SOFA ASTROMETRY TOOLS AT A GLANCE

The Astrometric Transformation Chain
ICRS ⇔ GCRS ⇔ CIRS ⇔ Observed (TIRS, ITRS)

The following four tables are a summary of the routines names and abbreviations for the transformation of star positions between various reference systems.

Table 1: Summary of abbreviations used in routine names	
AP	**A**strometric **P**arameters: routines that populate a *context* structure (ASTROM) that provide the star-independent parameters for the transformation, e.g. date-time, position and velocity of Earth, bias-precession-nutation matrix, Earth rotation angle (ERA). Only those parameters required for the particular transformation need to be supplied.
AT	**A**strometric **T**ransformations: routines that transform star coordinates from one reference system to another.
C	**C**atalog: i.e. International Celestial Reference System (ICRS).
G	Geocentric: an observer at the geocenter, suitable for use with positions in the Geocentric Celestial Reference System (GCRS).
I	**I**ntermediate: i.e. Celestial **I**ntermediate Reference System (CIRS) or Terrestrial **I**ntermediate Reference System.
N	Multiple deflections, i.e. light deflection from multiple solar-system bodies (see routine LDN).
O	**O**bserved: a position seen by a terrestrial observer, with refraction included.
Q	**Q**uick: i.e. the context structure (ASTROM) is used and items such as precession and nutation are not re-calculated.
S	Space: an observer with known geocentric position, suitable for use with positions in the Geocentric Celestial Reference System (GCRS).
Z	Assumes zero parallax and proper motion, or that these effects have already been allowed for.
13	Routines whose names end with **13** (meaning 2013 edition) use IAU 2006/2000A for the CIP and CIO locator (i.e. bias-precession-nutation), Earth rotation angle IAU 2000, TIO locator (s') IERS 2000, and the SOFA routine EPV00 for the approximate position and velocity of the Earth. See Table 4.

Table 2: Core routines for the transformation from the ICRS to the GCRS	
Routine	**Comment / Effects**
PMPX	Space motion and parallax.
LD	Light deflection, general.
LDSUN	Light deflection; Sun only.
LDN	Light deflection by multiple solar-system bodies, the position and velocity of which are supplied by the user.
AB	Aberration.
	Routines for the terrestrial observer
PVTOB	Position and velocity of a terrestrial observer. Conversion of WGS84 λ, φ, Ht, x_p,y_p, s' and ERA to PV (m, m/s) in the CIRS or true equator and equinox if GAST is used instead of ERA.
REFCO	Refraction constants for given ambient conditions.

Table 3: AT routines for transformation of coordinates; reference system A → B			
B→ **A↓**	ICRS Astrometric	CIRS (**I**ntermediate)	**O**bserved
Catalogue, ICRS		AT**CI**13 AT**CI**Q AT**CI**QN	AT**CO**13
ICRS, Astrometric		AT**CI**Q**Z**	
CIRS (**I**ntermediate)	AT**IC**13 AT**IC**Q AT**IC**QN		AT**IO**13 AT**IO**Q
Observed	AT**OC**13	AT**OI**13 AT**OI**Q	

Table 4: AP routines that populate and update the context structure ASTROM				
Routine **parameters required for**	**Location of observer**	**Prepare for transformations between coordinates in the:**	**AP- routines (*special*) Parameters supplied by the user**	**AP-13 routines Parameters supplied by the user**
APCG As APCS	Geocentric	ICRS & GCRS	1. Date/time 2. Earth ephemeris	1. Date/time
APCS Space motion parallax light deflection aberration	Space i.e. an observer with known geocentric position and velocity	ICRS & GCRS	1. Date/time 2. Position/velocity of observer 3. Earth ephemeris	1. Date/time 2. Position/velocity of observer
APCI As APCS, and bias-precession-nutation	Terrestrial	ICRS & CIRS	1. Date/time 2. Earth ephemeris 3. CIP/CIO (X,Y,s)	1. Date/time **Note**: Also returns the equation of the origins (EO)
APCO As APCS, and bias-precession-nutation, and Earth rotation	Terrestrial	ICRS & observed	See **APCI+APIO**	As for **APIO13** **Note**: Also returns the equation of the origins (EO)
APIO	Terrestrial	CIRS & observed	1. ERA and s' 2. Site coordinates (λ, φ, Ht) 3. IERS Earth orientation (x_p,y_p) 4. Refraction constants	1. UTC & UT1-UTC 2. Site coordinates 3. IERS Earth orientation (x_p,y_p) 4. Ambient air conditions and specified wavelength
APER Update ERA	Terrestrial	—	1. ERA (or GAST for classical apparent RA & Dec)	1. UT1

Note, all routine names are preceded by iau, e.g. iau_APCS (Fortran) or iauApcs (C).