UTC in Astronomical Metadata Standards

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Accuracy in Astronomical Data

- Determined by:
  - Clock parameters:
    - Read-out uncertainty
    - Relative stability
    - Tie-in to absolute time
    - Uncertainty in knowledge of location
    - …
  - Observer interest in reducing timing uncertainty
    - OK for astrometrists, ephemeris compilers, solar system data
    - Observing of pulsars and rise of interferometry have helped
    - Otherwise it's pretty dismal

Does It Matter?

- Yes!!!
- Observer's choice may be OK for his/her intents
- Archival importance of data is fast increasing
  - 60% of Chandra observations have been published three times or more after 9 years
- Original observer should not presume to know what future users of the data need
- Collect and preserve as much metadata as you can and as accurately as you can
- This requires standards

Collection Items

- Actual time stamp (clock reading)
- Time scale of time stamp
- Location (state vector) of observer
- Direction (celestial coordinates) of observation
- Fiducial reference position to which times are reduced (e.g., path length corrections – if applicable)
- Time resolution
- Relative (short-term) time error
- Absolute time error

Spatial Coordinates

- Note the number of spatial coordinate metadata in the list
- Space and time are intertwined:
- One cannot fix an observation's temporal location without knowledge of observer's spatial location
- And vice-versa
- I will highlight two broad-based standards:
  - FITS
  - IVOA STC

FITS WCS

- Flexible Image Transport System
- Roots in mid-1970s for image transport:
  - Computer to computer
  - Observatory to observatory
- Became used as archival file format (Vatican archives)
- Problem: syntax is defined, but semantics are not
- Particularly problematic for coordinate metadata
- Solution: World Coordinate System (WCS)
- Celestial coordinates, projections, spectral/Doppler

FITS WCS Time

- Next is Time
  - With Peter Bunclark, Mark Calabretta, Steve Allen, Dick Manchester, Bill Thompson
- Time scale
  - TT (ET), TAI, GPS, TDB, TCB, TCG, UTC (GMT), UT1
- Standard locations
  - Observer, geocenter, barycenter, heliocenter, planets, EM bary
- Expression of time
  - Restricted ISO-8601, JD, MJD, elapsed time
- Units

FITS WCS Time (2)

- Some durations
- Proper labeling:
  - Add time scale and reference position to time stamps
  - No cute self-invented time scales, please (TJD, BJD, …)
- Three major issues:
  - Besselian epochs
    - We can provide best possible conversion to Julian epoch, but no guarantee that is what was used – may not matter, though
  - Same is true for use of tropical year as unit
  - Use of fractional (M)JD on days with leap second: Don't!

FITS WCS Time (3)

- Use of any time scale and reference position is allowed
  - But not all make sense
  - Exception: file creation date-time has to be in UTC
- Use of UTC poses no problems
  - Use USNO leap second file
  - Elapsed time since UTC reference time:
    - Counted SI seconds – and that includes leap seconds

IVOA STC

- International Virtual Observatory Alliance (IVOA)
  - Foster interoperability between astronomical data repositories, to allow one-stop shopping
- Among the standards:
  - Space-Time Coordinate metadata (STC)
  - Space and time are handled together
  - Similar to FITS, but a longer list of spatial reference frames:
    - Accommodating both far-field and near-field interests

Conclusion

- Astronomical metadata standards have no problem with handling UTC – with or without leap seconds
- Keeping the leap second file up-to-date is not onerous
- Abolishing leap seconds does not make the issue of leap seconds go away:
  - One still needs to be able to handle historical leap seconds
- UTC without future leap seconds will only create yet another TAI look-alike
- Start distributing TAI, with TAI–UTC & UTC–UT1

Commentary

- There are two kinds of time:
  - Earth rotation (or hour angle)
  - Counting of SI seconds
- UT1 represents the angle-unit time
- All others (except UTC) are SI second counters
- UTC serves as a bridge between the two types
- If leap seconds are abolished:
  - UTC will have lost that unique role
  - There is no bridge between the two types of time anymore
  - UTC will be just another TAI look-alike SI second counter