Standards of Fundamental Astronomy

Journees 2013 *Systèmes de référence spatio-temporels*

Authoritative Tools & Standard Models

Paris Observatory
2013 September 16-18

SOFA is an IAU Division A Working Group that provides a library of building blocks of fundamental astronomy routines (186) in Fortran & ANSI C. The SOFA library is authoritative, constructed with great care, practical, accessible and supported.

59 canonical routines delivering IAU Standards, such as IAU 2006 precession, IAU 2000A nutation and other IAU Resolutions, at for example, IAU's in 1976, 1980, 1994, 2000, 2006.

http://www.iausofa.org

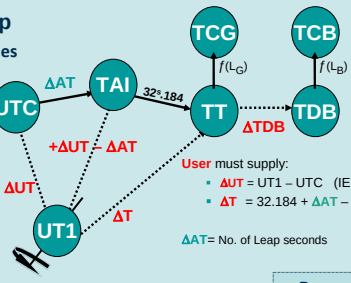
1. TIME SCALE & CALENDAR TOOLS

C O O K B O O K

Route Map

Routine **names** start **iau**

Adjacent time scales connected by 2 routines e.g. **UTCUT1** and **UT1UTC**



User must supply:
- ΔUT = UT1 – UTC (IERS)
- ΔT = 32.184 + ΔAT – ΔUT

ΔAT= No. of Leap seconds

Fortran & C Versions

27 Routines

Flexible structure

- *Parameters*: two argument Julian Date convention; Observables, as required e.g. UT1-UTC.
- Care taken; subtract tiny differences from smaller argument.

• Time & date ⇒ JD	DTF2D
• JD ⇒ date & time	D2DTF
• Date ⇒ JDN	CAL2JD
• JD ⇒ date, time, fraction	JD2CAL
	JDCALF
• Leap seconds	DAT
• TDB – TT	DTAB

- Epochs Julian, Besselian EPB, EPJ, EPB2JD, EPJ2JD

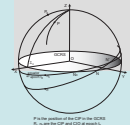
2. TOOLS FOR EARTH ATTITUDE

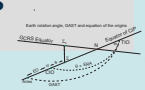
C O O K B O O K

Bias-Precession-Nutation, Polar Motion, Earth Rotation

GCRS ⇔ CIRS† ⇔ TIRS ⇔ ITRS

IAU2000A / IAU 2006 (06A)





B P N C *X,Y s,s' ε γ,φ,ψ ζ,z,θ π,Π Δψ,Δε ERA GAST GMST EO EqEq*

Celestial to Intermediate/ Eq & Eq — C2I...

Celestial to Terrestrial — C2T...

Selection from the 89 Routines

X, Y, s	CIP & CIO	XYS06A, XY06
ε,ψ,ω,χ	precession	FW2M
ε,ζ,z,θ	precession	P06E
Δψ,Δε	nutation	NUT06A, NUT00A
M = N P B	bias-precession-nutation	PNM06A
C = C(*X*+*DX*, *Y*+*DY*, *s*)		C2IXYS
W = $R_3(-x_p)$ $R_3(-y_p)$ $R_3(s')$		POM00
Q = W R_3(GAST) M		C2TEQX
Q = W R_3(ERA) C		C2T06A, C2TCIO

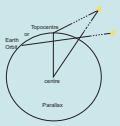
DX, DY, x_p y_p user supplied (IERS). Use iau_TR to calculate inverse matrix

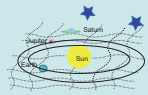
3. ASTROMETRY TOOLS

C O O K B O O K

2013 Dec 2 12:00 UTC

Coming soon ....





ICRS α,δ, α, δ, π r

space motion

BCRS α,δ,r

parallax

astrometric α,δ

light deflection aberration

GCRS α,δ

bias-precession-nutation

CIRS α,δ

CIRS α,δ

Earth rotation angle

TIRS

TIRS

polar motion

ITRS

topocentric az,alt or h,δ

refraction

observed az, alt

Transformation of coordinates:
Catalogue (ICRS), Astrometric (ICRS), Celestial Intermediate (and equator and equinox), Terrestrial Intermediate, ITRS and observed.

Methods / Accuracy:
Rigorous methods wherever possible. "Quick" routines deliver better than mas precision. A dependency on user choices e.g., refraction. An intermediate position can include light deflection from Saturn, Jupiter and the Sun and provide a CIRS position to within about ±2μas

Coming soon ....

4. THE MANUAL

M A N U A L

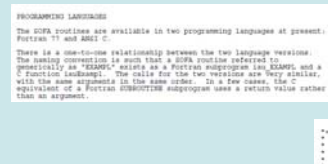

THE IAU-SOFA SOFTWARE LIBRARIES

SOFA stands for "Standards Of Fundamental Astronomy". The SOFA software libraries are a collection of subprograms, in source-code form, which implement official IAU algorithms for fundamental-astronomy computations. The subprograms at present comprise 131 "astronomy" routines supported by 55 "vector/matrix" routines, available in both Fortran77 and C implementations.

THE SOFA INITIATIVE

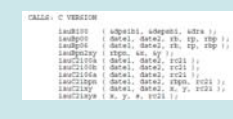
SOFA is an IAU Service which operates under Division I (Fundamental Astronomy) and reports through Commission 19 (Rotation of the Earth).

The IAU set up the SOFA initiative at the 1994 General Assembly, to promulgate an authoritative set of fundamental-astronomy constants and algorithms. At the subsequent General Assembly, in 1997, the appointment of a SOFA Review Board and the selection of a site for the SOFA Center (the outlet for SOFA products) were announced.

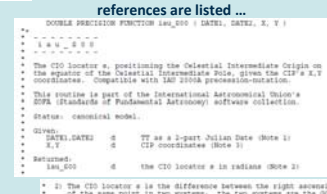

PROGRAMMING LANGUAGES

The SOFA routines are available in two programming languages at present: Fortran 77 and ANSI C.

There is a one-to-one relationship between the two language versions. The naming convention is such that a SOFA routine referred to generically as "EXAMPL" exists as a Fortran subprogram iau_EXAMPL and a C function iauExampl. The calls for the two versions are very similar, with the same arguments in the same order. In a few cases, the C equivalent of a Fortran SUBROUTINE subprogram uses a return value rather than an argument.


CALLS: C VERSION

```
iauBi00  ( &dpsibi, &depsbi, &dra );
iauPn00  ( date1, date2, &dr, &dp, &rbp );
iauPn00a ( date1, date2, &dr, &dp, &rbp );
iauPn00b ( date1, date2, &dr, &dp, &rbp );
iauPnm06a( date1, date2, rnpn );
iauC2i06a( date1, date2, rc2i );
iauC2ibpn( date1, date2, rnpn );
iauC2ixys( X, Y, s, rc2i );
iauC2t00a( tta, ttb, uta, utb, xp, yp, rc2t );
iauC2t00b( tta, ttb, uta, utb, xp, yp, rc2t );
iauC2t06a( tta, ttb, uta, utb, xp, yp, rc2t );
iauC2tcio( rc2i, era, rpom, rc2t );
iauC2teqx( rbpn, sp, rpom, rc2t );
iauC2tpe( tta, ttb, uta, utb, dpsi, deps, xp, yp, rc2t );
iauC2txy( tta, ttb, uta, utb, x, y, xp, yp, rc2t );
```


DOUBLE PRECISION FUNCTION iau_S00 (DATE1, DATE2, X, Y)

The CIO locator s, positioning the Celestial Intermediate Origin on the equator of the Celestial Intermediate Pole, given the CIP's X,Y coordinates. Compatible with IAU 2000A precession-nutation.

This routine is part of the International Astronomical Union's SOFA (Standards of Fundamental Astronomy) software collection.

Status: canonical model.

Given:
DATE1,DATE2 d TT as a 2-part Julian Date (Note 1)
X,Y d CIP coordinates (Note 3)

Returned:
iau_S00 d the CIO locator s in radians (Note 2)

1) The CIO locator s is the difference between the right ascensions of the same point in two systems. The two systems are the GCRS and the CIP,CIO, and the point is the ascending node of the CIP equator. The quantity s remains below 0.1 arcsecond throughout 1900-2100.

2) The series used to compute s is in fact for s+XY/2, where X and Y are the x and y components of the CIP unit vector; this series is more compact than a direct series for s would be. This routine requires X,Y to be supplied by the caller, who is responsible for providing values that are consistent with the supplied date.

4) The model is consistent with the IAU 2000A precession-nutation.

ASCII and Adobe pdf files, split into manageable sections:

Title page	title
T&C	copyr
Changes	changes
Introduction	intro
Astronomy library	sofa_lib
Vector Matrix library	sofa_vml
Board	board.lis

Extracts from all routines with arguments, initial comments and references are listed ...

Acknowledgements:
SOFA Board members & Board members' institutions
Web hosting by the UK Hydrographic Office
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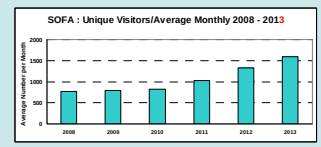
sofa@ukho.gov.uk

Statistics

No. Registered users	687
No. downloads (9a)	4497
ANSI C	2463
Fortran	2034



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