Standards of Fundamental Astronomy

Providing an authoritative set of algorithms that implement standard models used in fundamental astronomy

What is provided?
Software source code for
Categories
- Calendars
- Time Scales
- Earth Rotation & Sidereal Time
- Ephemerides
- Geocentric/Geodetic Systems
- Precession, Nutation, Polar motion
- Fundamental arguments
- Stars & also a Utility library (**VML**)

Who provides it?
IAU Division I, Commission 19 via the IAU SOFA Board

What standards?
Canonical routines adopt IAU standards:
- **IAU 2006,**
- **IAU 2000A, IAU 2000**
- **IAU 1980 & IAU 1976**

IAU SOFA Software

❖

A Service for All

http://www.iausofa.org

Documentation?
❖ **The Manual:**
ASCII & pdf from the comments
❖ **Cook Books:**
SOFA Tools for Earth Attitude
SOFA Time Scale & Calendar Tools

What Languages?
Fortran 77 & ANSI C

What is available?
Single download of the library:
UNIX tarball (UNIX line-terminators)
Zip archives for:
Windows
Macintosh system (DOS line-terminators)
Individual routines from the website
Archive of previous releases

Latest release?
2012 July 10 Updated **Release 9** of 2012 March 1

What tools provided?
makefile script to build library
Validation programs
t_sofa.for Fortran 77
t_sofa_c ANSI C

What terms?
- **Anyone may use SOFA, free of charge**
- **If you change any of the code you must say so & not claim that it is SOFA**
- **Please acknowledge use**
- **© SOFA Software belongs to the IAU SOFA Board**

Please check the website for the details

Please register. To receive information on corrections, updates, …

The SOFA Astronomy Library

Category	Comments
Calendars 7 routines	Civil and Julian date conversions. Besselian and Julian epoch conversions
Time scales: TAI, UTC, UT1, TT, TCG, TDB, TCB, TAI-UTC, TDB-TT 20 routines, 16 canonical	There are 16 routines that link the time scales, plus 2 routines to convert between time and date that caters for more than 59 seconds, the number of leap seconds, i.e. the difference between TAI and UTC, an approximation to TDB-TT.
Earth rotation & Sidereal time: GMST, GAST, ERA, … 15 routines, 10 canonical	Greenwich mean sidereal time (IAU 1982, 2000, 2006). Greenwich (apparent) sidereal time (IAU 1994, 2000A, 2000B, 2006/2000A). Equation of the equinoxes (IAU 1994, 2000A, 2000B 2006/2000A). Equation of the equinoxes "complementary terms" (IAU 2000). Earth rotation angle (IAU 2000).
Ephemerides 2 routines	Barycentric & heliocentric position & velocity of the Earth (medium precision). Approximate heliocentric position and velocity of planets.
Fundamental Arguments 14 canonical routines	Fundamental arguments used in the IAU 2000A nutation, taken from the IERS Conventions (2003).
Geocentric / Geodetic Systems 5 routines, 3 canonical	Conversions between geocentric and geodetic systems. The three standard reference ellipsoids supported are WGS84, GRS80 and WGS72, as well as a user specified ellipsoid.
Stars 8 routines	Conversions between star catalog coordinates & rectangular position & velocity vectors and the ICRS, viz: FK5 & Hipparcos star catalog coordinates Update a star's catalog position due to space motion.

The SOFA Astronomy Library *continued …*

Category	Comments
Precession, Nutation and Polar Motion 60 routines, 16 canonical	Frame bias components (IAU 2000) Precession angles ζ, z, θ, (IAU 1976, 2000, 2006) Precession angles including frame bias (IAU 2006) All equinox based precession angles (IAU 2006) Fukushima-Williams precession angles, including frame bias γ, ϕ, ψ (IAU 2006) Mean obliquity ε (IAU 1980, 2006) Nutation angles Δψ, Δε (IAU 1980, 2000A, 2000B) CIP *X*,*Y* and CIO Locator s and s' (IAU 2000A, 2000B, 2006/2000A) Equation of the origins Matrices for frame bias (IAU 2000) precession (IAU 1976, 2000, 2006) nutation (IAU 1980, 2000A, 2000B, 2006/2000A) polar motion matrix given position of the pole Celestial to intermediate **C** (IAU 1976/1980, 2000A, 2000B, 2006/2000A) Celestial to true equinox of date **NPB** (IAU1976/1980,2000A,2000B, 2006/2000A) Celestial to terrestrial, classical (IAU 2000A, 2000B, 2006/2000A) Celestial to terrestrial, CIO (IAU 2000A, 2000B, 2006/2000A)

Vector, Matrix & Utility Routines – VML (Support) Library

Vector, Matrix Routines 37 routines	Zeroize, initialize to identity, and manipulate a p-vector, pv-vector or matrix. Rotations about the *x*, *y*, or *z*-axis. Vector algebra; plus, minus, dot (scalar) & cross (vector) products, modulus, normalize, scalar times vector. Products of two matrices & transpose of a matrix, a matrix & vector & conversions between matrices & rotation vectors.
Spherical / Cartesian Conversions 6 routines	Conversions between the coordinate systems.
Operations on Angles 12 routines	Conversions between vectors & position angle and separation. Conversions between radians and ° (degrees) ' (arc minutes) " (arc seconds), radians and h (hours) m (minutes) s (seconds), and days and h m s. Normalize radians between 0 and 2π and - π to + π.

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