatch` returns an *iterator*.

```
function piton.ReadFile ( name , first_line , last_line )
  local s = ''
  local i = 0
  for line in my_file_lines ( name ) do
    i = i + 1
    if i >= first_line then
      s = s .. '\r' .. line
    end
    if i >= last_line then break end
  end
```

We extract the BOM of utf-8, if present.

```
  if s : sub ( 1 , 4 ) == string.char ( 13 , 239 , 187 , 191 ) then
    s = s : sub ( 5 , -1 )
  end
  sprintL3 ( [[ \tl_set:Nn \l_@@_listing_tl { ]])
  tex.sprint ( luatexbase.catcodetables.other , s )
  sprintL3 ( "}" )
end


function piton.RetrieveGobbleParse ( lang , n , splittable , code )
  local s
  s = ( ( P " " ^ 0 * "\r" ) ^ -1 * C ( P ( 1 ) ^ 0 ) * -1 ) : match ( code )
  piton.GobbleParse ( lang , n , splittable , s )
end
```

3.12 Two variants of the function Parse with integrated preprocessors

The following command will be used by the user command `\piton`. For that command, we have to undo the duplication of the symbols `#`.

```
function piton.ParseBis ( lang , code )
  return piton.Parse ( lang , code : gsub ( '##' , '#' ) )
end
```

Of course, `gsub` spans the string only once for the substitutions, which means that `####` will be replaced by `##` as expected and not by `#`.

The following command will be used when we have to parse some small chunks of code that have yet been parsed. They are re-scanned by LaTeX because it has been required by `\@@_piton:n` in the piton style of the syntaxic element. In that case, you have to remove the potential `\@@_breakable_space:` that have been inserted when the key `break-lines` is in force.

```
function piton.ParseTer ( lang , code )
```

Be careful: we have to write `[[\@@_breakable_space: ]]` with a space after the name of the LaTeX command `\@@_breakable_space:`.

```
  return piton.Parse
         (
           lang ,
           code : gsub ( [[\@@_breakable_space: ]] , ' ' )
         )
end
```

3.13 Preprocessors of the function Parse for gobble

We deal now with preprocessors of the function `Parse` which are needed when the "gobble mechanism" is used.

The following LPEG returns as capture the minimal number of spaces at the beginning of the lines of code.

```
local AutoGobbleLPEG =
      (  (
           P " " ^ 0 * "\r"
           +
           Ct ( C " " ^ 0 ) / table.getn
           * ( 1 - P " " ) * ( 1 - P "\r" ) ^ 0 * "\r"
         ) ^ 0
         * ( Ct ( C " " ^ 0 ) / table.getn
              * ( 1 - P " " ) * ( 1 - P "\r" ) ^ 0 ) ^ -1
       ) / math.min
```

The following LPEG is similar but works with the tabulations.

```
local TabsAutoGobbleLPEG =
       (
         (
           P "\t" ^ 0 * "\r"
           +
           Ct ( C "\t" ^ 0 ) / table.getn
           * ( 1 - P "\t" ) * ( 1 - P "\r" ) ^ 0 * "\r"
         ) ^ 0
         * ( Ct ( C "\t" ^ 0 ) / table.getn
             * ( 1 - P "\t" ) * ( 1 - P "\r" ) ^ 0 ) ^ -1
       ) / math.min
```

The following LPEG returns as capture the number of spaces at the last line, that is to say before the `\end{Piton}` (and usually it's also the number of spaces before the corresponding `\begin{Piton}` because that's the traditional way to indent in LaTeX).

```
local EnvGobbleLPEG =
      ( ( 1 - P "\r" ) ^ 0 * "\r" ) ^ 0
    * Ct ( C " " ^ 0 * -1 ) / table.getn
```

The function `gobble` gobbles n characters on the left of the code. The negative values of n have special significations.

```
function piton.Gobble ( n , code )
  if n == 0 then return
    code
  else
    if n == -1 then
      n = AutoGobbleLPEG : match ( code )
```

for the case of an empty environment (only blank lines)

```
      if tonumber(n) then else n = 0 end
    else
      if n == -2 then
        n = EnvGobbleLPEG : match ( code )
      else
        if n == -3 then
          n = TabsAutoGobbleLPEG : match ( code )
          if tonumber(n) then else n = 0 end
        end
      end
    end
```

We have a second test `if n == 0` because, even if the key like `auto-gobble` is in force, it's possible that, in fact, there is no space to gobble...

```
    if n == 0 then return
      code
    else return
```

We will now use a LPEG that we have to compute dynamically because it depends on the value of n.

```
      ( Ct (
             ( 1 - P "\r" ) ^ (-n) * C ( ( 1 - P "\r" ) ^ 0 )
               * ( C "\r" * ( 1 - P "\r" ) ^ (-n) * C ( ( 1 - P "\r" ) ^ 0 )
           ) ^ 0 )
        / table.concat
      ) : match ( code )
    end
  end
end
```

In the following code, `n` is the value of `\l_@@_gobble_int`.
`splittable` is the value of `\l_@@_splittable_int`.

```
function piton.GobbleParse ( lang , n , splittable , code )
```

```
  piton.ComputeLinesStatus ( code , splittable )
  piton.last_code = piton.Gobble ( n , code )
  piton.last_language = lang
```

We count the number of lines of the computer listing. The result will be stored by Lua in `\g_@@_nb_lines_int`.

```
  piton.CountLines ( piton.last_code )
  piton.Parse ( lang , piton.last_code )
  piton.join_and_write ( )
end
```

The following function will be used when the end user has used the key `join` or the key `write`. The value of the key `join` has been written in the Lua variable `piton.join`.

```
function piton.join_and_write ( )
  if piton.join ~= '' then
    if not piton.join_files [ piton.join ] then
      piton.join_files [ piton.join ] = piton.get_last_code ( )
    else
      if piton.join_separation == '' then
      piton.join_files [ piton.join ] =
      piton.join_files [ piton.join ]
        .. "\r\n"
        .. piton.get_last_code ( )
      else
      piton.join_files [ piton.join ] =
      piton.join_files [ piton.join ]
        .. "\r\n"
        .. ( piton.join_separation : gsub ( '##' , '#' ) )
        .. "\r\n"
        .. piton.get_last_code ( )
      end
    end
  end
```

Now, if the end user has used the key `write` to write the listing of the environment on an external file (on the disk).
We have written the values of the keys `write` and `path-write` in the Lua variables `piton.write` and `piton.path_write`.
If `piton.write` is not empty, that means that the key `write` has been used for the current environment and, hence, we have to write the content of the listing on the corresponding external file.

```
  if piton.write ~= '' then
```

We will write on `file_name` the full name (with the path) of the file in which we will write.

```
    local file_name = ''
    if piton.path_write == '' then
      file_name = piton.write
    else
```

If `piton.path-write` is not empty, that means that we will not write on a file in the current directory but in another directory. First, we verify that that directory actually exists.

```
      local attr = lfs.attributes ( piton.path_write )
      if attr and attr.mode == "directory" then
        file_name = piton.path_write .. "/" .. piton.write
      else
```

If the directory does *not* exist, you raise an (non-fatal) error since TeX is not able to create a new directory.

```
        sprintL3 [[ \@@_error_or_warning:n { InexistentDirectory } ]]
      end
    end
    if file_name ~= '' then
```

Now, `file_name` contains the complete name of the file on which we will have to write. Maybe the file does not exist but we are sure that the directory exist.
The Lua table `piton.write_files` is a table of Lua strings corresponding to all the files that we will write on the disk in the `\AtEndDocument`. They correspond to the use of the key `write` (and `path-write`).

```
      if not piton.write_files [ file_name ] then
        piton.write_files [ file_name ] = piton.get_last_code ( )
      else
        piton.write_files [ file_name ] =
        piton.write_files [ file_name ] .. "\n" .. piton.get_last_code ( )
      end
    end
  end
end
```

The following command will be used when the end user has set `print=false`.

```
function piton.GobbleParseNoPrint ( lang , n , code )
  piton.last_code = piton.Gobble ( n , code )
  piton.last_language = lang
  piton.join_and_write ( )
end
```

The following function will be used when the key `split-on-empty-lines` is in force. With that key, the computer listing is split in chunks at the empty lines (usually between the abstract functions defined in the computer code). LaTeX will be able to change the page between the chunks. The second argument `n` corresponds to the value of the key `gobble` (number of spaces to gobble).

```
function piton.GobbleSplitParse ( lang , n , splittable , code )
  local chunks
  chunks =
     (
       Ct (
            (
              P " " ^ 0 * "\r"
              +
              C ( ( ( 1 - P "\r" ) ^ 1 * ( P "\r" + -1 )
                    - ( P " " ^ 0 * ( P "\r" + -1 ) )
                  ) ^ 1
                )
            ) ^ 0
          )
     ) : match ( piton.Gobble ( n , code ) )
  sprintL3 [[ \begingroup ]]
  sprintL3
    (
      [[ \PitonOptions { split-on-empty-lines = false, gobble = 0, ]]
      .. "language = " .. lang .. ","
      .. "splittable = " .. splittable .. "}"
    )
  for k , v in pairs ( chunks ) do
    if k > 1 then
      sprintL3 ( [[ \l_@@_split_separation_tl ]] )
    end
    tex.print
      (
        [[\begin{]] .. piton.env_used_by_split .. "}\r"
        .. v
        .. [[\end{]] .. piton.env_used_by_split .. "}\r"
      )
  end
  sprintL3 [[ \endgroup ]]
end
```

```
function piton.RetrieveGobbleSplitParse ( lang , n , splittable , code )
  local s
  s = ( ( P " " ^ 0 * "\r" ) ^ -1 * C ( P ( 1 ) ^ 0 ) * -1 ) : match ( code )
  piton.GobbleSplitParse ( lang , n , splittable , s )
end
```

The following Lua string will be inserted between the chunks of code created when the key `split-on-empty-lines` is in force. It's used only once: you have given a name to that Lua string only for legibility. The token list `\l_@@_split_separation_tl` corresponds to the key `split-separation`. That token list must contain elements inserted in *vertical mode* of TeX.

```
piton.string_between_chunks =
 [[ \par \l_@@_split_separation_tl \mode_leave_vertical: ]]
 .. [[ \global \g_@@_line_int  = 0 ]]
```

The counter `\g_@@_line_int` will be used to control the points where the code may be broken by a change of page (see the key `splittable`).

The following public Lua function is provided to the developer.

```
function piton.get_last_code ( )
  return LPEG_cleaner[piton.last_language] : match ( piton.last_code )
         : gsub ( '\r\n?' , '\n' )
end
```

3.14 To count the number of lines

```
local CountBeamerEnvironments
function CountBeamerEnvironments ( code ) return
   (
     Ct (
          (
            P "\\begin{" * beamerEnvironments * ( 1 - P "\r" ) ^ 0 * C "\r"
            +
            ( 1 - P "\r" ) ^ 0 * "\r"
          ) ^ 0
          * ( 1 - P "\r" ) ^ 0
          * -1
        )  / table.getn
   ) : match ( code )
end
```

The following function counts the lines of `code` except the lines which contains only instructions for the environements of Beamer.
It is used in `GobbleParse` and at the beginning of `\@@_composition:` (in some rare circumstancies). Be careful. We have tried a version with `string.gsub` without success.

```
function piton.CountLines ( code )
  local count
  count =
     ( Ct ( ( ( 1 - P "\r" ) ^ 0 * C "\r" ) ^ 0
            *
            (
               space ^ 0 * ( 1 - P "\r" - space ) *  ( 1 - P "\r" ) ^ 0 * Cc "\r"
               + space ^ 0
            ) ^ -1
            * -1
          ) / table.getn
     ) : match ( code )
  if piton.beamer then
    count = count - 2 * CountBeamerEnvironments ( code )
  end
  sprintL3 ( [[ \int_gset:Nn \g_@@_nb_lines_int { ]] .. count .. "}" )
end
```

The following function is only used once (in `piton.GobbleParse`). We have written an autonomous function only for legibility. The number of lines of the code will be stored in `\l_@@_nb_non_empty_lines_int`. It will be used to compute the largest number of lines to write (when `line-numbers` is in force).

```
function piton.CountNonEmptyLines ( code )
  local count = 0
```

The following code is not clear. We should try to replace it by use of the `string` library of Lua.

```
  count =
     ( Ct ( ( P " " ^ 0 * "\r"
              + ( 1 - P "\r" ) ^ 0 * C "\r" ) ^ 0
            * ( 1 - P "\r" ) ^ 0
            * -1
          ) / table.getn
     ) : match ( code )
  count = count + 1
  if piton.beamer then
    count = count - 2 * CountBeamerEnvironments ( code )
  end
  sprintL3
   ( [[ \int_set:Nn  \l_@@_nb_non_empty_lines_int { ]] .. count .. "}" )
end
```

The following function stores in `\l_@@_first_line_int` and `\l_@@_last_line_int` the numbers of lines of the file `file_name` corresponding to the strings `marker_beginning` and `marker_end`.
`s` is the marker of the beginning and `t` is the marker of the end.

```
function piton.ComputeRange ( s , t , file_name )
  local first_line = -1
  local count = 0
  local last_found = false
  for line in io.lines ( file_name ) do
    if first_line == -1 then
      if line : sub ( 1 , #s ) == s then
        first_line = count
      end
    else
      if line : sub ( 1 , #t ) == t then
        last_found = true
        break
      end
    end
    count = count + 1
  end
  if first_line == -1 then
    sprintL3 [[ \@@_error_or_warning:n { begin~marker~not~found } ]]
  else
    if not last_found then
      sprintL3 [[ \@@_error_or_warning:n { end~marker~not~found } ]]
    end
  end
  sprintL3 (
      [[ \int_set:Nn \l_@@_first_line_int { ]] .. first_line .. ' + 2 }'
      .. [[ \global \l_@@_last_line_int = ]] .. count )
end
```

3.15 To determine the empty lines of the listings

Despite its name, the Lua function `ComputeLinesStatus` computes `piton.lines_status` but also `piton.empty_lines`.

In `piton.empty_lines`, a line will have the number 0 if it's a empty line (in fact a blank line, with only spaces) and 1 elsewhere.

In `piton.lines_status`, each line will have a status with regard the breaking points allowed (for the changes of pages).

- 0 if the line is empty and a page break is allowed;
- 1 if the line is not empty but a page break is allowed after that line;
- 2 if a page break is *not* allowed after that line (empty or not empty).

`splittable` is the value of `\l_@@_splittable_int`. However, if `splittable-on-empty-lines` is in force, `splittable` is the opposite of `\l_@@_splittable_int`.

```
function piton.ComputeLinesStatus ( code , splittable )
```

The lines in the listings which correspond to the beginning or the end of an environment of Beamer (eg. `\begin{uncoverenv}`) must be retrieved (those lines have *no* number and therefore, *no* status).

```
  local lpeg_line_beamer
  if piton.beamer then
    lpeg_line_beamer =
       space ^ 0
        * P [[\begin{]] * beamerEnvironments * "}"
        * ( "<" * ( 1 - P ">" ) ^ 0 * ">" ) ^ -1
       +
       space ^ 0
        * P [[\end{]] * beamerEnvironments * "}"
  else
    lpeg_line_beamer = P ( false )
  end
  local lpeg_empty_lines =
    Ct (
         ( lpeg_line_beamer * "\r"
           +
           P " " ^ 0 * "\r" * Cc ( 0 )
           +
           ( 1 - P "\r" ) ^ 0 * "\r" * Cc ( 1 )
         ) ^ 0
         *
         ( lpeg_line_beamer + ( 1 - P "\r" ) ^ 1 * Cc ( 1 ) ) ^ -1
       )
    * -1
  local lpeg_all_lines =
    Ct (
         ( lpeg_line_beamer * "\r"
           +
           ( 1 - P "\r" ) ^ 0 * "\r" * Cc ( 1 )
         ) ^ 0
         *
         ( lpeg_line_beamer + ( 1 - P "\r" ) ^ 1 * Cc ( 1 ) ) ^ -1
       )
    * -1
```

We begin with the computation of `piton.empty_lines`. It will be used in conjonction with `line-numbers`.

```
  piton.empty_lines = lpeg_empty_lines : match ( code )
```

Now, we compute `piton.lines_status`. It will be used in conjonction with `splittable` and `splittable-on-empty-lines`.
Now, we will take into account the current value of `\l_@@_splittable_int` (provided by the *absolute value* of the argument `splittable`).

```
  local lines_status
  local s = splittable
  if splittable < 0 then s = - splittable end
```

```
  if splittable > 0 then
    lines_status = lpeg_all_lines : match ( code )
  else
```

Here, we should try to copy `piton.empty_lines` but it's not easy.

```
    lines_status = lpeg_empty_lines : match ( code )
    for i , x in ipairs ( lines_status ) do
      if x == 0 then
        for j = 1 , s - 1 do
          if i + j > #lines_status then break end
          if lines_status[i+j] == 0 then break end
            lines_status[i+j] = 2
        end
        for j = 1 , s - 1 do
          if i - j == 1 then break end
          if lines_status[i-j-1] == 0 then break end
          lines_status[i-j-1] = 2
        end
      end
    end
  end
```

In all cases (whatever is the value of `splittable-on-empty-lines`) we have to deal with both extremities of the listing to format.
First from the beginning of the code.

```
  for j = 1 , s - 1 do
    if j > #lines_status then break end
    if lines_status[j] == 0 then break end
    lines_status[j] = 2
  end
```

Now, from the end of the code.

```
  for j = 1 , s - 1 do
    if #lines_status - j == 0 then break end
    if lines_status[#lines_status - j] == 0 then break end
    lines_status[#lines_status - j] = 2
  end


  piton.lines_status = lines_status
end
function piton.TranslateBeamerEnv ( code )
  local s
  s =
  (
    Ct (
         (
            space ^ 0
            * C (
                  ( P "\\begin{" + "\\end{" )
                  * beamerEnvironments * "}" * ( 1 - P "\r" ) ^ 0 * "\r"
                )
            + C ( ( 1 - P "\r" ) ^ 0 * "\r" )
          ) ^ 0
          *
          (
            (
              space ^ 0
              * C (
                    ( P "\\begin{" + "\\end{" )
                    * beamerEnvironments * "}" * ( 1 - P "\r" ) ^ 0 * -1
                  )
              + C ( ( 1 - P "\r" ) ^ 1 ) * -1
            ) ^ -1
```

```
          )
        ) ^ -1  / table.concat
    ) : match ( code )
    sprintL3 ( [[ \tl_set:Nn \l_@@_listing_tl { ]] )
    tex.sprint ( luatexbase.catcodetables.other , s )
    sprintL3 ( "}" )
end
```

3.16 To create new languages with the syntax of listings

```
function piton.new_language ( lang , definition )
  lang = lang : lower ( )

  local alpha , digit = lpeg.alpha , lpeg.digit
  local extra_letters = { "@" , "_" , "$" } --
```

The command `add_to_letter` (triggered by the key) don't write right away in the LPEG pattern of the letters in an intermediate `extra_letters` because we may have to retrieve letters from that "list" if there appear in a key `alsoother`.

```
  function add_to_letter ( c )
    if c ~= " " then table.insert ( extra_letters , c ) end
  end
```

For the digits, it's straitforward.

```
  function add_to_digit ( c )
    if c ~= " " then digit = digit + c end
  end
```

The main use of the key `alsoother` is, for the language LaTeX, when you have to retrieve some characters from the list of letters, in particular `@` and `_` (which, by default, are not allowed in the name of a control sequence in TeX).

(In the following LPEG we have a problem when we try to add `{` and `}`).

```
  local other = S ":_@+-*/<>!?;.()[]~^=#&\"\'\\$" --
  local extra_others = { }
  function add_to_other ( c )
    if c ~= " " then
```

We will use `extra_others` to retrieve further these characters from the list of the letters.

```
      extra_others[c] = true
```

The LPEG pattern `other` will be used in conjunction with the key `tag` (mainly for languages such as HTML and XML) for the character `/` in the closing tags `</....>`).

```
      other = other + P ( c )
    end
  end
```

Now, the first transformation of the definition of the language, as provided by the end user in the argument `definition` of `piton.new_language`.

```
  local def_table
  if ( S ", " ^ 0 * -1 ) : match ( definition ) then
    def_table = {}
  else
    local strict_braces  =
      P { "E" ,
          E = ( "{" * V "F" * "}" + ( 1 - S ",{}" ) ) ^ 0  ,
          F = ( "{" * V "F" * "}" + ( 1 - S "{}" ) ) ^ 0
        }
    local cut_definition =
      P { "E" ,
          E = Ct ( V "F" * ( "," * V "F" ) ^ 0 ) ,
          F = Ct ( space ^ 0 * C ( alpha ^ 1 ) * space ^ 0
```

```
                    * ( "=" * space ^ 0 * C ( strict_braces ) ) ^ -1 )
        }
    def_table = cut_definition : match ( definition )
end
```

The definition of the language, provided by the end user of piton is now in the Lua table `def_table`. We will use it *several times*.

The following LPEG will be used to extract arguments in the values of the keys (`morekeywords`, `morecomment`, `morestring`, etc.).

```
local tex_braced_arg = "{" * C ( ( 1 - P "}" ) ^ 0 ) * "}"
local tex_arg = tex_braced_arg + C ( 1 )
local tex_option_arg =  "[" * C ( ( 1 - P "]" ) ^ 0 ) * "]" + Cc ( nil )
local args_for_tag
  =  tex_option_arg
     * space ^ 0
     * tex_arg
     * space ^ 0
     * tex_arg
local args_for_morekeywords
  = "[" * C ( ( 1 - P "]" ) ^ 0 ) * "]"
     * space ^ 0
     * tex_option_arg
     * space ^ 0
     * tex_arg
     * space ^ 0
     * ( tex_braced_arg + Cc ( nil ) )
local args_for_moredelims
  = ( C ( P "*" ^ -2 ) + Cc ( nil ) ) * space ^ 0
    * args_for_morekeywords
local args_for_morecomment
  = "[" * C ( ( 1 - P "]" ) ^ 0 ) * "]"
     * space ^ 0
     * tex_option_arg
     * space ^ 0
     * C ( P ( 1 ) ^ 0 * -1 )
```

We scan the definition of the language (i.e. the table `def_table`) in order to detect the potential key `sensitive`. Indeed, we have to catch that key before the treatment of the keywords of the language. We will also look for the potential keys `alsodigit`, `alsoletter` and `tag`.

```
local sensitive = true
local style_tag , left_tag , right_tag
for _ , x in ipairs ( def_table ) do
  if x[1] == "sensitive" then
    if x[2] == nil or ( P "true" ) : match ( x[2] ) then
      sensitive = true
    else
      if ( P "false" + P "f" ) : match ( x[2] ) then sensitive = false end
    end
  end
  if x[1] == "alsodigit" then x[2] : gsub ( "." , add_to_digit ) end
  if x[1] == "alsoletter" then x[2] : gsub ( "." , add_to_letter ) end
  if x[1] == "alsoother" then x[2] : gsub ( "." , add_to_other ) end
  if x[1] == "tag" then
    style_tag , left_tag , right_tag = args_for_tag : match ( x[2] )
    style_tag = style_tag or [[\PitonStyle{Tag}]]
  end
end
```

Now, the LPEG for the numbers. Of course, it uses `digit` previously computed.

```
local Number =
  K ( 'Number.Internal' ,
      ( digit ^ 1 * "." * # ( 1 - P "." ) * digit ^ 0
```

```
          + digit ^ 0 * "." * digit ^ 1
          + digit ^ 1 )
        * ( S "eE" * S "+-" ^ -1 * digit ^ 1 ) ^ -1
        + digit ^ 1
      )
local string_extra_letters = ""
for _ , x in ipairs ( extra_letters ) do
  if not ( extra_others[x] ) then
   string_extra_letters = string_extra_letters .. x
  end
end
local letter = alpha + S ( string_extra_letters )
                + P "â" + "à" + "ç" + "é" + "è" + "ê" + "ë" + "ï" + "î"
                  + "ô" + "û" + "ü" + "Â" + "À" + "Ç" + "É" + "È" + "Ê" + "Ë"
                  + "Ï" + "Î" + "Ô" + "Û" + "Ü"
local alphanum = letter + digit
local identifier = letter * alphanum ^ 0
local Identifier = K ( 'Identifier.Internal' , identifier )
```

Now, we scan the definition of the language (i.e. the table `def_table`) for the keywords.
The following LPEG does *not* catch the optional argument between square brackets in first position.

```
local split_clist =
  P { "E" ,
       E = ( "[" * ( 1 - P "]" ) ^ 0 * "]" ) ^ -1
           * ( P "{" ) ^ 1
           * Ct ( V "F" * ( "," * V "F" ) ^ 0 )
           * ( P "}" ) ^ 1 * space ^ 0 ,
       F = space ^ 0 * C ( letter * alphanum ^ 0 + other ^ 1 ) * space ^ 0
    }
```

The following function will be used if the keywords are not case-sensitive.

```
local keyword_to_lpeg
function keyword_to_lpeg ( name ) return
  Q ( Cmt (
            C ( identifier ) ,
            function ( _ , _ , a ) return a : upper ( ) == name : upper ( )
            end
          )
    )
end
local Keyword = P ( false )
local PrefixedKeyword = P ( false )
```

Now, we actually treat all the keywords and also the key `moredirectives`.

```
for _ , x in ipairs ( def_table )
do if x[1] == "morekeywords"
      or x[1] == "otherkeywords"
      or x[1] == "moredirectives"
      or x[1] == "moretexcs"
   then
      local keywords = P ( false )
      local style = [[\PitonStyle{Keyword}]]
      if x[1] == "moredirectives" then style = [[\PitonStyle{Directive}]] end
      style =  tex_option_arg : match ( x[2] ) or style
      local n = tonumber ( style )
      if n then
        if n > 1 then style = [[\PitonStyle{Keyword]] .. style .. "}" end
      end
      for _ , word in ipairs ( split_clist : match ( x[2] ) ) do
        if x[1] == "moretexcs" then
          keywords = Q ( [[\]] .. word ) + keywords
        else
          if sensitive
```

The documentation of lstlistings specifies that, for the key `morekeywords`, if a keyword is a prefix of another keyword, then the prefix must appear first. However, for the lpeg, it's rather the contrary. That's why, here, we add the new element *on the left*.

```
            then keywords = Q ( word  ) + keywords
            else keywords = keyword_to_lpeg ( word ) + keywords
            end
          end
        end
        Keyword = Keyword +
           Lc ( "{" .. style .. "{" ) * keywords * Lc "}}"
    end
```

Of course, the feature with the key `keywordsprefix` is designed for the languages TeX, LaTeX, et *al.* In that case, there is two kinds of keywords (= control sequences).

- those beginning with \ and a sequence of characters of catcode "`letter`";
- those beginning by \ followed by one character of catcode "`other`".

The following code addresses both cases. Of course, the LPEG pattern `letter` must catch only characters of catcode "`letter`". That's why we have a key `alsoletter` to add new characters in that category (e.g. `:` when we want to format L3 code). However, the LPEG pattern is allowed to catch *more* than only the characters of catcode "other" in TeX.

```
    if x[1] == "keywordsprefix" then
      local prefix = ( ( C ( 1 - P " " ) ^ 1 ) * P " " ^ 0 ) : match ( x[2] )
      PrefixedKeyword = PrefixedKeyword
         + K ( 'Keyword' , P ( prefix ) * ( letter ^ 1 + other ) )
    end
  end
```

Now, we scan the definition of the language (i.e. the table `def_table`) for the strings.

```
  local long_string  = P ( false )
  local Long_string = P ( false )
  local LongString = P (false )
  local central_pattern = P ( false )
  for _ , x in ipairs ( def_table ) do
    if x[1] == "morestring" then
      arg1 , arg2 , arg3 , arg4 = args_for_morekeywords : match ( x[2] )
      arg2 = arg2 or [[\PitonStyle{String.Long}]]
      if arg1 ~= "s" then
        arg4 = arg3
      end
      central_pattern = 1 - S ( " \r" .. arg4 )
      if arg1 : match "b" then
        central_pattern = P ( [[\]] .. arg3 ) + central_pattern
      end
```

In fact, the specifier `d` is point-less: when it is not in force, it's still possible to double the delimiter with a correct behaviour of piton since, in that case, piton will compose *two* contiguous strings...

```
      if arg1 : match "d" or arg1 == "m" then
        central_pattern = P ( arg3 .. arg3 ) + central_pattern
      end
      if arg1 == "m"
      then prefix = B ( 1 - letter - ")" - "]" )
      else prefix = P ( true )
      end
```

First, a pattern *without captures* (needed to compute `braces`).

```
    long_string = long_string +
        prefix
        * arg3
        * ( space + central_pattern ) ^ 0
        * arg4
```

Now a pattern *with captures*.

```
    local pattern =
        prefix
        * Q ( arg3 )
        * ( SpaceInString + Q ( central_pattern ^ 1 ) + EOL ) ^ 0
        * Q ( arg4 )
```

We will need `Long_string` in the nested comments.

```
      Long_string = Long_string + pattern
      LongString = LongString +
        Ct ( Cc "Open" * Cc ( "{" ..  arg2 .. "{" ) * Cc "}}" )
        * pattern
        * Ct ( Cc "Close" )
    end
  end
```

The argument of `Compute_braces` must be a pattern *which does no catching* corresponding to the strings of the language.

```
  local braces = Compute_braces ( long_string )
  if piton.beamer then Beamer = Compute_Beamer ( lang , braces ) end

  DetectedCommands =
    Compute_DetectedCommands ( lang , braces )
    + Compute_RawDetectedCommands ( lang , braces )

  LPEG_cleaner[lang] = Compute_LPEG_cleaner ( lang , braces )
```

Now, we deal with the comments and the delims.

`sCmment` is for the comments (of `morecomment`) of type `s` (*standard*) or `n` (*nested*).

```
  local sComment = P ( false )
```

`lComment` is for the comments (of `morecomment`) of type `l` (*line*).

```
  local lComment = P ( false )
```

`fCmment` is for the comments (of `morecomment`) of type `f` (*first*).

```
  local fComment = P ( false )
```

```
  local fComment = P ( false )

  for _ , x in ipairs ( def_table ) do
    if x[1] == "morecomment" then
      local arg1 , arg2 , other_args = args_for_morecomment : match ( x[2] )
      arg2 = arg2 or [[\PitonStyle{Comment}]]
```

If the letter `i` is present in the first argument (eg: `morecomment = [si]{(*}{*)}`, then the corresponding comments are discarded.

```
      if arg1 : match "i" then arg2 = [[\PitonStyle{Discard}]] end
      if arg1 : match "l" or arg1 : match "f" then
        local arg3 = ( tex_braced_arg + C ( P ( 1 ) ^ 0 * -1 ) )
                     : match ( other_args )
        if arg3 == [[\#]] then arg3 = "#" end -- mandatory
        if arg3 == [[\%]] then arg3 = "%" end -- mandatory
        local MyLPEG =
            Ct ( Cc "Open"
                 * Cc ( "{" .. arg2 .. [[{\PitonSpaceSubstitute{]] )
                 * Cc "}}}"
               )
                 * Q ( arg3 )
                 * ( CommentMath + Q ( ( 1 - S "$\r" ) ^ 1 ) ) ^ 0 -- $ noqa
            * Ct ( Cc "Close" )
            * ( EOL + -1 )
         if arg1 : match "l" then
           lComment = lComment + MyLPEG
```

```
        else
          fComment = fComment + MyLPEG
        end
      else
        local arg3 , arg4 =
          ( tex_arg * space ^ 0 * tex_arg ) : match ( other_args )
        if arg1 : match "s" then
          sComment = sComment +
              Ct ( Cc "Open" * Cc ( "{" .. arg2 .. "{" ) * Cc "}}" )
              * Q ( arg3 )
              * (
                  CommentMath
                  + Q ( ( 1 - P ( arg4 ) - S "$\r" ) ^ 1 ) -- $
                  + EOL
                ) ^ 0
              * Q ( arg4 )
              * Ct ( Cc "Close" )
        end
        if arg1 : match "n" then
          sComment = sComment +
            Ct ( Cc "Open" * Cc ( "{" .. arg2 .. "{" ) * Cc "}}" )
             * P { "A" ,
                  A = Q ( arg3 )
                      * ( V "A"
                          + Q ( ( 1 - P ( arg3 ) - P ( arg4 )
                                  - S "\r$\"" ) ^ 1 ) -- $
                          + long_string
                          +   "$" -- $
                              * K ( 'Comment.Math' , ( 1 - S "$\r" ) ^ 1 ) --$
                              * "$" -- $
                          + EOL
                        ) ^ 0
                      * Q ( arg4 )
                }
            * Ct ( Cc "Close" )
        end
      end
    end
```

For the keys `moredelim`, we have to add another argument in first position, equal to `*` or `**`.

```
    if x[1] == "moredelim" then
      local arg1 , arg2 , arg3 , arg4 , arg5
        = args_for_moredelims : match ( x[2] )
      local MyFun = Q
      if arg1 == "*" or arg1 == "**" then
        function MyFun ( x )
          if x ~= '' then return
            LPEG1[lang] : match ( x )
          end
        end
      end
      local left_delim
      if arg2 : match "i" then
        left_delim = P ( arg4 )
      else
        left_delim = Q ( arg4 )
      end
      if arg2 : match "l" then
        sComment = sComment +
            Ct ( Cc "Open" * Cc ( "{" .. arg3 .. "{" ) * Cc "}}" )
            * left_delim
            * ( MyFun ( ( 1 - P "\r" ) ^ 1 ) ) ^ 0
            * Ct ( Cc "Close" )
            * ( EOL + -1 )
```

```
      end
      if arg2 : match "s" then
        local right_delim
        if arg2 : match "i" then
          right_delim = P ( arg5 )
        else
          right_delim = Q ( arg5 )
        end
        sComment = sComment +
            Ct ( Cc "Open" * Cc ( "{" .. arg3 .. "{" ) * Cc "}}" )
            * left_delim
            * ( MyFun ( ( 1 - P ( arg5 ) - "\r" ) ^ 1 ) + EOL ) ^ 0
            * right_delim
            * Ct ( Cc "Close" )
      end
    end
  end

  local Delim = Q ( S "{[()]}" )
  local Punct = Q ( S "=,:;!\\'\"" )

  local EOL =
    P "\r"
    *
    (
      space ^ 0 * -1
      +
      Cc "EOL"
    )
    * ( ( fComment + lComment ) ^ 0 * LeadingSpace ^ 0 * # ( 1 - S " \r" ) ) ^ -1

  local Main =
    space ^ 0 * EOL * ( fComment + lComment ) ^ 0
       + Space
       + Tab
       + Escape + EscapeMath
       + CommentLaTeX
       + Beamer
       + DetectedCommands
       + sComment
       + lComment
```

We must put `LongString` before `Delim` because, in PostScript, the strings are delimited by parenthesis and those parenthesis would be caught by `Delim`.

```
       + LongString
       + Delim
       + PrefixedKeyword
       + Keyword * ( -1 + # ( 1 - alphanum ) )
       + Punct
       + K ( 'Identifier.Internal' , letter * alphanum ^ 0 )
       + Number
       + Word
```

The LPEG `LPEG1[lang]` is used to reformat small elements, for example the arguments of the "detected commands".
Of course, here, we must not put `local`, of course.

```
  LPEG1[lang] = Main ^ 0
```

The LPEG `LPEG2[lang]` is used to format general chunks of code.

```
  LPEG2[lang] =
    Ct (
         ( space ^ 0 * P "\r" ) ^ -1
         * Lc [[ \@@_begin_line: ]]
         * ( fComment + lComment ) ^ 0 -- 2026-05-12
         * LeadingSpace ^ 0
```

```
          * ( space ^ 1 * -1 + Main ) ^ 0
          * -1
          * Lc [[ \@@_end_line: ]]
        )
```

If the key `tag` has been used. Of course, this feature is designed for the languages such as HTML and XML.

```
  if left_tag then
    local Tag = Ct ( Cc "Open" * Cc ( "{" .. style_tag .. "{" ) * Cc "}}" )
                * Q ( left_tag * other ^ 0 ) -- $
                * ( ( ( 1 - P ( right_tag ) ) ^ 0 )
                  / ( function ( x ) return LPEG0[lang] : match ( x ) end ) )
                * Q ( right_tag )
                * Ct ( Cc "Close" )
    MainWithoutTag
            = space ^ 1 * -1
            + space ^ 0 * EOL
            + Space
            + Tab
            + Escape + EscapeMath
            + CommentLaTeX
            + Beamer
            + DetectedCommands
            + sComment
            + Delim
            + LongString
            + PrefixedKeyword
            + Keyword * ( -1 + # ( 1 - alphanum ) )
            + Punct
            + K ( 'Identifier.Internal' , letter * alphanum ^ 0 )
            + Number
            + Word
    LPEG0[lang] = MainWithoutTag ^ 0
    local LPEGaux = Tab + Escape + EscapeMath + CommentLaTeX
                    + Beamer + DetectedCommands + sComment + Tag
    MainWithTag
            = space ^ 1 * -1
            + space ^ 0 * EOL
            + Space
            + LPEGaux
            + Q ( ( 1 - EOL - LPEGaux ) ^ 1 )
    LPEG1[lang] = MainWithTag ^ 0
    LPEG2[lang] =
      Ct (
           ( space ^ 0 * P "\r" ) ^ -1
           * Lc [[ \@@_begin_line: ]]
           * Beamer
           * LeadingSpace ^ 0
           * LPEG1[lang]
           * -1
           * Lc [[ \@@_end_line: ]]
         )
  end
end
```

3.17 We write the files (key 'write') and join the files in the PDF (key 'join')

```
function piton.write_files_now ( )
  for file_name , file_content in pairs ( piton.write_files ) do
    local file = io.open ( file_name , "w" )
    if file then
      file : write ( file_content )
```

```
      file : close ( )
    else
      sprintL3
        ( [[ \@@_error_or_warning:nn { FileError } { ]] .. file_name .. "}" )
    end
  end
end
```

3.18 Conversion from utf8 to utf16

Caution: the following function should be considered as public.

```
function piton.utf16 ( str )
  local hex = { "FEFF" }  -- BOM UTF-16BE
  for _, codepoint in utf8.codes(str) do
    table.insert(hex, string.format("%04X", codepoint))
  end
  return table.concat(hex)
end
```

⟨/LUA⟩