United Kingdom Hydrographic Office

Standards of Fundamental Astronomy

Dr. Steve Bell: HM Nautical Almanac Office

XXXIth IAU GA Busan, South Korea, August 5th 2022

HM Nautical Almanac Office

Dr. Steve Bell – SOFA Webmaster & Board Member
Ms. Toni Wilmot – SOFA Board Member

What is SOFA?

- The SOFA Software Collection provides an authoritative set of algorithms that implement standard models used in Fundamental Astronomy

- SOFA is a functional working group of IAU Division A

- SOFA material available via a web site https://iausofa.org

- SOFA library first released in 2001 as a Fortran only release

- First C and Fortran release in 2009 (6th release)

- There have been a total of 18 major releases

- The latest release (2021-05-12) was made available on 2021 May 21

- Anyone can use SOFA, free of charge

Release
18
2021-05-12

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Principal Sections ...

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- Software Archive
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Related Links ...

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- IERS

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Acknowledge SOFA ...

If you make use of the SOFA Software, please include a citation.

Your support matters!!

The International Astronomical Union's SOFA service has the task of establishing and maintaining an accessible and authoritative set of algorithms and procedures that implement standard models used in fundamental astronomy. The service is managed by an international panel, the SOFA Board, appointed through IAU Division A — Fundamental Astronomy. SOFA also works closely with the International Earth Rotation and Reference Systems Service (IERS).

IAU SOFA Center

This web site provides access to the SOFA Software Collection which is currently available for both Fortran 77 and ANSI C. Information on how to obtain it and instructions for its use are available by following the link to Current Software.

Using SOFA software is free of charge under the terms and conditions of the SOFA licence.

Registration is encouraged as it helps to demonstrate the use being made of the SOFA Libraries and also provides users with e-mail notification of bugs and updates.

Quick start ...

- **Download the latest release:**

  - Latest Fortran 77 release is available.
    [Released 2021-05-12]
  - Latest ANSI C release is available.
    [Released 2021-05-12]
  - A summary of changes for the latest release is available.

Release

18

2021-05-12

News ...

- **2021 May 12 / Eighteenth SOFA release**

This notice is to inform users of the 18th release of the SOFA software library on 2021 May 12 @ 14:00 UTC. This major release implements three new support routines. Two deal with calculating astrometric places, while the third provides the

Introduction to SOFA

SOFA Board – I

SOFA is managed through an international panel known as the SOFA Board

- John Bangert — United States Naval Observatory (retired)

- Steven Bell — Her Majesty's Nautical Almanac Office (Webmaster)

- Nicole Capitaine — Paris Observatory

- Maria Davis — United States Naval Observatory (IERS)

- Mickaël Gastineau — Paris Observatory, IMCCE

- Catherine Hohenkerk — Her Majesty's Nautical Almanac Office (Chair, retired)

- Li Jinling — Shanghai Astronomical Observatory

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- Zinovy Malkin — Pulkovo Observatory, St Petersburg

- Jeffrey Percival — University of Wisconsin

- Wendy Puatua — United States Naval Observatory

- Scott Ransom — National Radio Astronomy Observatory

- Nick Stamatakos — United States Naval Observatory

- Patrick Wallace — RAL Space (retired)

- Toni Wilmot — Her Majesty's Nautical Almanac Office

What is available?

- SOFA provides two source libraries of routines, one for Fortran 77 and one for ANSI C

- Material available for most operating systems via tarballs and zip files

- Individual routines can be downloaded from the web site

- Archive of previous releases

- Unix makefiles used to build libraries

- Validation programs t_sofa_for and t_sofa_c

- Documentation and Cookbooks

- 247 routines (including 55 vector matrix routines and 59 canonical routines)

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Documentation and Cookbooks

- Web site https://iausofa.org

- SOFA Manual

- SOFA Astrometry Tools at a Glance (2-page quick look document)

- Four Cookbooks:

  - SOFA Tools for Earth Attitude

  - SOFA Time Scales & Calendar Tools

  - SOFA Astrometry Tools

  - SOFA Vector Matrix Library

Introduction to SOFA

Routines – I

- Astrometry – 38 routines

- Calendars – 7 routines

- Time Scales – 20 routines

- Ecliptic Coordinates – 6 routines

- Earth Rotation and Sidereal Time – 15 routines

- Ephemerides – 3 routines

- Fundamental Arguments – 14 routines

- Galactic Coordinates – 2 routines

- Geocentric/Geodetic Transformation – 5 routines

Routines – II

- Gnomonic Projections – 6 routines

- Horizonal / Equatorial Coordinates – 3 routines

- Precession / Nutation / Polar Motion – 64 routines

- Star Catalog conversions – 9 routines

- Vector / Matrix Routines – 55 routines

Licensing

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- Licensing information is provided in every SOFA routine.

- The routines are "read only".

- The one exception is the leap second routine. This is classified as "user replaceable" and has a mitigated licensing statement that permits the distribution of local variants under the same name. This measure allows other SOFA routines to call the local variant which may be file or network based or otherwise equipped to pick up IERS leap second updates with no need to download new SOFA code.

- If <u>you</u> change any code, <u>you</u> must say so and <u>not</u> claim that it is still a SOFA product (with the exemption of the leap second routines in both sets of code).

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Since the last IAU GA XXX Vienna

- **15th release**: Four new routines in the Star Catalogue Section (FK4/FK5 transformations for dealing with pre-1984 publications) . One correction and seventeen enhancements. Updates to the Astrometry Tools Cookbook.

- **16th release**: corrections and improvements to several routines including PO6E, PB06, JD2CAL, JDCALF and sofam.h.

- **17th release**: improvements to the atmospheric refraction routines and a new cookbook on the SOFA Vector Matrix Library. Better handling of polar motion. Minor release 17a: updates to implementation of leap seconds 1960-1971.

- **18th release**: two routines for the Astrometry section and one for the ephemeris section for approximate lunar positions and velocities. Rearrangement of SOFA headers files sofam.h and sofa.h.

Usage of SOFA

- ~1000 registered users

- Average monthly visits ~1550 in the period 2018-2022

- Release 18 downloads for both Fortran 77 and ANSI C are ~10,500

- Registrations show a global distribution

- 75% of users expressed an interest in both Fortran and ANSI C distributions

- 6% of users expressed an interest in Fortran only

- 19% of users expressed an interest in ANSI C only

- In terms of downloads, 70% are for ANSI C and 30% are for Fortran with the latest 18th release having been downloaded ~10,500 times.

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Other Implementations

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- The following are supported independently of the SOFA Libraries but are derived from SOFA

  - Java version from Jodrell Bank Centre

  - ERFA – Essential Routines for fundamental Astronomy – rebranded ANSI C version from AstroPy

  - World wide Astronomy C# Library

Download SOFA …

- https://iausofa.org

- Please register to receive information on corrections, updates and new releases etc.

- If you use SOFA, please acknowledge its use.

- The SOFA Board thanks its board members' institutions for their support and the UK Hydrographic Office for hosting its web site.

- **Thank you to all our users!**

Any Questions?