EphemerisSources.jl: Idiomatic Ephemeris Sourcing and Parsing in Julia

Joseph D. Carpinelli 🄪 1

1 Independent Researcher, USA

Summary

Students and professionals in astronomy, astrodynamics, astrophysics, and other related fields often download and parse data about objects in our solar system — ephemeris data — from two major providers: JPL's publicly-available Generic SPICE Kernels and JPL's Horizons platform. SPICE kernels are typically read through the SPICE Toolkit, which is available in a variety of programming languages, including the C Programming Language with CSPICE (Acton, 1996). The Julia packages `CSPICE_jll.jl` and `SPICE.jl` expose many CSPICE functions through Julia functions. Julia users can load and interact with SPICE kernels through methods such as `SPICE.furnsh` and `SPICE.spkez`. Horizons provides data through a variety of methods, including email, command-line, graphical web interfaces, and a REST API (Giorgini, 2015).

This paper introduces several packages — `SPICEKernels.jl`, `SPICEBodies.jl`, `HorizonsAPI.jl` and `HorizonsEphemeris.jl` — which allow users to download and process Cartesian state vector data idiomatically, all from within Julia. While ephemeris data comes in many forms, including observer tables, osculating orbital elements, and binary formats, these packages currently target Cartesian state vector (position and velocity) ephemeris data. Through the use of these packages, users can share replicable code which automatically fetches data from publicly-available ephemeris sources, as opposed to manually including ephemeris data files with their source code distribution.

Statement of Need

While astronomers, astrodynamicists, and other ephemeris users have the tools they need to fetch and parse position and velocity data from multiple sources within Julia, they do not have the tools to do so *simply* or *idiomatically*. Horizons' ephemeris data is distributed in plain text with surrounding metadata, and manual parsing is required for users to programmatically use the fetched ephemeris data. Generic SPICE kernels are freely available and can be used with `CSPICE` (and wrapper libraries) for kernel inspection and data retrieval, but new users and students may find the required workflows unfamiliar. The packages presented in this paper may be used by students and professionals to idiomatically inspect and use Cartesian state vector ephemeris data, without prior knowledge of SPICE Toolkit utilities or REST APIs.

JPL Horizons

The two Horizons-related packages presented in this paper — `HorizonsAPI.jl` and `HorizonsEphemeris.jl` — are respectively the first Julia packages to precisely match the REST API with tab-completion through *static keyword arguments*[1], and the first to offer automatic response parsing into `NamedTuple` types. The `NamedTuple` output of

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[1] The code required to support static keyword arguments was provided by Joseph Wilson, as described in the **Acknowledgements** section.

HorizonsEphemeris.ephemeris, the top-level method for fetching Cartesian state vectors from the Horizons platform, allows for easy plotting, CSV file-saving, and DataFrame construction. Both HorizonsAPI.jl and HorizonsEphemeris.jl offer users a simple, repeatable way to query and parse Horizons state vector data. Parsing for other ephemeris types, including observer tables and osculating orbital element tables, are desired features but are not yet implemented. For sending Horizons requests for these other ephemeris types, use HorizonsAPI methods to manually construct each request, or see Horizons.jl.

JPL SPICE

The two SPICE-related packages presented in this paper — SPICEKernels.jl, and SPICEBodies.jl — provide idiomatic kernel fetching, inspection, and caching from within Julia. Previously, Julia users interacted with SPICE kernels by manually downloading publicly-available generic kernels and parsing the data using SPICE.jl, or another ephemeris parsing source. This workflow requires that users know how to find the appropriate generic kernels for their chosen application, and that they know how to use CSPICE functions to retrieve their desired data. SPICEKernels.jl and SPICEBodies.jl offer idiomatic interfaces to ephemeris fetching and parsing respectively. The SPICEKernels.jl project uses continuous integration to fetch and parse publicly-available kernels and expose each kernel as a variable in a new package release. SPICE Toolkit executables, provided by SPICEApplications.jl, are used to fill each corresponding kernel variable's docstring with a description of the kernel's contents. SPICEKernels.jl users can utilize tab-completion and Julia's built-in documentation tools to help select the most appropriate generic kernel for their application. Once each kernel is loaded into the SPICE kernel pool with SPICE.jl, users can use SPICEBodies.jl to idiomatically fetch state vector data at provided epochs.

Usage

For detailed usage examples, consult the common documentation site.

External Packages

The packages presented in this paper which interact with the SPICE Toolkit require users to use SPICE.jl, or another SPICE-compatible kernel loading tool. SPICEBodies.jl uses the kernel cache that is created with SPICE.furnsh. Support for other SPICE kernel management packages, such as Ephemerides.jl, may be added in the future. Support for Ephemerides.jl is particularly desirable, as it enables fetching kernel data in multi-threaded contexts. In addition to the packages in this paper which interface with the JPL Horizons ephemeris platform, the Horizons.jl package offers simplified interfaces for constructing and sending queries to the JPL Horizons REST API. The Horizons.jl package provides support for all Horizons query types, as does HorizonsAPI.jl. As stated previously, HorizonsEphemeris.jl currently only supports parsing for Cartesian state vector data.

Acknowledgements

Disclaimers

The software developed in this paper, and the paper itself, was written by the author in a personal capacity. This work does not reflect the views of any organization, employer, or entity, except for the author as an individual.

References

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