

The `lualatex-math` package*

Philipp Stephani
p.stephani2@gmail.com

2021/07/05

Contents

1	Introduction	1
2	Interface	2
3	Implementation of the $\LaTeX 2_{\epsilon}$ package	2
3.1	Requirements	2
3.2	Messages	3
3.3	Initialization	3
3.4	Patching	3
3.5	$\LaTeX 2_{\epsilon}$ kernel	5
3.6	<code>amsmath</code>	5
3.7	<code>mathtools</code>	8
3.8	<code>icomma</code>	9
4	Implementation of the <code>Lua\LaTeX</code> module	10

1 Introduction

`Lua \TeX` brings major improvements to all areas of \TeX typesetting and programming. They are made available through new primitives or the embedded Lua interpreter, and combining them with existing $\LaTeX 2_{\epsilon}$ packages is not a task the average \LaTeX user should have to care about. Therefore a multitude of $\LaTeX 2_{\epsilon}$ packages have been written to bridge the gap between documents and the new features. The `lualatex-math` package focuses on the additional possibilities for mathematical typesetting. The most eminent of the new features is the ability to use Unicode and OpenType fonts, as provided by Will Robertson's `unicode-math` package. However, there is a smaller group of changes unrelated to Unicode: these are to be dealt with in this package. While in principle most \TeX documents written for traditional engines should work just fine with `Lua \TeX` , there is a small number of breaking changes that require the attention of package authors. The `lualatex-math` package tries to fix some of the issues encountered while porting traditional macro packages to `Lua \LaTeX` .

The decision to write patches for existing macro packages should not be made lightly: monkey patching done by somebody different from the original package author ties the patching package to the implementation details of the patched functionality and breaks all rules of encapsulation. However, due to the lack of

*This document corresponds to `lualatex-math` v1.11, dated 2021/07/05.

alternatives, it has become an accepted way of providing new functionality in L^AT_EX. To keep the negative impact as small as possible, the `lualatex-math` package patches only the L^AT_EX 2_ε kernel and a small number of popular packages. In general, this package should be regarded as a temporary kludge that should be removed once the math-related packages are updated to be usable with LuaT_EX. By its very nature, the package is likely to cause problems; in such cases, please refer to the issue tracker¹.

2 Interface

The `lualatex-math` package can be loaded with `\usepackage` or `\RequirePackage`, as usual. It has no options and no public interface; the patching is always done when the package is loaded and cannot be controlled. As a matter of course, the `lualatex-math` package needs LuaL^AT_EX to function; it will produce error messages and refuse to load under other engines and formats. The package depends on the `expl3` bundle, the `etoolbox` package and the `filehook` package. The `lualatex-math` package is independent of the `unicode-math` package; the fixes provided here are valid for both Unicode and legacy math typesetting.

Currently patches for the L^AT_EX 2_ε kernel and the `amsmath`, `mathtools` and `icomma` packages are provided. It is not relevant whether you load these packages before or after `lualatex-math`. They should work as expected (and ideally you shouldn't notice anything), but if you load other packages that by themselves overwrite commands patched by this package, bad things may happen, as it is usual with L^AT_EX.

One user-visible change is that the new `\mathstyle` primitive should work in all cases after the `lualatex-math` package has been loaded, provided you use the high-level macros `\frac`, `\binom`, and `\genfrac`. The fraction-like T_EX primitives like `\over` or `\atopwithdelims` and the plain T_EX leftovers like `\brack` or `\choose` cannot be patched, and you shouldn't use them.

3 Implementation of the L^AT_EX 2_ε package

3.1 Requirements

```

1 (*package)
2 (@@=lltxmath)
3 \NeedsTeXFormat{LaTeX2e}[2020/02/02]
4 \RequirePackage{expl3}[2018/06/18]
5 \ProvidesExplPackage{lualatex-math}{2021/07/05}{1.11}%
6   {Patches for mathematics typesetting with LuaLaTeX}
7 \RequirePackage { etoolbox } [ 2007/10/08 ]
8 \cs_if_exist:NF \newluabytecode
9   { \RequirePackage { luatexbase } [ 2010/05/27 ] }
10 \directlua{require("lualatex-math")}

```

`\@@_restore_catcode:N` Executing the exhaustive expansion of `\@@_restore_catcode:N`*<character token>* restores the category code of the *<character token>* to its current value.

```

11 \cs_new_nopar:Npn \@@_restore_catcode:N #1 {
12   \char_set_catcode:nn { \int_eval:n { `#1 } }
13   { \char_value_catcode:n { `#1 } }
14 }

```

¹<https://github.com/phst/lualatex-math/issues>

We use the macro defined above to restore the category code of the dollar sign. There are packages that make the dollar sign active; hopefully they get loaded after the packages we are trying to patch.

```

15 \exp_args:Nx \AtEndOfPackage {
16   \@@_restore_catcode:N \$
17 }
18 \char_set_catcode_math_toggle:N \$

```

3.2 Messages

- luatex-required Issued when not running under LuaTeX.
- ```

19 \msg_new:nnn { lualatex-math } { luatex-required } {
20 The~ lualatex-math~ package~ requires~ LuaTeX. \\
21 I~ will~ stop~ loading~ now.
22 }

```
- macro-expected Issued when trying to patch a non-macro. The first argument must be the detokenized macro name.
- ```

23 \msg_new:nnn { lualatex-math } { macro-expected } {
24   I've~ expected~ that~ #1~ is~ a~ macro,~ but~ it~ isn't.
25 }

```
- wrong-meaning Issued when trying to patch a macro with an unexpected meaning. The first argument must be the detokenized macro name; the second argument must be the actual detokenized meaning; and the third argument must be the expected detokenized meaning.
- ```

26 \msg_new:nnn { lualatex-math } { wrong-meaning } {
27 I've~ expected~ #1~ to~ have~ the~ meaning \\
28 #3, \\
29 but~ it~ has~ the~ meaning \\
30 #2.
31 }

```
- patch-macro Issued when a macro is patched. The first argument must be the detokenized macro name.
- ```

32 \msg_new:nnn { lualatex-math } { patch-macro } {
33   I'm~ going~ to~ patch~ macro~ #1.
34 }

```

3.3 Initialization

Unless we are running under LuaTeX, we issue an error and quit immediately.

```

35 \sys_if_engine_luatex:F {
36   \msg_error:nn { lualatex-math } { luatex-required }
37   \endinput
38 }

```

3.4 Patching

- \@@_temp:w A scratch macro.
- ```

39 \cs_new_eq:NN \@@_temp:w \prg_do_nothing:

```
- \@@\_patch:NNnnn The auxiliary macro `\@@_patch:NNnnn⟨command⟩⟨factory command⟩⟨parameter text⟩⟨expected replacement text⟩⟨new replacement text⟩` tries to patch `⟨command⟩`. If `⟨command⟩` is undefined, do nothing. Otherwise it must be a macro with the given `⟨parameter text⟩` and `⟨expected replacement text⟩`, created by the

given  $\langle factory command \rangle$  or equivalent. In this case it will be overwritten using the  $\langle parameter text \rangle$  and the  $\langle new replacement text \rangle$ . Otherwise issue a warning and don't overwrite.

```

40 \cs_new_protected_nopar:Npn \@@_patch:NNnnn #1 #2 #3 #4 #5 {
41 \cs_if_exist:NT #1 {
42 \token_if_macro:NTF #1 {
43 \group_begin:
44 #2 \@@_temp:w #3 { #4 }
45 \cs_if_eq:NNTF #1 \@@_temp:w {
46 \msg_info:nxx { lualatex-math } { patch-macro }
47 { \token_to_str:N #1 }
48 \group_end:
49 #2 #1 #3 { #5 }
50 } {
51 \msg_warning:nxxxx { lualatex-math } { wrong-meaning }
52 { \token_to_str:N #1 } { \token_to_meaning:N #1 }
53 { \token_to_meaning:N \@@_temp:w }
54 \group_end:
55 }
56 } {
57 \msg_warning:nxx { lualatex-math } { macro-expected }
58 { \token_to_str:N #1 }
59 }
60 }
61 }
62 \cs_generate_variant:Nn \@@_patch:NNnnn { c }

```

$\backslash\@_set\_mathchar:NN$  The macro  $\backslash\@_set\_mathchar:NN\langle control sequence \rangle\langle token \rangle$  defines the  $\langle control sequence \rangle$  as an extended mathematical character shorthand whose mathematical code is given by the mathematical code of the character  $\langle token \rangle$ . We cannot use the  $\backslash\Umathcharnumdef$  primitive here since we would then rely on the  $\backslash\Umathcodenum$  primitive which is currently broken.<sup>2</sup>

```

63 \cs_new_protected_nopar:Npn \@@_set_mathchar:NN #1 #2 {
64 \Umathchardef #1
65 \lua_now:e {
66 lualatex.math.print_class_fam_slot(\int_eval:n { `#2 })
67 }
68 \scan_stop:
69 }

```

$\backslash\@_before\_package:nn$  The macro  $\backslash\@_before\_package:nn\{\langle package \rangle\}\{\langle code \rangle\}$  executes the  $\langle code \rangle$  before the  $\langle package \rangle$  is loaded. Accordingly,  $\backslash\@_after\_package:nn\{\langle package \rangle\}\{\langle code \rangle\}$  executes the  $\langle code \rangle$  after the  $\langle package \rangle$  is loaded. If the  $\langle package \rangle$  is already loaded, nothing happens. We prefer using native L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> hooks if possible.

```

70 \ifl@t@r \fmtversion { 2020/10/01 } {
71 \cs_new_protected_nopar:Npn \@@_before_package:nn #1 #2 {
72 \AddToHook { package/before/#1 } { #2 }
73 }
74 \cs_new_protected_nopar:Npn \@@_after_package:nn #1 #2 {
75 \AddToHook { package/after/#1 } { #2 }
76 }
77 } {
78 \RequirePackage { filehook } [2011/03/09]
79 \cs_new_protected_nopar:Npn \@@_before_package:nn #1 #2 {
80 \AtBeginOfPackageFile { #1 } { #2 }
81 }

```

<sup>2</sup><http://tug.org/pipermail/luatex/2012-October/003794.html>

```

82 \cs_new_protected_nopar:Npn \@@_after_package:nn #1 #2 {
83 \AtEndOfPackageFile { #1 } { #2 }
84 }
85 }

```

`\@@_after_package_or_now:nn` The macro `\@@_after_package_or_now:nn{<package>}{<code>}` executes the `<code>` after the `<package>` is loaded. If the `<package>` is already loaded, the `<code>` is executed immediately.

```

86 \cs_new_protected_nopar:Npn \@@_after_package_or_now:nn #1 #2 {
87 \ifpackageloaded { #1 } { #2 } { \@@_after_package:nn { #1 } { #2 } }
88 }

```

### 3.5 L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> kernel

LuaT<sub>E</sub>X enables access to the current mathematical style via the `\mathstyle` primitive. For this to work, fraction-like constructs (e.g., `<numerator> \over <denominator>`) have to be enclosed in a `\Ustack` group. `\frac` can be patched to do this, but the plain T<sub>E</sub>X remnants `\choose`, `\brack` and `\brace` should be discouraged.

`\frac` Here we assume that nobody except `amsmath` redefines `\frac`. This is obviously not the case, but we ignore other packages (e.g., `nath`) for the moment. We only patch the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> kernel definition if the `amsmath` package is not loaded; the corresponding patch for `amsmath` follows below. Since `\frac` is declared by `\DeclareRobustCommand`, we must patch the macro `\frac⏟`.

```

89 \AtEndPreamble {
90 \ifpackageloaded { amsmath } { } {
91 \@@_patch:cNnnn { frac~ } \cs_set:Npn { #1 #2 } {
92 {
93 \begingroup #1 \endgroup \over #2
94 }
95 } {

```

To do: do we need the additional set of braces around `\Ustack`?

```

96 {
97 \Ustack { \group_begin: #1 \group_end: \over #2 }
98 }
99 }
100 }
101 }

```

### 3.6 amsmath

The popular `amsmath` package is subject to three LuaT<sub>E</sub>X-related problems:

- The `\mathcode` primitive is used several times, which fails for Unicode math characters. `\Umathcode` should be used instead.
- Legacy font dimensions are used for constructing stacks in the `\substack` command and the `subarray` environment. This doesn't work if a Unicode math font is selected.
- The fraction commands `\frac` and `\genfrac` don't use the `\Ustack` primitive.

These problems have been fixed in version 2.17i of `amsmath`, so we don't attempt to patch it if that version is loaded.

`\c_@@_std_minus_mathcode_int` `\c_@@_std_equal_mathcode_int` These constants contain the standard  $\TeX$  mathematical codes for the minus and the equal signs. We temporarily set the math codes to these constants before loading the `amsmath` package so that it can request the legacy math code without error.

```
102 \int_const:Nn \c_@@_std_minus_mathcode_int { "2200 }
103 \int_const:Nn \c_@@_std_equal_mathcode_int { "303D }
```

`\l_@@_minus_mathchar` `\l_@@_equal_mathchar` These mathematical characters are saved before `amsmath` is loaded so that we can temporarily assign the  $\TeX$  values to the mathematical codes of the minus and equals signs. The `amsmath` package queries these codes, and if they represent Unicode characters, the package loading will fail. If `amsmath` has already been loaded, there is nothing we can do, therefore we use the non-starred version of `\AtBeginOfPackageFile`.

```
104 \tl_new:N \l_@@_minus_mathchar
105 \tl_new:N \l_@@_equal_mathchar
106 \@@_before_package:nn { amsmath } {
107 \ifpackagelater { amsmath } { 2020/08/24 } { } {
108 \@@_set_mathchar:NN \l_@@_minus_mathchar \-
109 \@@_set_mathchar:NN \l_@@_equal_mathchar \=
110 }
```

Now we temporarily reset the mathematical codes.

```
110 \char_set_mathcode:nn { \- } { \c_@@_std_minus_mathcode_int }
111 \char_set_mathcode:nn { \= } { \c_@@_std_equal_mathcode_int }
112 \@@_after_package:nn { amsmath } { }
```

`\std@minus` `\std@equals` The `amsmath` package defines the control sequences `\std@minus` and `\std@equal` as mathematical character shorthands while loading, but uses our restored mathematical codes, which must be fixed.

```
113 \cs_set_eq:NN \std@minus \l_@@_minus_mathchar
114 \cs_set_eq:NN \std@equal \l_@@_equal_mathchar
```

Finally, we restore the original mathematical codes of the two signs.

```
115 \Umathcodenum \- \l_@@_minus_mathchar
116 \Umathcodenum \= \l_@@_equal_mathchar
117 }
118 }
119 }
```

All of the following fixes work even if `amsmath` is already loaded.

`\@begindocumenthook` `amsmath` repeats the definition of `\std@minus` and `\std@equal` at the beginning of the document, so we also have to patch the internal kernel macro `\@begindocumenthook` which contains the hook code.

```
120 \@@_after_package_or_now:nn { amsmath } {
121 \ifpackagelater { amsmath } { 2020/08/24 } { } {
122 \tl_replace_once:Nnn \@begindocumenthook {
123 \mathchardef \std@minus \mathcode \- \relax
124 \mathchardef \std@equal \mathcode \= \relax
125 } {
126 \@@_set_mathchar:NN \std@minus \-
127 \@@_set_mathchar:NN \std@equal \=
128 }
129 }
```

`subarray` The `subarray` environment uses legacy font dimensions. We simply patch it to use  $\text{\LaTeX}$  font parameters (and  $\text{\LaTeX}$  expressions instead of  $\text{\TeX}$  arithmetic). Since subscript arrays are conceptually vertical stacks, we use the sum of top and bottom

shift for the default vertical baseline distance (`\baselineskip`) and the minimum vertical gap for stack for the minimum baseline distance (`\lineskip`).

```

130 \ifpackagelater { amsmath } { 2020/09/23 } { } {
131 \@@_patch:NNnnn \subarray \cs_set:Npn { #1 } {
132 \vcenter
133 \bgroup
134 \Let@
135 \restore@math@cr
136 \default@tag
137 \baselineskip \fontdimen 10~ \scriptfont \tw@
138 \advance \baselineskip \fontdimen 12~ \scriptfont \tw@
139 \@@=}
140 \lineskip \thr@@ \fontdimen 8~ \scriptfont \thr@@
141 \@@=||txmath)
142 \lineskiplimit \lineskip
143 \ialign
144 \bgroup
145 \ifx c #1 \hfil \fi
146 $ \m@th \scriptstyle ## $
147 \hfil
148 \crcr
149 } {
150 \vcenter
151 \c_group_begin_token
152 \Let@
153 \restore@math@cr
154 \default@tag
155 \skip_set:Nn \baselineskip {
156 \Umathstacknumup \scriptstyle
157 + \Umathstackdenomdown \scriptstyle
158 }
159 \lineskip \Umathstackvgap \scriptstyle
160 \lineskiplimit \lineskip
161 \ialign
162 \c_group_begin_token
163 \token_if_eq_meaning:NNT c #1 { \hfil }
164 \Ustartmath
165 \m@th
166 \scriptstyle
167 \alignmark \alignmark
168 \Ustopmath
169 \hfil
170 \crcr
171 }

```

`\frac` Since `\frac` is declared by `\DeclareRobustCommand`, we must patch the macro `\frac_`.

```

172 \@@_patch:cNnnn { frac~ } \cs_set:Npn { #1 #2 } {
173 {
174 \@@=}
175 \begingroup #1 \endgroup \@@over #2
176 }
177 } {
178 {
179 \Ustack { \group_begin: #1 \group_end: \@@over #2 }
180 \@@=||txmath)
181 }
182 }

```

`\genfrac` Generalized fractions are typeset by the `\genfrac` command. Since `\genfrac` is declared by `\DeclareRobustCommand`, we have to patch the macro `\genfrac_U`.

```

183 \@@_patch:cNnnn { genfrac~ } \cs_set:Npn {
184 #1 #2 #3 #4 #5 #6
185 } {
186 {
187 \@mathstyle { #4 }
188 \genfrac@choice o { #1 }
189 {
190 \begingroup #5 \endgroup
191 <@@=)
192 \ifx @ #3 @ \@@over \else \@@above \fi #3 \relax
193 #6
194 }
195 \genfrac@choice c { #2 }
196 }
197 } {
198 {
199 \@mathstyle { #4 }
200 \genfrac@choice o { #1 }
201 {
202 \Ustack {
203 \group_begin: #5 \group_end:
204 \tl_if_empty:nTF { #3 } {
205 \@@over
206 } {
207 \@@above #3 \scan_stop:
208 }
209 <@@=lltxmath)
210 #6
211 }
212 }
213 \genfrac@choice c { #2 }
214 }
215 }
216 }
217 }

```

### 3.7 mathtools

`mathtools`' `\cramped` command and others that make use of its internal version use a hack involving a null radical. LuaTeX has primitives for setting material in cramped mode, so we make use of them.

In newer versions of `mathtools`, this issue is fixed, in which case we skip the patch.

`\MT_cramped_internal:Nn` The macro `\MT_cramped_internal:Nn<style>{<expression>}` typesets the *<expression>* in the cramped style corresponding to the given *<style>* (`\displaystyle` etc.); all we have to do in LuaTeX is to select the correct primitive. Rewriting the user-level `\cramped` command and employing `\mathstyle` would be possible as well, but we avoid this way since we want to patch only a single command.

```

218 \@@_after_package_or_now:nn { mathtools } {
219 \ifpackagelater { mathtools } { 2021/03/28 } { } {
220 \@@_patch:NNnnn \MT_cramped_internal:Nn
221 \cs_set_nopar:Npn { #1 #2 } {
222 \setbox \z@ \hbox {

```



```

223 $
224 \m@th
225 #1
226 \kern -\nulldelimiterspace
227 \radical \z@ { #2 }
228 $
229 }
230 \ifx #1 \displaystyle
231 \dimen@ = \fontdimen 8 \textfont 3
232 \advance \dimen@ .25 \fontdimen 5 \textfont 2
233 \else
234 \dimen@ = 1.25 \fontdimen 8
235 \ifx #1 \textstyle
236 \textfont
237 \else
238 \ifx #1 \scriptstyle
239 \scriptfont
240 \else
241 \scriptscriptfont
242 \fi
243 \fi
244 3
245 \fi
246 \advance \dimen@ -\ht\z@
247 \ht\z@ = -\dimen@
248 \ifvmode \leavevmode \fi
249 { }
250 \box\z@
251 } {

```

Here the additional set of braces is absolutely necessary, otherwise the changed mathematical style would be applied to the material after the `\mathchoice` construct. As the original command works in both text and math mode, we use `\ensuremath` here.

```

252 {
253 \ensuremath {
254 \use:c { cramped \cs_to_str:N #1 } #2
255 }
256 }
257 }
258 }
259 }

```

### 3.8 icomma

The `icomma` package uses `\mathchardef` to save the mathematical code of the comma character. This breaks for Unicode fonts. The incompatibility was noticed by Peter Breinfeld.<sup>3</sup>

`\mathcomma` `icomma` defines the mathematical character shorthand `\icomma` at the beginning of the document, therefore we again patch `\@begindocumenthook`.

```

260 \@@_after_package_or_now:nn { icomma } {
261 \@ifl@t@r \fmtversion { 2020/10/01 } {
262 \hook_gput_code:nnn { begindocument } { lualatex-math } {
263 \@@_set_mathchar:NN \mathcomma \,
264 \mathcode `\", = "8000 ~

```

<sup>3</sup><https://groups.google.com/forum/#!topic/de.comp.text.tex/Cputk-AJS5I/discussion>

```

265 }
266 \hook_gset_rule:nnnn
267 { begindocument } { lualatex-math } { voids } { icomma }
268 } {
269 \tl_replace_once:Nnn \@begindocumenthook {
270 \mathchardef \mathcomma \mathcode `\",
271 } {
272 \@_set_mathchar:NN \mathcomma \,
273 }
274 }
275 }
276 </package>

```

## 4 Implementation of the Lua<sup>A</sup>T<sub>E</sub>X module

For the Lua module, we use the standard luatexbase-modutils template.

```

277 <*lua>
278 lualatex = lualatex or {}
279 lualatex.math = lualatex.math or {}
280 luatexbase.provides_module({
281 name = "lualatex-math",
282 date = "2013/08/03",
283 version = 1.3,
284 description = "Patches for mathematics typesetting with LuaLaTeX",
285 author = "Philipp Stephani",
286 licence = "LPPL v1.3+"
287 })

```

`unpack` The function `unpack` needs to be treated specially as it got moved around in Lua 5.2.

```

288 local unpack = unpack or table.unpack

289 local cctb = luatexbase.catcodetables or
290 {string = luatexbase.registernumber("catcodetable@string")}

```

`print_class_fam_slot` The function `print_class_fam_slot` takes one argument which must be a number. It interprets the argument as a Unicode code point whose mathematical code is printed in the form  $\langle class \rangle_{\square} \langle family \rangle_{\square} \langle slot \rangle$ , suitable for the right-hand side of `\Umathchardef`.

```

291 function lualatex.math.print_class_fam_slot(char)
292 local code = tex.getmathcode(char)
293 local class, family, slot = unpack(code)
294 local result = string.format("%i %i %i ", class, family, slot)
295 tex.sprint(cctb.string, result)
296 end

297 return lualatex.math
298 </lua>

```

## Change History

|                                                          |   |
|----------------------------------------------------------|---|
| v0.1                                                     |   |
| General: Initial version                                 | 1 |
| v0.2                                                     |   |
| General: Added patch for the <code>icomma</code> package | 9 |

|       |                                                                                                                         |      |
|-------|-------------------------------------------------------------------------------------------------------------------------|------|
| v0.3  | General: Patched math group allocation to gain access to all families                                                   | 5    |
| v0.3a | General: Updated for changes in l3kernel                                                                                | 1    |
| v0.3b | \@begindocumenthook: Another update for a change in l3kernel                                                            | 6    |
| v0.3c | \@@_set_mathchar:NN: l3kernel renamed \lua_now:x to \lua_now_x:n                                                        | 4    |
| v1.0  | General: Switched to l3docstrip                                                                                         | 1    |
| v1.1  | \@@_set_mathchar:NN: Update reasoning why \Umathcharnumdef is not used here                                             | 4    |
|       | General: Add fix and unit test for amsopn                                                                               | 8    |
| v1.10 | General: Skip patch if mathtools is recent enough                                                                       | 8    |
|       | Use new L <sup>A</sup> T <sub>ε</sub> X hook management if available                                                    | 9    |
| v1.11 | General: Adapt to March 2021 changes to mathtools                                                                       | 8    |
| v1.2  | \l_@@_equal_mathchar: Replace removed macro \chk_if_free_cs:N                                                           | 6    |
| v1.3  | General: Stop using the deprecated module function                                                                      | 10   |
| v1.3a | \@@_set_mathchar:NN: l3kernel has (currently) dropped \lua_now_x:n                                                      | 4    |
| v1.4  | \MT_cramped_internal:Nn: Added \ensuremath to work around <a href="#">issue 11</a>                                      | 9    |
|       | General: Removed patch for math group allocation; the kernel itself now supports<br>all available math families         | 5    |
| v1.4a | \@@_set_mathchar:NN: \lua_now_x:n is back                                                                               | 4    |
|       | General: Avoid \RequireLuaModule                                                                                        | 2    |
|       | Load luatexbase only if required                                                                                        | 2    |
|       | Load all of luatexbase                                                                                                  | 10   |
|       | Pick up new name for string catcode table where available                                                               | 10   |
|       | Use expl3 versions of LuaT <sub>ε</sub> X math primitives                                                               | 2    |
| v1.5  | General: Removed patch for \Mathstrutbox@; amsmath now has a definition<br>usable in LuaL <sup>A</sup> T <sub>ε</sub> X | 6    |
|       | Removed unused helper macro \@@_char_dim:NN                                                                             | 6    |
|       | Removed unused Lua function print_fam_slot                                                                              | 10   |
| v1.6  | General: Removed patch for \newmcodes@; amsmath now has a definition usable in<br>LuaL <sup>A</sup> T <sub>ε</sub> X    | 8    |
| v1.7  | \genfrac: Adapt patch to changes in amsmath                                                                             | 8    |
| v1.8  | \@@_set_mathchar:NN: \lua_now_x:n is now called \lua_now:e                                                              | 4    |
|       | Stop using \...:D control sequences                                                                                     | 4    |
|       | \frac: Stop using \...:D control sequences                                                                              | 5, 7 |
|       | \genfrac: Stop using \...:D control sequences                                                                           | 8    |
|       | General: Stop using \...:D control sequences                                                                            | 6    |
|       | subarray: Stop using \...:D control sequences                                                                           | 7    |
| v1.9  | \@begindocumenthook: Don't patch newer versions of amsmath                                                              | 6    |
|       | \MT_cramped_internal:Nn: Stop using \...:D control sequences                                                            | 9    |
|       | \frac: Adapt to changes in L <sup>A</sup> T <sub>ε</sub> X kernel                                                       | 5    |
|       | \l_@@_equal_mathchar: Don't patch newer versions of amsmath                                                             | 6    |
|       | General: Require 2020 version of L <sup>A</sup> T <sub>ε</sub> X                                                        | 2    |

|                                                                               |   |
|-------------------------------------------------------------------------------|---|
| Use builtin L <sup>A</sup> T <sub>E</sub> X 2 <sub>ε</sub> hooks if available | 2 |
| <code>subarray</code> : Don't patch newer versions of <code>amsmath</code>    | 7 |
| Stop using <code>\...:D</code> control sequences                              | 7 |

## Index

Numbers written in *italic* refer to the page where the corresponding entry is described; numbers underlined refer to the code line of the definition; numbers in *roman* refer to the code lines where the entry is used.

### Symbols

|                                          |                                          |
|------------------------------------------|------------------------------------------|
| <code>\\$</code>                         | 16, 18                                   |
| <code>\,</code>                          | 263, 264, 270, 272                       |
| <code>\-</code>                          | 108, 110, 115, 123, 126                  |
| <code>\=</code>                          | 109, 111, 116, 124, 127                  |
| <code>\@@_after_package:mn</code>        | 70, 87, 112                              |
| <code>\@@_after_package_or_now:mn</code> | <u>86</u> , 120, 218, 260                |
| <code>\@@_before_package:mn</code>       | 70, 106                                  |
| <code>\@@_patch:NNnnn</code>             | <u>40</u> , 131, 220                     |
| <code>\@@_patch:cNnnn</code>             | <u>40</u> , 91, 172, 183                 |
| <code>\@@_restore_catcode:N</code>       | <u>11</u> , 16                           |
| <code>\@@_set_mathchar:NN</code>         | <u>63</u> , 108, 109, 126, 127, 263, 272 |
| <code>\@@_temp:w</code>                  | <u>39</u> , 44, 45, 53                   |
| <code>\@@above</code>                    | 192, 207                                 |
| <code>\@@cover</code>                    | 175, 179, 192, 205                       |
| <code>\@begindocumenthook</code>         | <u>120</u> , 269                         |
| <code>\@ifl@t@r</code>                   | 70, 261                                  |
| <code>\@ifpackagelater</code>            | 107, 121, 130, 219                       |
| <code>\@ifpackageloaded</code>           | 87, 90                                   |
| <code>\@mathstyle</code>                 | 187, 199                                 |
| <code>\@</code>                          | 20, 27, 28, 29                           |

### A

|                                    |                    |
|------------------------------------|--------------------|
| <code>\AddToHook</code>            | 72, 75             |
| <code>\advance</code>              | 138, 232, 246      |
| <code>\alignmark</code>            | 167                |
| <code>amsmath</code> (package)     | 1, 2, 5, 6, 11, 12 |
| <code>amsopn</code> (package)      | 11                 |
| <code>\AtBeginOfPackageFile</code> | 80                 |
| <code>\AtEndOfPackage</code>       | 15                 |
| <code>\AtEndOfPackageFile</code>   | 83                 |
| <code>\AtEndPreamble</code>        | 89                 |

### B

|                            |               |
|----------------------------|---------------|
| <code>\baselineskip</code> | 137, 138, 155 |
| <code>\begingroup</code>   | 93, 175, 190  |
| <code>\bgroup</code>       | 133, 144      |
| <code>\binom</code>        | 2             |
| <code>\box</code>          | 250           |
| Breitfeld, Peter           | 9             |

### C

|                                              |                  |
|----------------------------------------------|------------------|
| <code>\c_@@_std_equal_mathcode_int</code>    | <u>102</u> , 111 |
| <code>\c_@@_std_minus_mathcode_int</code>    | <u>102</u> , 110 |
| <code>\c_group_begin_token</code>            | 151, 162         |
| <code>\char_set_catcode:mn</code>            | 12               |
| <code>\char_set_catcode_math_toggle:N</code> | 18               |
| <code>\char_set_mathcode:mn</code>           | 110, 111         |

|                                                |                            |
|------------------------------------------------|----------------------------|
| <code>\char_value_catcode:n</code> .....       | 13                         |
| <code>\crr</code> .....                        | 148, 170                   |
| <code>\cs_generate_variant:Nn</code> .....     | 62                         |
| <code>\cs_if_eq:NMTF</code> .....              | 45                         |
| <code>\cs_if_exist:NF</code> .....             | 8                          |
| <code>\cs_if_exist:NT</code> .....             | 41                         |
| <code>\cs_new_eq:NN</code> .....               | 39                         |
| <code>\cs_new_nopar:Npn</code> .....           | 11                         |
| <code>\cs_new_protected_nopar:Npn</code> ..... | 40, 63, 71, 74, 79, 82, 86 |
| <code>\cs_set:Npn</code> .....                 | 91, 131, 172, 183          |
| <code>\cs_set_eq:NN</code> .....               | 113, 114                   |
| <code>\cs_set_nopar:Npn</code> .....           | 221                        |
| <code>\cs_to_str:N</code> .....                | 254                        |

## D

|                                  |                         |
|----------------------------------|-------------------------|
| <code>\default@tag</code> .....  | 136, 154                |
| <code>\dimen@</code> .....       | 231, 232, 234, 246, 247 |
| <code>\directlua</code> .....    | 10                      |
| <code>\displaystyle</code> ..... | 230                     |

## E

|                                       |                    |
|---------------------------------------|--------------------|
| <code>\else</code> .....              | 192, 233, 237, 240 |
| <code>\endgroup</code> .....          | 93, 175, 190       |
| <code>\endinput</code> .....          | 37                 |
| <code>\ensuremath</code> .....        | 253                |
| environments:                         |                    |
| <code>subarray</code> .....           | 130                |
| <code>etoolbox</code> (package) ..... | 2                  |
| <code>\exp_args:Nx</code> .....       | 15                 |
| <code>expl3</code> (package) .....    | 2, 11              |

## F

|                                         |                              |
|-----------------------------------------|------------------------------|
| <code>\fi</code> .....                  | 145, 192, 242, 243, 245, 248 |
| <code>filehook</code> (package) .....   | 2                            |
| <code>\fmtversion</code> .....          | 70, 261                      |
| <code>\fontdimen</code> .....           | 137, 138, 140, 231, 232, 234 |
| <code>\frac</code> .....                | 2, 89, 172                   |
| functions:                              |                              |
| <code>module</code> .....               | 11                           |
| <code>print_class_fam_slot</code> ..... | 10, 291                      |
| <code>print_fam_slot</code> .....       | 11                           |
| <code>unpack</code> .....               | 10, 288                      |

## G

|                                    |                      |
|------------------------------------|----------------------|
| <code>\genfrac</code> .....        | 2, 183               |
| <code>\genfrac@choice</code> ..... | 188, 195, 200, 213   |
| <code>\group_begin:</code> .....   | 43, 97, 179, 203     |
| <code>\group_end:</code> .....     | 48, 54, 97, 179, 203 |

## H

|                                         |                    |
|-----------------------------------------|--------------------|
| <code>\hbox</code> .....                | 222                |
| <code>\hfil</code> .....                | 145, 147, 163, 169 |
| <code>\hook_gput_code:nmn</code> .....  | 262                |
| <code>\hook_gset_rule:nmmn</code> ..... | 266                |
| <code>\ht</code> .....                  | 246, 247           |

## I

|                                     |             |
|-------------------------------------|-------------|
| <code>\ialign</code> .....          | 143, 161    |
| <code>icomma</code> (package) ..... | 1, 2, 9, 10 |

|                            |                         |
|----------------------------|-------------------------|
| <code>\ifvmode</code>      | 248                     |
| <code>\ifx</code>          | 145, 192, 230, 235, 238 |
| <code>\int_const:Nn</code> | 102, 103                |
| <code>\int_eval:n</code>   | 12, 66                  |

## K

|                    |     |
|--------------------|-----|
| <code>\kern</code> | 226 |
|--------------------|-----|

## L

|                                   |                    |
|-----------------------------------|--------------------|
| <code>l3docstrip</code> (package) | 11                 |
| <code>l3kernel</code> (package)   | 11                 |
| <code>\l_@_equal_mathchar</code>  | 104, 114, 116      |
| <code>\l_@_minus_mathchar</code>  | 104, 113, 115      |
| <code>\leavevmode</code>          | 248                |
| <code>\Let@</code>                | 134, 152           |
| <code>\lineskip</code>            | 140, 142, 159, 160 |
| <code>\lineskiplimit</code>       | 142, 160           |
| <code>\lua_now:e</code>           | 65                 |
| luatex-required (message)         | 19                 |
| luatexbase (package)              | 11                 |
| luatexbase-modutils (package)     | 10                 |

## M

|                                      |                    |
|--------------------------------------|--------------------|
| <code>\m@th</code>                   | 146, 165, 224      |
| macro-expected (message)             | 23                 |
| <code>\mathchardef</code>            | 123, 124, 270      |
| <code>\mathcode</code>               | 123, 124, 264, 270 |
| <code>\mathcomma</code>              | 260                |
| <code>\mathstyle</code>              | 2                  |
| mathtools (package)                  | 1, 2, 8, 11        |
| messages:                            |                    |
| luatex-required                      | 19                 |
| macro-expected                       | 23                 |
| patch-macro                          | 32                 |
| wrong-meaning                        | 26                 |
| module (function)                    | 11                 |
| <code>\msg_error:nm</code>           | 36                 |
| <code>\msg_info:nmx</code>           | 46                 |
| <code>\msg_new:nm</code>             | 19, 23, 26, 32     |
| <code>\msg_warning:nmx</code>        | 57                 |
| <code>\msg_warning:nmxxx</code>      | 51                 |
| <code>\MT_cramped_internal:Nn</code> | 218                |

## N

|                                  |     |
|----------------------------------|-----|
| <code>nath</code> (package)      | 5   |
| <code>\NeedsTeXFormat</code>     | 3   |
| <code>\newluabytcode</code>      | 8   |
| <code>\nulldelimiterspace</code> | 226 |

## O

|                    |        |
|--------------------|--------|
| <code>\over</code> | 93, 97 |
|--------------------|--------|

## P

|           |                    |
|-----------|--------------------|
| packages: |                    |
| amsmath   | 1, 2, 5, 6, 11, 12 |
| amsopn    | 11                 |
| etoolbox  | 2                  |
| expl3     | 2, 11              |
| filehook  | 2                  |

|                                 |             |
|---------------------------------|-------------|
| icomma                          | 1, 2, 9, 10 |
| l3docstrip                      | 11          |
| l3kernel                        | 11          |
| luatexbase                      | 11          |
| luatexbase-modutils             | 10          |
| mathtools                       | 1, 2, 8, 11 |
| nath                            | 5           |
| unicode-math                    | 1, 2        |
| patch-macro (message)           | 32          |
| \prg_do_nothing:                | 39          |
| print_class_fam_slot (function) | 10, 291     |
| print_fam_slot (function)       | 11          |
| \ProvidesExplPackage            | 5           |

## R

|                  |               |
|------------------|---------------|
| \radical         | 227           |
| \relax           | 123, 124, 192 |
| \RequirePackage  | 4, 7, 9, 78   |
| \restore@math@cr | 135, 153      |
| Robertson, Will  | 1             |

## S

|                         |                              |
|-------------------------|------------------------------|
| \scan_stop:             | 68, 207                      |
| \scriptfont             | 137, 138, 140, 239           |
| \scriptscriptfont       | 241                          |
| \scriptstyle            | 146, 156, 157, 159, 166, 238 |
| \setbox                 | 222                          |
| \skip_set:Nn            | 155                          |
| \std@equal              | 114, 124, 127                |
| \std@equals             | 113                          |
| \std@minus              | 113, 123, 126                |
| \subarray               | 131                          |
| subarray (environment)  | 130                          |
| \sys_if_engine_luatex:F | 35                           |

## T

|                          |               |
|--------------------------|---------------|
| \textfont                | 231, 232, 236 |
| \textstyle               | 235           |
| \thr@@                   | 140           |
| \tl_if_empty:NTF         | 204           |
| \tl_new:N                | 104, 105      |
| \tl_replace_once:Nnn     | 122, 269      |
| \token_if_eq_meaning:NNT | 163           |
| \token_if_macro:NTF      | 42            |
| \token_to_meaning:N      | 52, 53        |
| \token_to_str:N          | 47, 52, 58    |
| \tw@                     | 137, 138      |

## U

|                        |              |
|------------------------|--------------|
| \Umathchardef          | 64           |
| \Umathcodenum          | 115, 116     |
| \Umathstackdenomdown   | 157          |
| \Umathstacknumup       | 156          |
| \Umathstackvgap        | 159          |
| unicode-math (package) | 1, 2         |
| unpack (function)      | 10, 288      |
| \use:c                 | 254          |
| \Ustack                | 97, 179, 202 |
| \Ustartmath            | 164          |

|                               |          |                         |
|-------------------------------|----------|-------------------------|
| <code>\Ustopmath</code> ..... |          | 168                     |
|                               | <b>V</b> |                         |
| <code>\vcenter</code> .....   |          | 132, 150                |
|                               | <b>W</b> |                         |
| wrong-meaning (message) ..... |          | <a href="#">26</a>      |
|                               | <b>Z</b> |                         |
| <code>\z0</code> .....        |          | 222, 227, 246, 247, 250 |