

# Π Ο Λ Υ Γ Λ Ω Σ Σ Ι Α

## Polyglossia: A Babel Replacement for X<sub>Y</sub>LaTeX and LuaLaTeX

FRANÇOIS CHARETTE

Current maintainer: ARTHUR REUTENAUER

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## 1 Introduction

Polyglossia is a package for facilitating multilingual typesetting with  $\text{X}_{\text{L}}\text{A}\text{T}_{\text{E}}\text{X}$  and (at an early stage)  $\text{Lua}\text{L}_{\text{A}}\text{T}_{\text{E}}\text{X}$ . Basically, it can be used as a replacement of `babel` for performing the following tasks automatically:

1. Loading the appropriate hyphenation patterns.
2. Setting the script and language tags of the current font (if possible and available), via the package `fontspec`.
3. Switching to a font assigned by the user to a particular script or language.
4. Adjusting some typographical conventions according to the current language (such as `afterindent`, `frenchindent`, spaces before or after punctuation marks, etc.).

5. Redefining all document strings (like “chapter”, “figure”, “bibliography”).
6. Adapting the formatting of dates (for non-Gregorian calendars via external packages bundled with polyglossia: currently the Hebrew, Islamic and Farsi calendars are supported).
7. For languages that have their own numbering system, modifying the formatting of numbers appropriately (this also includes redefining the alphabetic sequence for non-Latin alphabets).<sup>1</sup>
8. Ensuring proper directionality if the document contains languages that are written from right to left (via the package `bidi`, available separately).

Several features of `babel` that do not make sense in the  $\text{\XeTeX}$  world (like font encodings, shorthands, etc.) are not supported. Generally speaking, `polyglossia` aims to remain as compatible as possible with the fundamental features of `babel` while being cleaner, light-weight, and modern. The package `antomega` has been very beneficial in our attempt to reach this objective.

**Requirements:** The current version of `polyglossia` makes use of some convenient macros defined in the `etoolbox` package by Philipp Lehmann. Being designed for  $\text{\XeTeX}$  and  $\text{\LuaTeX}$ , it obviously also relies on `fontspec` by Will Robertson. For languages written from right to left, it needs the package `bidi` by Vafa Khalighi (وفا خليلي). `Polyglossia` also bundles three packages for calendaric computations (`hebrewcal`, `hijrical`, and `farsical`).

## 2 Loading language definition files

### 2.1 The recommended way

You can determine the default language by means of the command:

```
\setdefaultlanguage[options]{lang}
```

(or equivalently `\setmainlanguage`). Secondary languages can be loaded with

```
\setotherlanguage[options]{lang}.
```

These commands have the advantage of being explicit and of allowing you to set language-specific options.<sup>2</sup> It is also possible to load a series of secondary languages at once using

```
\setotherlanguages{lang1,lang2,lang3,...}.
```

Language-specific options can be set or changed at any time by means of

```
\setkeys{lang}{opt1=value1,opt2=value2,...}.
```

<sup>1</sup>For the Arabic script this is now done by the bundled package `arabicnumbers`.

<sup>2</sup>More on language-specific options below.

## 2.2 The “Babel way”

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← **Warning:** `polyglossia` no longer supports loading language definition files as package options!

## 2.3 Supported languages

Table 2.3 lists all languages currently supported. Those in red have specific options and/or commands that are explained in section 5 below.

albanian	czech	hindi	norsk	spanish
amharic	danish	icelandic	nynorsk	swedish
arabic	divehi	interlingua	occitan	syriac
armenian	dutch	irish	piedmontese	tamil
asturian	english	italian	polish	telugu
bahasai	esperanto	kannada	portuges	tibetan
bahasam	estonian	lao	romanian	thai
basque	farsi	latin	romansh	turkish
bengali	finnish	latvian	russian	turkmen
brazil[ian]	french	lithuanian	samin	ukrainian
breton	friulan	lsorbian	sanskrit	urdu
bulgarian	galician	magyar	scottish	usorbian
catalan	german	malayalam	serbian	vietnamese
coptic	greek	marathi	slovak	welsh
croatian	hebrew	nko	slovenian	

Table 1: Languages currently supported in `polyglossia`

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*NB:* The support for Amharic ← should be considered an experimental attempt to port the package `ethiop`.<sup>3</sup> Version 1.1.1 ← added support for Asturian, Lithuanian, and Urdu. Version 1.2 ← adds support for Armenian, Occitan, Bengali, Lao, Malayalam, Marathi, Tamil, Telugu, and Turkmen.<sup>4</sup>

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Polyglossia can also be loaded with the option ‘babelshorthands’ ←, which globally activates `babel` shorthands whenever available. Currently shorthands are implemented for Catalan, Dutch, German, Italian, and Russian: see these respective languages for details.

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Another option (turned off by default) is ‘localmarks’, which redefines the internal  $\LaTeX$  macros `\markboth` and `\markright`. ← Note that this was formerly

<sup>3</sup>Feedback is welcome.

<sup>4</sup>See acknowledgements at the end for due credit to the various contributors.

turned on by default, but we now realize that it causes more problems than otherwise. For backwards-compatibility the opposite option ‘nolocalmarks’ is still available.

There is also the option ‘quiet’ which turns off most info messages and some of the warnings issued by  $\text{\LaTeX}$ , `fontspec` and `polyglossia`.

### 3 Language-switching commands

Whenever a language definition file `gloss-(lang).ldf` is loaded, the command `\text{lang}` `\text{lang}[(options)]{...}` becomes available for short insertions of text in that language. For example `\textrussian{\today}` yields 28 мая 2013 г. Longer passages are better put between the environment `(lang)` (again with the possibility of setting language options locally. For instance the following allows us to quote the beginning of Homer’s *Iliad*:

```
\begin{greek}[variant=ancient]
μῆνιν ἄειδε θεὰ Πηληϊάδεω Ἀχιλῆος οὐλομένην, ἣ μυρὶ' Ἀχαιοῖς ἄλγε'
ἔθηκε, πολλὰς δ' ἰφθίμους ψυχὰς Ἄϊδι προΐαψεν ἡρώων, αὐτοὺς δὲ ἐλώρια
τεῦχε κύνεσσιν οἰωνοῖσί τε πᾶσι, Διὸς δ' ἐτελείετο βουλή, ἐξ οὗ δὴ τὰ
πρῶτα διαστήτην ἐρίσαντε Ἀτρεΐδης τε ἄναξ ἀνδρῶν καὶ δῖος Ἀχιλλεύς.
\end{greek}
```

μῆνιν ἄειδε θεὰ Πηληϊάδεω Ἀχιλῆος οὐλομένην, ἣ μυρὶ' Ἀχαιοῖς ἄλγε' ἔθηκε, πολλὰς δ' ἰφθίμους ψυχὰς Ἄϊδι προΐαψεν ἡρώων, αὐτοὺς δὲ ἐλώρια τεῦχε κύνεσσιν οἰωνοῖσί τε πᾶσι, Διὸς δ' ἐτελείετο βουλή, ἐξ οὗ δὴ τὰ πρῶτα διαστήτην ἐρίσαντε Ἀτρεΐδης τε ἄναξ ἀνδρῶν καὶ δῖος Ἀχιλλεύς.

Note that for Arabic one cannot use the environment `arabic`, as `\arabic` is defined internally by  $\text{\LaTeX}$ . In this case we need to use the environment `Arabic` instead.

#### 3.1 Other commands

The following commands are probably of lesser interest to the end user, but ought to be mentioned here.

`\selectbackgroundlanguage`    ▶ `\selectbackgroundlanguage`: this selects the global font setup and the numbering definitions for the default language.

<code>\resetdefaultlanguage</code>	<ul style="list-style-type: none"> <li>▸ <code>\resetdefaultlanguage</code> (experimental): completely switches the default language to another one in the middle of a document: <i>this may have adverse effects!</i></li> </ul>
<code>\normalfontlatin</code>	<ul style="list-style-type: none"> <li>▸ <code>\normalfontlatin</code>: in an environment where <code>\normalfont</code> has been redefined to a non-latin script, this will call the font defined with <code>\setmainfont</code> etc. Likewise it is possible to use <code>\rmfamilylatin</code>, <code>\sffamilylatin</code>, and <code>\ttfamilylatin</code>.</li> </ul>
<code>\rmfamilylatin</code>	
<code>\sffamilylatin</code>	
<code>\ttfamilylatin</code>	<ul style="list-style-type: none"> <li>▸ Some macros defined in <a href="#">babel's hyphen.cfg</a> (and thus usually compiled into the <math>\text{\LaTeX}</math> and <math>\text{\LuaTeX}</math> format) are redefined, but keep a similar behaviour, namely <code>\selectlanguage</code>, <code>\foreignlanguage</code>, and the environment <code>otherlanguage</code>.</li> </ul>
<code>\selectlanguage</code>	
<code>\foreignlanguage</code>	
<code>otherlanguage</code>	Since the $\text{\LaTeX}$ and $\text{\LuaTeX}$ format incorporate <a href="#">babel's hyphen.cfg</a> , the low-level commands for hyphenation and language switching defined there are also accessible.

## 4 Font setup

With polyglossia it is possible to associate a specific font with any script or language that occurs in the document. That font should always be defined as `\(script)font` or `\(language)font`. For instance, if the default font defined by `\setmainfont` does not support Greek, then one can define the font used to display Greek with:

```
\newfontfamily\greekfont[Script=Greek,(...)]{(font)}.
```

Note that polyglossia will use the font thus defined as is. for instance if `\arabicfont` is explicitly defined, then one should take care of including the option `Script=Arabic` in that definition. See the [fontspec](#) documentation for more information. If a specific sans or monospace font is needed for a particular script or language, it can be defined by means of  $\leftarrow \text{\(script)fontsf}$  or `\(language)fontsf` and `\(script)fonttt` or `\(language)fonttt`, respectively.

Whenever a new language is activated, [polyglossia](#) will first check whether a font has been defined for that language or – for languages in non-Latin scripts – for the script it uses. If it is not defined, it will use the currently active font and – in the case of OpenType fonts – will attempt to turn on the appropriate OpenType tags for the script and language used, in case these are available in the font, by means of [fontspec's](#) `\addfontfeature`. If the current font does not appear to support the script of that language, an error message is displayed.

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## 5 Language-specific options and commands

This section gives a list of all languages for which options and end-user commands are defined. The default value of each option is given in *italic*.

### 5.1 arabic

Options:

- **calendar** = *gregorian* or *islamic* (= *hijri*)
- **locale** = *default*,<sup>5</sup> *mashriq*,<sup>6</sup> *libya*, *algeria*, *tunisia*, *morocco*, or *mauritania*. This setting influences the spelling of the month names for the Gregorian calendar, as well as the form of the numerals (unless overridden by the following option).
- **numerals** = *mashriq* or *maghrib* (the latter is the default when *locale* = *algeria*, *tunisia* or *morocco*)
- **abjadjimnotail** = *false* or *true*. ← Set this to *true* if you want the *abjad* form of the number three to be ٣ – as in the manuscript tradition – instead of the modern usage ج.

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Commands:

- `\abjad` ▸ `\abjad` and `\abjadmaghribi` (see section 8)
- `\abjadmaghribi` ▸ `\aemph` to emphasize text with `\overline`. ← `\textarabic{\aemph{ب|}}` yields  $\overline{ب}$ . This command is also available for Farsi, Urdu, etc.
- `\aemph`

v1.2.0

### 5.2 bengali

← Options:

- **numerals** = *Western* or *Devanagari*

v1.2.0

### 5.3 catalan

Options:

- **babelshorthands** = *false* or *true*. ← Activates the shorthands "l and "L to type geminated l's.

v1.1.1

Commands:

- `\l.l` ▸ `\l.l` and `\L.L` behave as in **babel** to type a geminated l, as in *collaborar*. ←
- `\L.L` In polyglossia the same can also be achieved with `\l.l` and `\L.L`.<sup>7</sup>

v1.1.1

<sup>5</sup>For Egypt, Sudan, Yemen and the Gulf states.

<sup>6</sup>For Iraq, Syria, Jordan, Lebanon and Palestine.

<sup>7</sup>NB: · is the glyph U+00B7 MIDDLE DOT.

## 5.4 dutch

### Options:

- **babelshorthands** = *false* or *true*. ← if this is turned on, all shorthands defined in **babel** for fine-tuning the hyphenation of Dutch words are activated.
  - "- for an explicit hyphen sign, allowing hyphenation in the rest of the word
  - "~ for a compound word mark without a breakpoint
  - "|" disables the ligature at this position
  - "" is like "-", but produces no hyphen sign (for compound words with a hyphen, e.g., foo-""bar)
  - "/" to enable hyphenation in two words written together but separated by a slash.
- \- ▸ In addition, the macro \- is redefined to allow hyphens in the rest of the word.

## 5.5 english

### Options:

- **variant** = *american* (= us), *usmax* (same as 'american' but with additional hyphenation patterns), *british* (= uk), *australian* or *newzealand*
- **ordinalmonthday** = *true/false* (true by default only when variant = british)

## 5.6 esperanto

### Commands:

- \hodiau ▸ \hodiau and \hodiaun are special forms of \today (see the **babel** documentation)
- \hodiaun

## 5.7 farsi

### Options:

- **numerals** = *western* or *eastern*
- **locale** (not yet implemented)
- **calendar** (not yet implemented)

### Commands:

- \abjad ▸ \abjad (see section 8)
- \aemph ▸ \aemph (see section 5.1).



## 5.8 german

### Options:

- ▶ **spelling** = *new* (= 1996) or *old* (= 1901): indicates whether hyphenation patterns for traditional (1901) or reformed (1996) orthography should be used. The latter is the default.
- ▶ **latesthyphen** = *false* or *true*: if this option is set to *true*, the latest (experimental) hyphenation patterns '(n)german-x-latest' will be loaded instead of 'german' or 'ngerman'. NB: This is based on the file `language.dat` that comes with  $\TeX$ Live 2008 and later.
- ▶ **babelshorthands** = *false* or *true*: ← if this is turned on, all shorthands defined in **babel** for fine-tuning the hyphenation of German words are activated.
  - ▶ "ck for ck to be hyphenated as k-k
  - ▶ "ff for ff to be hyphenated as ff-f; this is also available for the letters l, m, n, p, r and t
  - ▶ "|" disables the ligature at this position
  - ▶ "-" for an explicit hyphen sign, allowing hyphenation in the rest of the word
  - ▶ "" is like "-", but produces no hyphen sign (for compound words with a hyphen, e.g., foo-""bar)
  - ▶ "~ for a compound word mark without a breakpoint
  - ▶ "=" for a compound word mark with a breakpoint, allowing hyphenation in the composing words.

There are also four shorthands for quotation signs:

- ▶ "` for German left double quotes („)
  - ▶ "'" for German right double quotes (")
  - ▶ "< for French left double quotes («)
  - ▶ "> for French right double quotes (»).
- ▶ **script** = *latin* or *fraktur*. ← Setting `script=fraktur` modifies the captions for typesetting German in Fraktur.

## 5.9 greek

### Options:

- ▶ **variant** = *monotonic* (= mono), *polytonic* (= poly), or *ancient*
- ▶ **numerals** = *greek* or *arabic*
- ▶ **attic** = *false*/*true*

### Commands:

<code>\Greeknnumber</code>	▶ <code>\Greeknnumber</code> and <code>\greeknumber</code> (see section 8).
<code>\greeknumber</code>	▶ The command <code>\atticnumeral</code> (= <code>\atticnum</code> ) (activated with the option <code>attic=true</code> ), displays numbers using the acrophonic numbering system (defined in the Unicode range U+10140–U+10174). <sup>8</sup>
<code>\atticnumeral</code>	
<code>\atticnum</code>	

## 5.10 hebrew

### Options:

- ▶ **numerals** = hebrew or *arabic*
- ▶ **calendar** = hebrew or *gregorian*

### Commands:

<code>\hebrewnumeral</code>	▶ <code>\hebrewnumeral</code> (= <code>\hebrewalph</code> ) (see section 8).
<code>\hebrewalph</code>	▶ <code>\aemph</code> (see section 5.1).
<code>\aemph</code>	

## 5.11 hindi

### ← Options:

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- ▶ **numerals** = Western or *Devanagari*

## 5.12 italian

### Option:

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- ▶ **babelshorthands** = *false* or *true*. ←Activates the " character as a switch to perform etymological hyphenation when followed by a letter, or other tasks when followed by certain alphabetic characters; in particular " " is used to enter double raised open quotes (the Italian keyboard misses the backtick), and "< and "> to insert open and closed guillemets without any spacing after the open or before the closed sign. "/" is made equivalent to / allowing a linebreak after the slash without any hyphen sign; "-" produces a short rule/hyphen and a discretionary line break allowing line breaks in the second compound word fragment.

## 5.13 lao

### ← Options:

v1.2.0

- ▶ **numerals** = lao or *arabic*

---

<sup>8</sup>See the documentation of the **xgreek** package for more details.

## 5.14 lsorbian and usorbian

### Commands:

`\oldtoday` ▶ `\oldtoday`: see the [babel](#) documentation.

## 5.15 magyar

### Commands:

`\ontoday` ▶ `\ontoday` (= `\onatemagyar`): special forms of `\today` (see the [babel](#) documentation).  
`\onatemagyar`

## 5.16 russian

### Options:

- ▶ `babelshorthands` = *false* or *true*.
- ▶ `spelling` = *modern* or *old* (for captions and date only, not for hyphenation)

### Commands:

`\Asbuk` ▶ `\Asbuk`: produces the uppercase Russian alphabet, for environments such as `enumerate`  
`\asbuk` ▶ `\asbuk`: same in lowercase

## 5.17 sanskrit

### Options:

- ▶ `Script` (default = Devanagari). ← The value is passed to `fontspec` in cases where `\sanskritfont` or `\devanagarifont` are not defined. This can be useful if you typeset Sanskrit texts in scripts other than Devanagari.

v1.0.2

## 5.18 serbian

### Options:

- ▶ `script` = *cyrillic* or *latin*

## 5.19 syriac

### Options:

- ▶ `numerals` = *western* (i.e., 1234567890), *eastern* (for which the Oriental Arabic numerals are used: ١٢٣٤٥٦٧٨٩٠), or *abjad*. ←.

v1.0.1

### Commands:

`\abjadsyriac` ▶ `\abjadsyriac` (see section 8)

`\aemph`      ▶ `\aemph` (see section 5.1).

## 5.20 `thai`

Options:

▶ `numerals` = `thai` or `arabic`

To insert the word breaks, you need to use an external processor. See the documentation to `thai-latex` and the file `testthai.tex` that comes with this package.

## 6 Modifying or extending captions and date formats

To redefine internal macros, you can use the command `\gappto` from the package `etoolbox`. For compatibility with `babel` the command `\addto` is also available with the same effect. For instance, to change the `\chaptername` for language `lingua`, you can do this:

```
\gappto\captionslingua{\renewcommand{\chaptername}{Caput}}
```

## 7 Non-Western decimal digits

Several scripts have their own versions of the decimal digits commonly called ‘Arabic numerals’. With the appropriate language option set, `polyglossia` will automatically convert the output of internal  $\TeX$  counters to their localized forms, for instance to display page, chapter and section numbers.

In previous versions this conversion was achieved by means of TECKit fontmappings. If needed they can be activated with the `fontspec Mapping` option, using `arabicdigits`, `farsidigits` or `thaidigits`. For instance if `\arabicfont` is defined with the option `Mapping=arabicdigits`, then by typing `\textarabic{2010}` one will obtain ٢٠١٠.

v1.1.1

With version v1.1.1 ← the same conversion is achieved directly by simple  $\TeX$  macros. This prevents some problems that occur when the value of a counter has to be written and read from auxiliary files.<sup>9</sup> These macros (currently `\arabicdigits`, `\farsidigits` and `\thaidigits` are provided) are also available to the users. For instance in an Arabic environment `\arabicdigits{9182/738543-X}` yields ٩١٨٢/٧٣٨٥٤٣-X.

---

<sup>9</sup>For instance the package `lastpage` did not work with `polyglossia` in situations where the display of counters was redefined to include a font-switching command.

## 8 Alphabetic numbering in Greek, Arabic, Hebrew, Syriac and Farsi

In certain languages, numbers can be represented by a special alphanumerical notation.<sup>10</sup>

<code>\greeknumeral</code>	The Greek numerals are obtained with <code>\greeknumeral</code> (or <code>\Greeknnumeral</code> in uppercase). Example: <code>\greeknumeral{1863}</code> yields $\alpha\omega\xi\gamma'$ .
<code>\abjad</code>	The Arabic <i>abjad</i> numbers can be generated with the command <code>\abjad</code> . Example: <code>\abjad{1863}</code> yields غضسج. In the Maghrib the conventions are somewhat different, and the maghribi forms of the <i>abjad</i> numerals are obtained with the
<code>\abjadmaghribi</code>	<code>\abjadmaghribi</code> command. Example: <code>\abjadmaghribi{1863}</code> yields شظصج.
v1.1.1 <code>\hebrewnumeral</code> <code>\Hebrewnumeral</code> <code>\Hebrewnumeralfinal</code>	The code for Hebrew numerals, which was incorrect in previous versions, was ported from the implementation in <code>babel</code> with v1.1.1 ←, and the user interface is identical to the one in <code>babel</code> . The commands <code>\hebrewnumeral</code> , <code>\Hebrewnumeral</code> and <code>\Hebrewnumeralfinal</code> behave exactly as they do in <code>babel</code> : the second command prints the number with <i>gereshayim</i> before the last letter, and the latter uses in addition the final forms of Hebrew letters. Examples: <code>\hebrewnumeral{1750}</code> yields א'תשנ"א, <code>\Hebrewnumeral{1750}</code> yields א'תשנ"א, and <code>\Hebrewnumeralfinal{1750}</code> yields א'תשנ"א.
<code>\abjadsyriac</code>	Support is also provided for Syriac abjad numerals, which can be generated with <code>\abjadsyriac</code> . <sup>11</sup> Example: <code>\abjadsyriac{463}</code> yields ܐܬܬܝܬ.

## 9 Calendars

### 9.1 Hebrew calendar (hebrewcal.sty)

The package `hebrewcal.sty` is almost a verbatim copy of `hebcacal.sty` that comes with `babel`. The command `\Hebrewtoday` formats the current date in the Hebrew calendar (depending of the current writing direction this will automatically set either in Hebrew script or in roman transliteration).

<sup>10</sup>See, e.g., [http://en.wikipedia.org/wiki/Greek\\_numerals](http://en.wikipedia.org/wiki/Greek_numerals), [http://en.wikipedia.org/wiki/Abjad\\_numerals](http://en.wikipedia.org/wiki/Abjad_numerals), and [http://en.wikipedia.org/wiki/Hebrew\\_numerals](http://en.wikipedia.org/wiki/Hebrew_numerals).

<sup>11</sup>A fine guide to numerals in Syriac can be found at <http://www.garzo.co.uk/documents/syriac-numerals.pdf>.

## 9.2 Islamic calendar (hijrical.sty)

This package computes dates in the lunar Islamic (Hijra) calendar.<sup>12</sup> It provides two macros for the end-user. The command

`\HijriFromGregorian`                      `\HijriFromGregorian{<year>}{<month>}{<day>}`

`\Hijritoday` sets the counters `Hijriday`, `Hjrimonth` and `Hjriyear`. `\Hijritoday` formats the Hijri date for the current day. This command is now locale-aware ←: its output will differ depending on the currently active language. Presently [polyglossia](#)’s language definition files for Arabic, Farsi, Urdu, Turkish, Bahasa Indonesia and Bahasa Melayu provide a localized version of `\Hijritoday`. If the formatting macro for the current language is undefined, the Hijri date will be formatted in Arabic or in roman transliteration, depending of the current writing direction. You can define a new format or redefine one with the command

v1.1.1

`\DefineHijriDateFormat`                      `\DefineHijriDateFormat{<lang>}{<code>}`.

The command `\Hijritoday` also accepts an optional argument to add or subtract a correction (in days) to the date computed by the arithmetical algorithm.<sup>13</sup> For instance if `\Hijritoday` yields the date “7 Rajab 1429” (which is the date that was displayed on the front page of [aljazeera.net](#) on 11th July 2008), `\Hijritoday[1]` would rather print “8 Rajab 1429” (the date indicated the same day on the site [gulfnews.com](#)).

## 9.3 Farsi (jalālī) calendar (farsical.sty)

This package is an almost verbatim copy of `ArabiToday.sty` (in the [Arabi](#) package), itself a slight modification of `ftoday.sty` in Farsi $\TeX$ .<sup>14</sup> Here we have renamed the command `\ftoday` to `\Jalalitoday`. Example: today is 7 Khordād 1392.

`\Jalalitoday`

## 10 Acknowledgements (by François Charette)

[Polyglossia](#) is notable for being a recycle box of previous contributions by other people. I take this opportunity to thank the following individuals, whose splen-

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<sup>12</sup>It makes use of the arithmetical algorithm in chapter 6 of Reingold & Gershowitz, *Calendrical calculation: the Millenium edition* (Cambridge University Press, 2001).

<sup>13</sup>The Islamic calendar is indeed a purely lunar calendar based on the observation of the first visibility of the lunar crescent at the beginning of the lunar month, so there can be differences between different localities, as well as between civil and religious authorities.

<sup>14</sup>One day I may rewrite [farsical](#) from scratch using the algorithm in Reingold & Gershowitz (ref. n. 12).

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