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To: iaufwg@fits.cv.nrao.edu
Subject: Year 2000 Proposal
Date: Wed, 13 Aug 1997 17:12:10 -0400 (EDT)

Dear FITSers,

Here is the last version of the proposal that I will be able
to send out before the IAU, since I will be leaving for Kyoto
tomorrow. It incorporates some suggestions by Bob Hanisch
that were transmitted privately.

I will send a second message with the diffs.

- Arnold Rots

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Precise re-definition of DATE-OBS Keyword encompassing the millennium

Peter Bunclark 1996 Nov 19
Amended: Arnold Rots 1997-08-13T21:05:00

1) Introduction

Although this document formally defines the format of the value field of the DATE-OBS keyword, the same format applies to all keywords beginning with the string "DATE" and which values contain date, and optionally time, information. We shall refer to these keywords collectively as DATExxxx. The original DATExxxx keywords, including in particular DATE-OBS, have several shortcomings which make it desirable to alter the definition:

1.1) The year is expressed in only two digits; currently, digitized astronomical data span more than a century; and furthermore, the implied most-significant two digits of the year will change from 19 to 20 shortly.

1.2) The timescale of DATExxxx is not defined.

1.3) The relation of DATE-OBS to the start, middle or end of an observation is not defined.

1.4) The order of day, month, year is least-significant first, so lists of dates cannot be sorted simply on the ASCII collating sequence.

2) Scope

Three main issues are addressed:

2.1) The format of date strings to be used in any DATExxxx keyword.

2.2) The future of the DATE-OBS keyword itself.

2.3) The specification of the time scales (time systems) used.

3) The Date-String format Proposal

3.1) A DATExxxx field in the old format of 'DD/MM/YY' will explicitly refer to a year 1900-1999. The very few instances of digitized nineteenth-century plates represented as FITS files (only files created before this proposal went into effect) must be handled as special cases.

3.2) The new format is a restricted subset of ISO-8601, being one of two options:

a) 'CCYY-MM-DD'

b) 'CCYY-MM-DDThh:mm:ss[.sss...]'

<CCYY> represents a calendar year, <MM> the ordinal number of a calendar month within the calendar year, and <DD> the ordinal number of a day within the calendar month. <hh> represents the hour in the day, <mm> the minutes, <ss[.s...]> the seconds. The value of the integer part of the seconds field is normally in the range [0..59] but may take the value 60, if the time scale is UTC, to indicate a leap second. The literal 'T' is the ISO 8601 time designator.

In the short form (a), there must not be any additional terminator/separator (such as T). In the long form, there must be a 'T' time designator between the date and the time.
The decimal point character is an ASCII full-stop (hexadecimal value 0x2E). The number of decimal places in the 'seconds' field may be arbitrarily long, up to the FITS header-card limitations.

3.3) Only fully-specified date or date/time strings are permitted. No fields may be defaulted, no leading zeroes omitted. The decimal part of the seconds field is optional.

4) Use of the DATE-OBS keyword

4.1) The name of the keyword shall remain DATE-OBS.

4.2) Henceforth, DATE-OBS shall be assumed to refer to the start of an observation. Other interpretations must be clearly explained in the comment field.

4.3) The default interpretation of all DATExxxx keywords shall use the Gregorian Calendar for the date portion.

4.4) The value of the DATExxxx keywords, with the exception of DATE (see section 5), shall be expressed in the principal time scale or time system of the HDU to which they belong. The default interpretation shall use UTC (for dates since 1972) or UT (for dates before 1972). If there is any chance of ambiguity as to which is the principal time scale, the choice shall be clarified in comments.

4.5) It is recommended that the time scale or time system be specified explicitly. However, implementors can be assured that the error resulting from ignoring the time scale specification and making the default assumption will not exceed 1000 s for the period 1001-01-01 through 3000-12-31.

4.6) By default, times will be deemed to be as measured at the detector (or in practical cases, at the observatory) for TAI and times that run synchronously with TAI (i.e., UTC and TT). In the case of coordinate times (such as TCG and TCB) and TDB which are tied to an unambiguous coordinate origin, the default meaning of time values will be: time as if the observation had taken place at the origin of the coordinate time system. These defaults follow common practice; a future convention on time scale issues in FITS files may allow other combinations but shall preserve this default behavior.

5) Use of the DATE keyword

5.1) The date-time string value of the DATE keyword indicates the creation time of the HDU.

5.2) The value of the DATE keyword shall always be expressed in UTC whenever

the date-string format defined in this proposal is used.

6) Examples

Three legal representations of the date of October 14, 1996, are possible:

```
DATE-OBS= '14/10/96'           / Original format, means 1996 Oct 14.

DATE-OBS= '1996-10-14'         / Date of start of observation, by default UTC.

DATE-OBS= '1996-10-14T10:14:36.123' / Date and time of start of obs. in UTC.
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7) Transition

FITS readers must continue to interpret the old format, as a twentieth century date, indefinitely. Readers should be altered as soon as possible to cope with the new format. In order to give adequate time for the major package writers to revise their software, FITS writers should commence writing the new format between 1998-01-01T00:00:00 and 2000-01-01T00:00:00.

A) Appendix: Suggested time scale specification

[Note: this appendix is not part of the formal DATExxxx agreement]

A.1) Use of the keyword TIMESYS is suggested as an implementation of the time scale specification. It sets the principal time system for time-related keywords and data in the HDU (i.e., it does not preclude the addition of keywords or data columns that provide information for transformations to other time scales, such as sidereal times or barycenter corrections). Each HDU shall contain not more than one TIMESYS keyword.
Initially, officially allowed values are:

- UTC Coordinated Universal Time; defined since 1972.
- UT Universal Time, equal to Greenwich Mean Time (GMT) since 1925; the UTC equivalent before 1972; see: Explanatory Supplement, p. 76.
- TAI International Atomic Time; "UTC without the leap seconds"; 31 s ahead of UTC on 1997-07-01.
- IAT International Atomic Time; deprecated synonym of TAI.
- ET Ephemeris Time, the predecessor of TT; valid until 1984.
- TT Terrestrial Time, the IAU standard time scale since 1984; continuous with ET and synchronous with (but 32.184 s ahead of) TAI.
- TDT Terrestrial Dynamical Time; =TT.
- TDB Barycentric Dynamical Time.
- TCG Geocentric Coordinate Time; runs ahead of TT since 1977-01-01 at a rate of approximately 22 ms/year.
- TCB Barycentric Coordinate Time; runs ahead of TDB since 1977-01-01 at a rate of approximately 0.5 s/year.

For reference, see:

Explanatory Supplement to the Astronomical Almanac, P. K. Seidelmann, ed., University Science Books, 1992, ISBN 0-935702-68-7.
http://tycho.usno.navy.mil/systime.html

Use of GPS time (19 s behind TAI) is deprecated.

A.2) By default, times will be deemed to be as measured at the detector (or in practical cases, at the observatory) for times that run synchronously with TAI (i.e., TAI, UTC, and TT). In the case of coordinate times (such as TCG and TCB) and TDB which are tied to an unambiguous coordinate origin, the default meaning of time values will be: time as if the observation had taken place at the origin of the coordinate time system. These defaults follow common practice; a future convention on time scale issues in FITS files may allow other combinations but shall preserve this default

behavior. The rationale is that raw observational data are most likely to be tagged by a clock that is synchronized with TAI, while a transformation to coordinate times or TDB is usually accompanied by a spatial transformation, as well. This implies that path length differences have been corrected for. Note that the difference TDB-UTC, in that case, is approximately sinusoidal, with period one year and amplitude up to 500 s, depending on source position. Also, note that when the location is not unambiguous (such as in the case of an interferometer) precise specification of the location is strongly encouraged in, for instance, geocentric Cartesian coordinates.

A.3) Note that "TT" is the IAU preferred standard. It may be considered equivalent to "TDT" and "ET", though "ET" should not be used for data taken after 1984. For reference, see: Explanatory Supplement, pp. 40-48.

A.4) If the TIMESYS keyword is absent or has an unrecognized value, the value "UTC" will be assumed for dates since 1972, and "UT" for pre-1972 data.

A.5) Examples
The three legal representations of the date of October 14, 1996, from Section 6 might be written as:

```
DATE-OBS= '14/10/96'           / Original format, means 1996 Oct 14.

TIMESYS = 'UTC     '           / Explicit time scale specification: UTC.
DATE-OBS= '1996-10-14'         / Date of start of observation in UTC.

DATE-OBS= '1996-10-14'         / Date of start of observation, also in UTC.

TIMESYS = 'TT      '           / Explicit time scale specification: TT.
DATE-OBS= '1996-10-14T10:14:36.123' / Date and time of start of obs. in TT.
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A.6) The convention suggested in this Appendix is part of the mission-specific FITS conventions adopted for, and used in, the RXTE archive, building on existing High Energy Astrophysics FITS conventions. See:
http://legacy.gsfc.nasa.gov/docs/xte/abc/time_tutorial.html
http://heasarc.gsfc.nasa.gov/docs/xte/abc/time.html
The VLBA project has adopted a convention where the keyword TIMSYS, rather than TIMESYS, is used, currently allowing the values UTC and IAT.
See p.9 and p.16 of:
http://www.cv.nrao.edu/fits/documents/drafts/vlba_format.ps