Standards Of Fundamental Astronomy

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

SOFA & Astrometry

Astrometry AT Routines

Fortran iau_AT... or ANSI C iauAT...

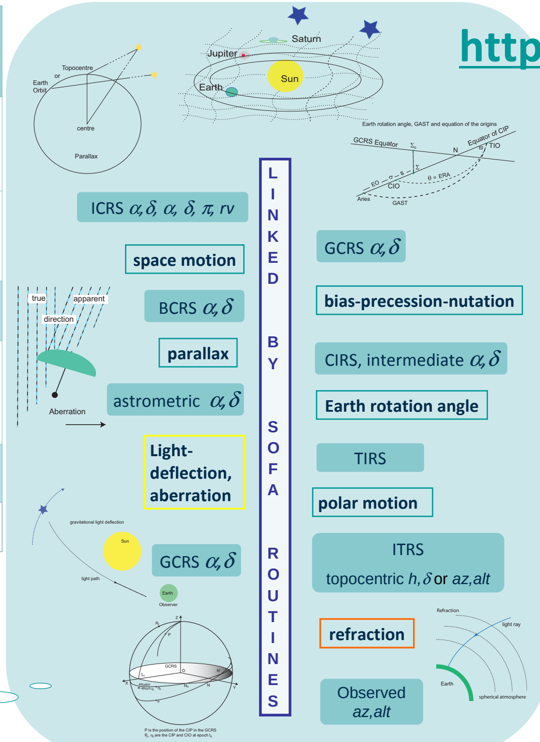
Transformation of coordinates: System A→B

Reference System A↓ B→	Astrometric (ICRS) $\alpha_0\ \delta_0$	CIRS Intermediate $\alpha_i\ \delta_i$	ITRS Observed $\alpha_o\ \delta_o$
Catalog, ICRS $\alpha_c\ \delta_c\ \mu_\alpha\ \mu_\delta\ \pi$ rv		...ATCI13* ...ATCIQ ...ATCIQN	..ATCO13*
Astrometric (ICRS) $\alpha_0\ \delta_0$		...ATCIQZ	
Celestial Intermediate Reference System (CIRS), $\alpha_i\ \delta_i$	...ATIC13* ...ATICQ ...ATICQN		...ATIO13 ...ATIOQ
ITRS/Observed $\alpha_o\ \delta_o$	...ATOC13	...ATOI13 ...ATOI1Q	

* Right ascension with respect to the true equinox of date, given by $\alpha_e = \alpha_i - E_o$ where E_o is an output argument of these routines.

... 13 → IAU 2013

Routines with **13** in their name mean that they use IAU 2006/2000A for the CIP and CIO locator (i.e. bias-precession-nutation), IAU/IERS 2000 ERA, TIO locator, and EPV00 for approximate position and velocity of the Earth.



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Core astrometry routines:

Routine iau_... or Iau---	Function / Effects / Comments
PMPX	Space motion, including Roemer effect, and parallax.
LD	Light-deflection, general.
LDSUN	Light-deflection for stars by the Sun only.
LDN	Light deflection by multiple (N) solar-system bodies, the mass, position and velocity of which are supplied by the user.
AB	Aberration.
PVTOB	Position & velocity of a terrestrial observing station.
REFCO	Refraction (very basic model) constants for given ambient conditions.

What parameters do I need ...?

Star dependent parameters: star position, etc. This depends on the initial reference system, supplied via the input arguments, such as $\alpha\ \ \delta\ \mu_\alpha\ \mu_\delta\ \pi$ rv.

Star-independent parameters provided via a context array called ASTROM. Array is filled via **AP..[13]** routines by SOFA or the user, depending on systems being transformed, the location of the observer and the effects required.

If there are many stars that are to be reduced for one date/time, then first set up the **Context Array** with a CALL to the appropriate **AP..[13]** routine, so the star-independent parameters are evaluated only once.

Input Parameters: User Choice

Observer	AT/AP...13 Routines	AT/AP Routines with User Supplied Parameters
Geocentric	Date/time (UTC)	Earth position & velocity CIO/CIP (X+DX, Y+DY, s)
Space	Date/time (UTC), Observer's position & velocity	Earth position & velocity CIO/CIP (X+DX, Y+DY, s)
Terrestrial	Date/time (UTC & UT1) Site coordinates (λ, φ, Ht) IERS Earth orientation (x_p,y_p) Ambient air conditions & wavelength	Date/time (UTC & UT1−UTC) Site coordinates (λ, φ, Ht) IERS Earth orientation (x_p,y_p) User's refraction model Earth Rotation Angle (ERA)

Consult the CookBook

SOFA Astrometry Tools

Aberration & Earth Ephemeris

If the EPV00 routine is used (e.g. in the **...13** routines) for the Earth ephemeris, errors in the aberration predictions of up to 5 µas can occur. Note that an error in the observer's speed of 1.5 mm/s gives an aberration error of about 1 µas.

Accuracy

Quick (..**Q**..) routines deliver milliarcsecond (mas) accuracy.

The **..13** routines use the IAU 2006/IAU 2000A precession-nutation models — limits the accuracy to about 1 mas (excluding those involving refraction).

Care is taken to ensure that given transformations and their inverses match to high precision. Where this is not achievable simply through rigor (by the use of vector methods for example), iteration is used.

Without refraction the inversions are self-consistent to better than 1 µas all over the celestial sphere. With refraction included, consistency falls off at high zenith distances, but is still better than 0.05 arc seconds at ζ = 85°.

Light Deflection

Over much of the sky, SOFA's predictions of light deflection by the Sun are accurate to 1 µas.

Close to the Sun, errors may approach the 0.5 mas level.

Close to other solar-system bodies, unmodeled deflections of several mas can arise, e.g. over 16 mas at Jupiter's limb. If this is significant, use routines ATCIQN, ATICQN and LDN, as appropriate.

Observed Place

Limited by refraction predictions. This is likely to be true even if better refraction constants are supplied than those from the very basic model used by REFCO. Even the best available refraction models in practice struggle to achieve 0".1tan ζ.

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