IDL Interface to CSPICE "Icy"

How to Access the CSPICE library from the Interactive Data Language (IDL)©

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Topics

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Icy Benefits

- Ease of use: Icy operates as an extension to the IDL language regime.
- Icy supports more than four-hundred CSPICE routines.
- Icy calls usually correspond to the call format of the underlying CSPICE routine, returning IDL native data types.
- Icy has some capability not available in CSPICE such as vectorization.
- CSPICE error messages return to IDL in a form usable by the *catch* error handler construct.

How Does It Work? (1)

Navigation and Ancillary Information Facility

- **The IDL environment includes an intrinsic capability to use external routines.**
  - Icy functions as an IDL Dynamically Loadable Module (DLM). A DLM consists of a shared object library (icy.so/.dll) and a DLM text definition file (icy.dlm).
    - » The shared library contains a set of IDL callable C interface routines that wrap a subset of CSPICE wrapper calls.
    - » The text definition file lists the routines within the shared library and the format for the routine's call parameters.

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How Does It Work? (2)

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- **Using Icy from IDL requires you register the Icy DLM with IDL to access the interface routines. Several means exist to do so.**
  - **On Unix/Linux, start IDL from the directory containing icy.dlm and icy.so**
  - **From the IDL interpreter (or from a command script), execute the dlm_register command:** IDL> dlm_register,'*_path_to_directory_containing_icy.dlm_*'
    - » **Examples (Unix and Windows):**
      - » `IDL> dlm_register, '/naif/icy/lib/icy.dlm'`
      - » `IDL> dlm_register, 'c:\naif\icy\lib\icy.dlm'`
  - **Copy icy.dlm and icy.so or icy.dll to IDL's binary directory:**

    {The IDL install directory}/bin/bin.*user_architecture*
    - » **Examples (Unix and Windows):**
      - » `cp icy.dlm icy.so   /Applications/exelis/idl/bin/bin.darwin.x86_64/`
      - » `cp icy.dlm icy.dll  C:\Program Files\Exelis\idl83\bin\bin.x86_64\`
  - **Append to the IDL_DLM_PATH environment variable the directory name containing icy.dlm and icy.so or icy.dll:**

```
setenv IDL_DLM_PATH "<IDL_DEFAULT>:_path_to_directory_containing_icy.dlm_"
```

Caveat: with regards to the Icy source directory, *icy/src/icy*, do not invoke IDL from the directory, do not register the directory, and do not append IDL_DLM_PATH to the directory. This directory contains an "icy.dlm" but no "icy.so."

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How Does It Work? (3)

When a user invokes a call to a DLM routine:

1. **IDL calls…**
   2. **the interface routine in the shared object library, linked against…**
      3. **CSPICE, which performs its function and returns the result…**
      4. **to IDL…**

… transparent from the user's perspective.

Icy Distribution

- NAIF distributes the Icy package as an independent product analogous to SPICELIB and CSPICE.
- The package includes:
  - the CSPICE source files
  - the Icy interface source code
  - platform specific build scripts for Icy and CSPICE
  - IDL versions of the SPICE cookbook programs, *states*, *tictoc*, *subpt*, and *simple*
  - an HTML based help system for both Icy and CSPICE, with the Icy help cross-linked to CSPICE
  - the Icy shared library and DLM file. The system is ready for use after installation of these files
- Note: You do not need a C compiler to use Icy.

Icy Operation (1)

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- A user may occasionally encounter an IDL math exception:

```
% Program caused arithmetic error: Floating underflow
```

  – This warning occurs most often as a consequence of CSPICE math operations.

- In all known cases, the SIGFPE exceptions caused by CSPICE can be ignored. CSPICE assumes numeric underflow as zero.
  – A user can adjust IDL's response to math exceptions by setting the `!EXCEPT` variable:
    » `!EXCEPT = 0` suppresses the SIGFPE messages, and even more (e.g. a fatal error).
    » `!EXCEPT = 1`, the default, reports math exceptions on return to the interactive prompt.
      - NAIF recommends this be used.
    » `!EXCEPT = 2` reports exceptions immediately after executing the command.

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Icy Operation (2)

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- A possible irritant exists in loading kernels using the `cspice_furnsh` function.
  - Kernels are loaded into your IDL session, not into your IDL scripts. This means:
    - » loaded <u>binary</u> kernels remain accessible ("active") throughout your IDL session
    - » data from loaded <u>text</u> kernels remain in the kernel pool (in the IDL memory space) throughout your IDL session
  - Consequence: some kernel data may be available to one of your scripts even though not intended to be so.
    - » You could get incorrect results!
    - » If you run only one script during your IDL session, there's no problem.

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Icy Operation (3)

- Mitigation: two approaches
  - Load all needed SPICE kernels for your IDL <u>session</u> at the beginning of the session, paying careful attention to the files loaded and the loading order (loading order affects precedence)
    - » Convince yourself that this approach will provide ALL of the scripts you will run during this IDL session with the appropriate SPICE data
  - At or near the end of every IDL <u>script</u>:
    - » include a call to `cspice_unload` for each kernel loaded using `cspice_furnsh`
    - » or include a call to `cspice_kclear` to remove <u>ALL</u> kernel data from the kernel pool loaded using `cspice_furnsh`

Icy Vectorization (1)

- Several common Icy functions include use of vectorized arguments, a capability not available in C or FORTRAN toolkits.
  - Note: IDL indexes arrays using a base value of zero as opposed to FORTRAN, which uses a base value of one.
    - Example: access the first element of an IDL 1xN array using array[0], the second element using array[1], etc.
- Example: use Icy to retrieve state vectors and light-time values for 1000 ephemeris times.
  - Create an array of 1000 ephemeris times with step size of 10 hours, starting from July 1, 2005.

```
cspice_str2et, 'July 1, 2005', start
et = dindgen( 1000 )*36000.d + start
```

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Icy Vectorization (2)

- **Retrieve the state vectors and corresponding light times from Mars to earth at each `et`, in the J2000 frame, using LT+S aberration correction:**

```
cspice_spkezr, 'Earth', et, 'J2000', 'LT+S', 'MARS', state, ltime
```

- **Access the *ith* state 6-vector corresponding to the *ith* ephemeris time with the expression**

```
state_i = state[*,i]
```

• **Convert the ephemeris time vector `et` from the previous example to UTC calendar strings with three decimal places accuracy.**

```
format = 'C'
prec   = 3
cspice_et2utc, et, format, prec, utcstr
```

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Icy Vectorization (3)

Navigation and Ancillary Information Facility

- – **The call returns `utcstr`, an array of 1000 strings each *ith* string the calendar date corresponding to `et[i]`. Access the *ith* string of utcstr corresponding to the *ith* ephemeris time with the expression**

```
utcstr_i = utcstr[i]
```

- **Convert the position components of the N state vectors to latitudinal coordinates (the first three components of a state vector - IDL uses a zero based vector index).**

```
cspice_reclat, state[0:2,*], radius, latitude, longitude
```

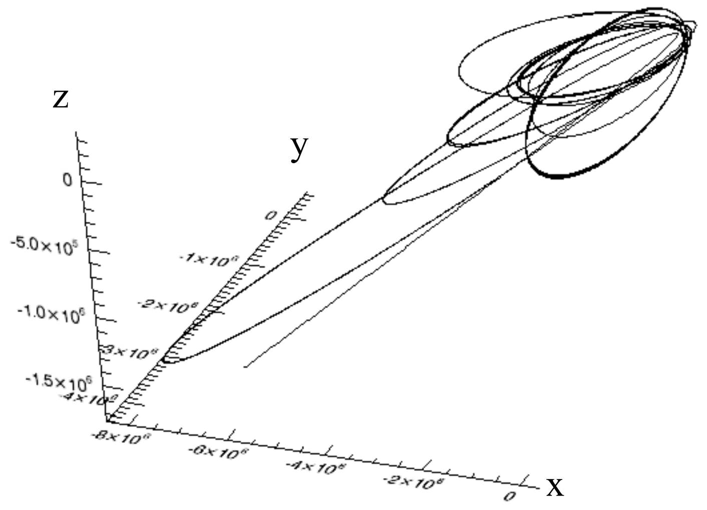
- – **The call returns three double precision variables of type Array[1000] (vectorized scalars): `radius, latitude, longitude`.**

Simple Icy Example

- **As an example of using Icy with vectorization, calculate and plot, in the J2000 inertial frame, the trajectory of the Cassini spacecraft from June 20 2004 to December 1 2005.**

```
;; Construct a meta kernel, "standard.tm”, which will be used to load the needed
;; generic kernels:  "naif0011.tls," "de421.bsp,” and "pck00010.tpc.”

;; Load the generic kernels using the meta kernel, and a Cassini spk.

cspice_furnsh, ['standard.tm’, ‘/kernels/cassini/spk/030201AP_SK_SM546_T45.bsp’ ]

;; Define the number of divisions of the time interval and the time interval.
STEP = 10000
cspice_str2et, [ 'Jun 20, 2004', 'Dec 1, 2005' ] , et
times = dindgen(STEP)*(et[1]-et[0])/STEP + et[0]

cspice_spkpos, 'Cassini', times, 'J2000', 'NONE', 'SATURN BARYCENTER', pos, ltime

;; Plot the resulting trajectory.
x = pos[0,*]
y = pos[1,*]
z = pos[2,*]
iplot, x, y, z

cspice_kclear
```

Icy Example Graphic Output



Trajectory of the Cassini spacecraft, in the J2000 frame, from June 20 2004 to Dec 1 2005