The SPICE Toolkit

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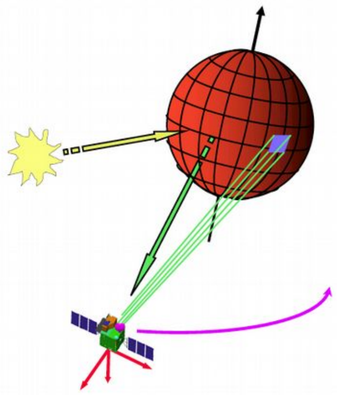
What Can One Do With SPICE?

Navigation and Ancillary Information Facility

Compute many kinds of observation geometry parameters at selected times

Examples



- **Positions and velocities of planets, satellites, comets, asteroids and spacecraft**
- **Size, shape and orientation of planets, satellites, comets and asteroids**
- **Orientation of a spacecraft and its various moving structures**
- **Instrument field-of-view location on a planet's surface or atmosphere**

- How was Pluto orientated at your day of birth?
- How to convert between SolO's SC clock and UT?
- How to rotate between different coordinate systems?

SPICE data

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Data sets are stored in **kernels**:

- SPK: SC and planet ephemeris
- FK: Reference frame specification
- SCLK: SC clock correlation data
- LSK: Leapseconds
- ...

```
Geocentric Solar Ecliptic (GSE) Frame

     Definition of the Geocentric Solar Ecliptic frame:

              All vectors are geometric: no aberration corrections are
              used.

              The position of the sun relative to the earth is the primary
              vector: the X axis points from the earth to the sun.

              The northern surface normal to the mean ecliptic of date is the
              secondary vector: the Z axis is the component of this vector
              orthogonal to the X axis.

              The Y axis is Z cross X, completing the right-handed
              reference frame.

\begindata

        FRAME_GSE                     =  1803311
        FRAME_1803311_NAME            = 'GSE'
        FRAME_1803311_CLASS           =  5
        FRAME_1803311_CLASS_ID        =  1803311
        FRAME_1803311_CENTER          =  399
        FRAME_1803311_RELATIVE        = 'J2000'
        FRAME_1803311_DEF_STYLE       = 'PARAMETERIZED'
        FRAME_1803311_FAMILY          = 'TWO-VECTOR'
        FRAME_1803311_PRI_AXIS        = 'X'
        FRAME_1803311_PRI_VECTOR_DEF  = 'OBSERVER_TARGET_POSITION'
        FRAME_1803311_PRI_OBSERVER    = 'EARTH'
        FRAME_1803311_PRI_TARGET      = 'SUN'
        FRAME_1803311_PRI_ABCORR      = 'NONE'
        FRAME_1803311_SEC_AXIS        = 'Z'
        FRAME_1803311_SEC_VECTOR_DEF  = 'CONSTANT'
        FRAME_1803311_SEC_FRAME       = 'ECLIPDATE'
        FRAME_1803311_SEC_SPEC        = 'RECTANGULAR'
        FRAME_1803311_SEC_VECTOR      = ( 0, 0, 1 )
```

How to use SPICE

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SPICE → SpiceyPy → ET SPICE

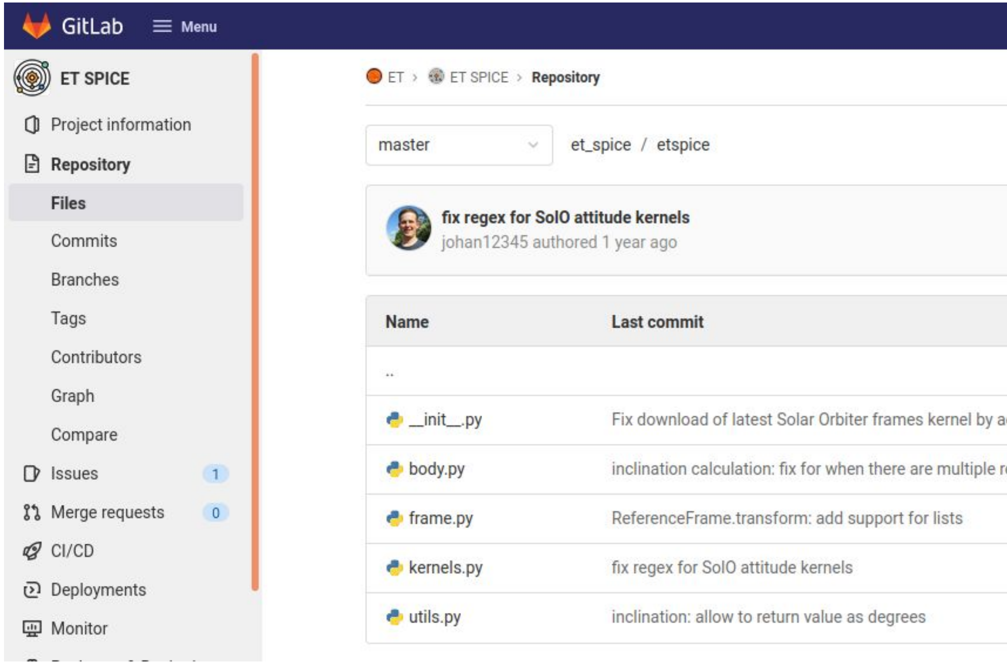
NASA NAIF
C, FORTRAN, MATLAB, ...

Andrew Annex
Python

Johan v. Forstner
Python

ET SPICE available in the ET GitLab:
https://gitlab.physik.uni-kiel.de/ET/et_spice

Installation via pip:
pip3 install git+https://gitlab.physik.uni-kiel.de/ET/et_spice.git



ET SPICE

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- automatically loads kernels
- downloads latest kernels
- works with datetime.datetime
- less cryptic syntax
- extensible with SpiceyPy functions

- leapseconds
- reference frames

- Sun, planets, Pluto, moons

- Lagrange points

- MSL
- STEREO
- PSP
- SolO*
- SOHO
- Ulysses
- Helios
- MAVEN
- BepiColombo
- LRO

Functions

- position( )
- sclk_to_datetime( )
- datetime_to_sclk( )
- inclination( )

Code example

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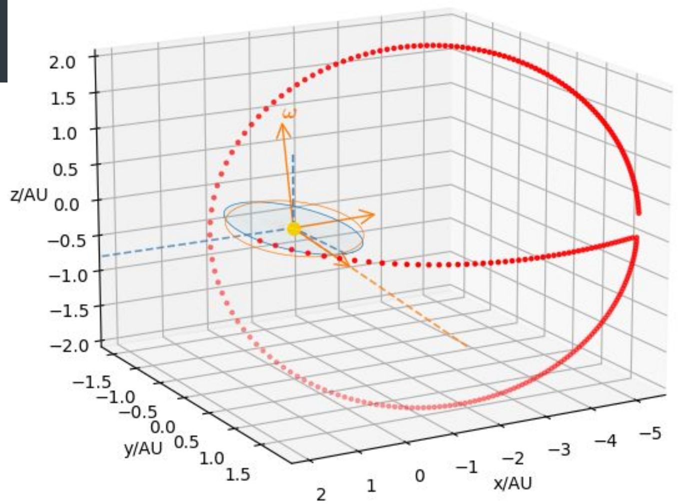
```python
import datetime
from etspice import *

# STEREO Kernel "heliospheric... .tf"
HCI = ReferenceFrame([kernels.heliospheric_frames],'HCI')
# DIY kernels:
my_kernel = kernels.LocalKernel('Ulysses/Trajectory/SPICE/data/test_tf.tf')
my_kernel.load()

date = datetime.datetime(1992,2,18,9,30)

pos = ULYSSES.position(time = date, relative_to = SUN, reference_frame = HCI)

from spiceypy import spkezr, datetime2et
[x, y, z, vx, vy, vz] = spkezr('ULYSSES', datetime2et(date), 'HCI', 'None', 'SUN')[0]

print(f"\nPosition of Ulysses @ {date}:\n", pos)
print(f"\nVelocity of Ulysses @ {date}:\n", [vx, vy, vz])
```

```
In [7]: %run Ulysses/Trajectory/SPICE/spice_minimal_example.py

Position of Ulysses @ 1992-02-18 09:30:00:
 [ 1.06407939e+08  7.95783856e+08 -9.31722588e+07]

Velocity of Ulysses @ 1992-02-18 09:30:00:
 [-0.9815017498929168, -0.9585219125953374, -8.271585085037566]
```



Jet Propulsion Laboratory
California Institute of Technology

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NAIF

The Navigation and Ancillary Information Facility

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SPICE Tutorials

Updated December 11, 2019

This is a collection of tutorials, in chart style using PDF format, covering most aspects of **using** SPICE kernel files and allied Toolkit software to compute observation geometry parameters. There is also limited discussion about **making** SPK and CK kernels. Included in this collection is a working programming example, provided in each supported language.

At the bottom of the list is a link to a zip file containing the entire tutorial collection in PDF format.

File Name	Topic
01_welcome_to_tutorials	About this set of tutorials
02_motivation	Why SPICE was conceived
03_spice_overview	An overview of the entire SPICE system
04_concepts	Some discussion on concepts of space geometry and time
05_conventions	Summary of many conventions and the lingo used within SPICE
06_naif_ids	A discourse on the numeric IDs used throughout SPICE
07_installing_toolkit	General instructions for obtaining and installing a SPICE Toolkit package