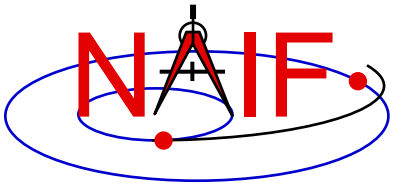


Navigation and Ancillary Information Facility

Planetary Constants Kernel
PCK

June 2019

(Class version)

Overview

- **The Planetary Constants Kernel (PCK) subsystem comprises both text and binary kernels.**
  - **Text PCKs provide orientation and shape models for the sun, planets, natural satellites and a few asteroids.**
  - **Binary PCKs are used only when very high accuracy orientation data are available.**
    - » **Currently available only for the earth and the moon**
    - » **One still needs to use a text-style PCK to get shape data**

Text PCKs - 1

- **Text PCK files contain size, shape and orientation data associated with natural solar system bodies: planets, satellites, and a few comets and asteroids.**
  - **Some additional kinds of data might also be included.**
- **NAIF creates and distributes a "generic" text PCK based on the latest IAU/IAG Report.***
  - **The reports are issued about once every three years, and so might not contain the very latest available results.**
- **SPICE PCK software is designed to use these data to compute orientation of body-fixed, body-centered frames.**
  - **These frames have a name style of "IAU_*body-name*"**
- **Text PCKs are sometimes produced by flight projects and others–not only by NAIF.**

* "Report of the IAU/IAG Working Group on cartographic coordinates and rotational elements: <year issued>"; published in *Celestial Mechanics and Dynamical Astronomy*

Text PCKs - 2

- **The SPICE text kernel mechanism is used to implement PCK files.**
  - **Kernel variables contain the mathematical terms appearing in rotation or shape models. For example:**

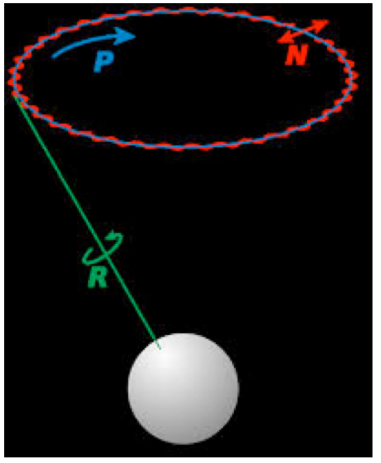
```
BODY699_POLE_RA =   ( 40.589   -0.036      0. )
BODY699_POLE_DEC =  ( 83.537   -0.004      0. )
BODY699_PM =        ( 38.90   810.7939024  0. )
BODY699_RADII   =   ( 60268    60268   54364   )
```

  - **Users may easily inspect data in text PCKs.**
  - **Users may (carefully!) modify text PCKs with a text editor.**
    - » **Data or comments may be added, deleted, or changed.**
    - » **Comments should be added to explain changes.**
  - **Kernel variable names are case-sensitive.**
    - » **NAIF uses only upper case for variable names; we suggest you do the same.**

Text PCK Orientation Models - 1

- **For the sun, planets and a few major asteroids:**
  - **PCK models use low-degree (typically linear) polynomials to represent RA and DEC of the pole (body-fixed +Z-axis) as a function of time.**
  - **The prime meridian is also represented by a low-degree polynomial.**
  - **For a few planets, trigonometric polynomial terms are used to more accurately represent precession and nutation of the pole.**

R = rotation of the body about its rotational axis
P = precession of the bodies' rotational axis
N = nutation of the bodies' rotational axis



- **For natural satellites:**
  - **In addition to low-degree polynomials for the spin axis and prime meridian, trigonometric polynomial terms are used to more accurately represent precession and nutation.**
  - **A few satellites have chaotic rotation and so are not modeled.**

Text PCK Orientation Models - 2

- **The base frame for PCK orientation models is the International Celestial Reference Frame (ICRF), as defined by the International Earth Rotation Service (IERS).**
  - **For historical and backwards compatibility reasons SPICE uses the name "J2000" as a synonym for the ICRF inertial reference frame, even though J2000 and ICRF are, in fact, not identical. (The difference is well under 0.1 arc second.)**

Text PCK Orientation Models - 3

- **Body-fixed frames provided in text PCKs have +Z axes consistent with planetocentric coordinate systems. The +X axes of these frames coincide with planetocentric longitude 0.**

- **For planets and satellites the +Z axis (+90 LAT) always points to the north side of the invariable plane – the plane whose normal vector is the angular momentum vector of the solar system.**
  - **Planetocentric longitude increases positively eastward**
  - **Planetocentric latitude increases positively northward**

- **Dwarf planets*, asteroids and comets spin in the right hand sense about their "positive pole."**
  - **What the IAU now calls the "positive pole" is still referred to as the "north pole" in SPICE documentation.**
  - **The "positive pole" may point above or below the invariable plane of the solar system (see above).**
  - **This revision by the IAU Working Group (2006) inverts what had been the direction of the north pole for Pluto, Charon and Ida.**

*The dwarf planets are: Ceres, Pluto, Haumea, Makemake, Eris

Binary PCK Orientation Models

- When available, the SPICE system can store high-accuracy orientation model data in binary PCKs.
- Binary PCKs are limited to storing orientation data.
  - Applications that require shape data must also load a text PCK.
- Orientation data from a binary PCK always supersede orientation data for the same object obtained from a text PCK, no matter the order in which the kernels are loaded.
- Binary PCKs for only the earth and the moon are available from NAIF.
  - The accuracy of these is much better than what is provided in the generic text PCK.

Location of Text PCK Reference Frame Specifications

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- **Many PCK reference frame specifications are built into SPICE. Examples are IAU_SATURN and IAU_TITAN.**
  - **To use these, load a text PCK file containing orientation data for the body of interest.**
    - » **Typically this is the current generic text PCK**
  - **Be very cautious about using IAU_EARTH and IAU_MOON; the binary PCKs for these two bodies offer much more accuracy**

- **Other PCK frames are not built-in and must be defined in a frames kernel that is loaded by your program. Examples are body fixed frames for asteroids or "newer" natural satellites.**
  - **See the Frames Required Reading technical reference for information on creating frame kernels that specify PCK reference frames.**

PCK Shape Models

- **PCK shape models are nominally triaxial ellipsoids**
  - **For many bodies, two of the axes (equatorial axes) have the same value; these bodies have a spheroidal shape.**
  - **For some bodies, one or more radii have not been determined.**
  - **See the DSK tutorial for information about other kinds of shape models available within SPICE.**

- **Although many bodies are in fact modeled as spheres or spheroids, SPICE usually deals with the general, triaxial case.**
  - **Exception: SPICE supports geodetic coordinate transformations only for bodies modeled as spheres or spheroids.**
    - » **RECGEO, GEOREC, DGEODR, DRDGEO and XFMSTA are the modules performing these transformations.**
  - **Exception: SPICE supports planetographic coordinate transformations only for bodies modeled as spheres or spheroids.**
    - » **PGRREC, RECPGR, DPGRDR, DRDPGR and XFMSTA are the modules supporting these transformations.**