sbpy

An Astropy Affiliated Package for Small-Body Planetary Astronomy

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What is this workshop about?

- sbpy!
  - What is it, how can it help you, how can you use it?
  - sbpy is for you: what would you like to see?

- This workshop is not:
  - An introduction to Python programming
  - An attempt to convert you into a Python programmer

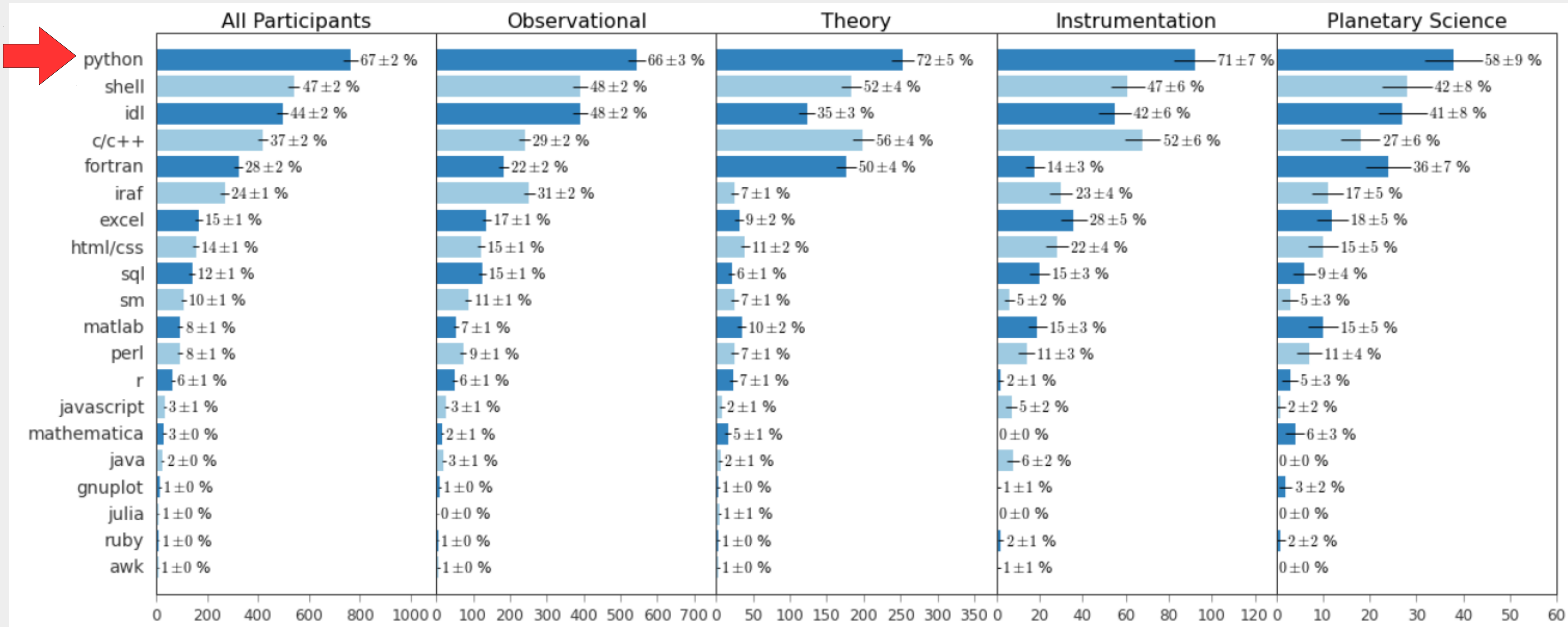
What is sbpy?

- A Python package for **s**mall-**b**ody planetary astronomy (asteroid and comet observers/researchers)
- A collection of basic functions and methods
- Compatible with astropy, numpy, scipy methods
- Tested against published results
- Well-documented (sbpy.readthedocs.io)
- Funded through NASA PDART

Motivation

- Imagine… you need some code to solve a problem…
  - Write the code from scratch (time intensive)
  - Use somebody's code (is it reliable?)
  - Re-write somebody's FORTRAN code (ewww…)
  - Use a well-tested and documented existing code
- Astropy (astropy.org)
- Provide especially young researchers with a code base to kick-start their research

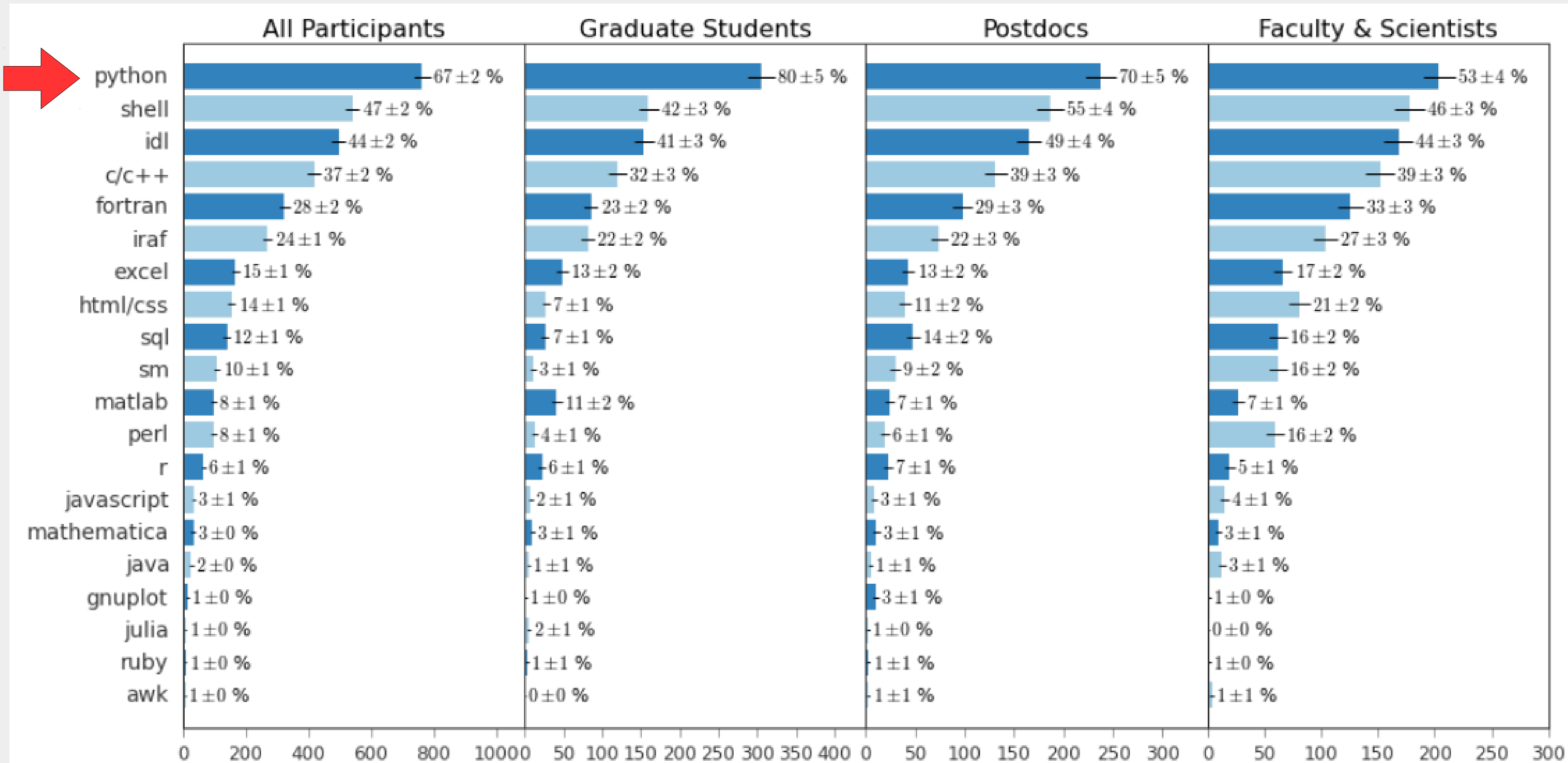
Why Python?



"Which of these programming languages do you frequently use in your research?"

Momcheva and Tollerud (2015)

Why Python?



"Which of these programming languages do you frequently use in your research?"

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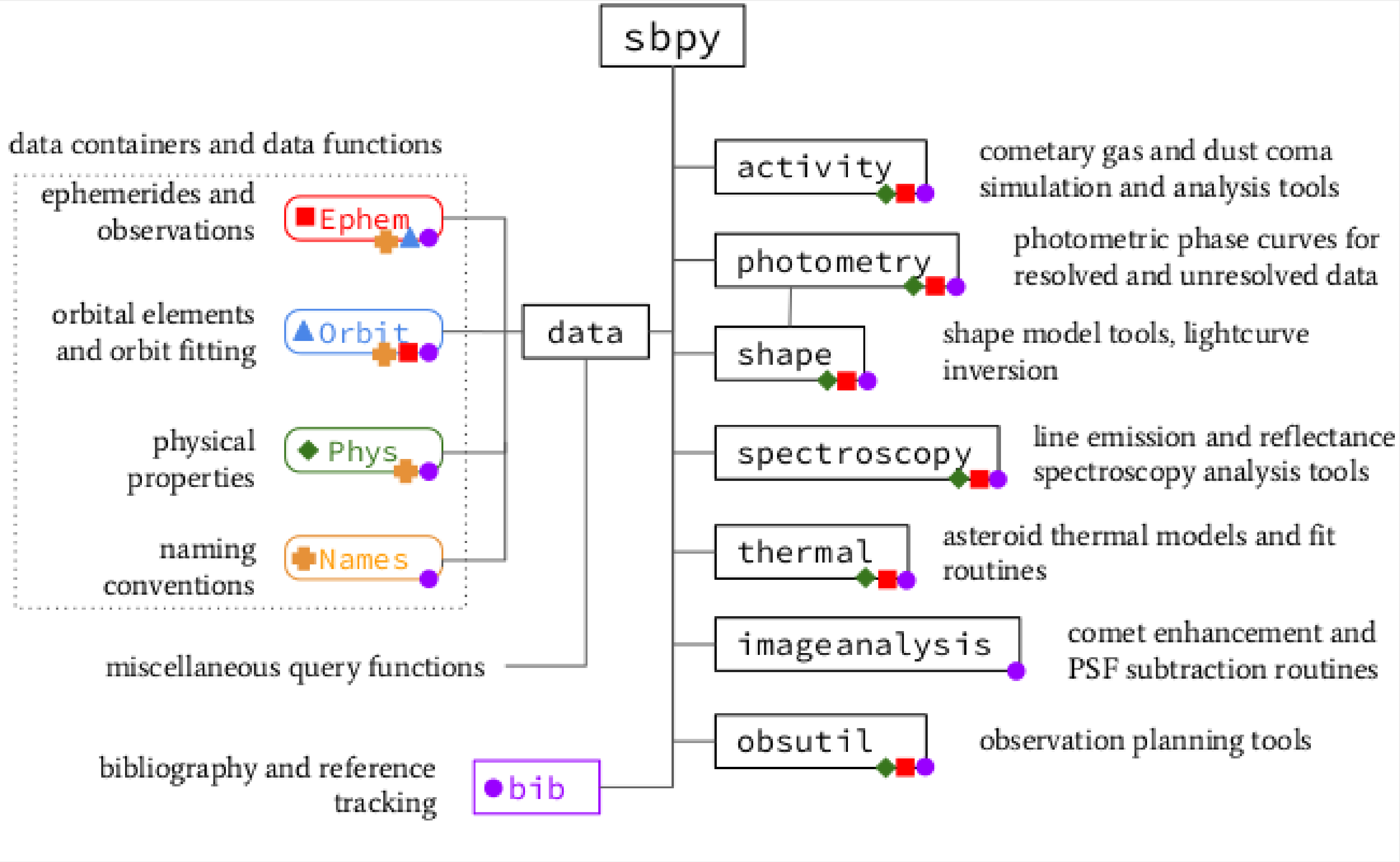
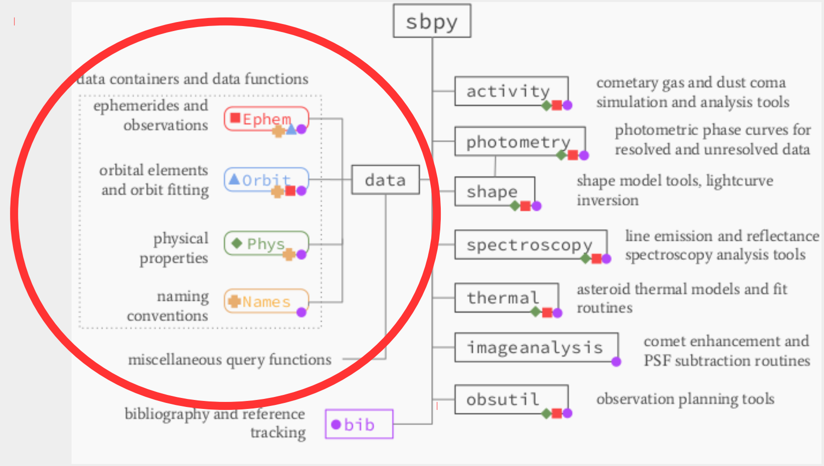
sbpy – Inventory

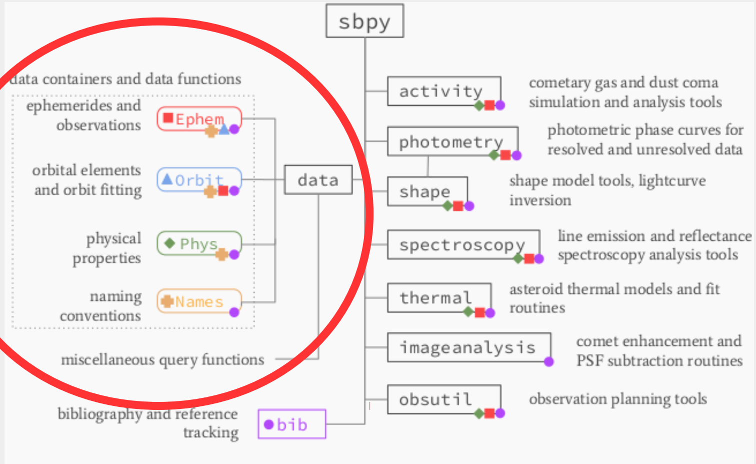




sbpy.data

- A collection of data containers:
  - **Orbit**: orbital elements notebook
  - **Ephem**: ephemerides and observational data notebook
  - **Phys**: physical properties notebook
  - **Names**: asteroid and comet name/number/designation notebook
- Common functionality (use the same base class) utilizing astropy.table
- Data input/output of all sbpy functions uses sbpy.data
- Aimed at convenience and flexibility

sbpy.data - Examples



notebook

- Different ways to generate data objects:
  - from a list or array:

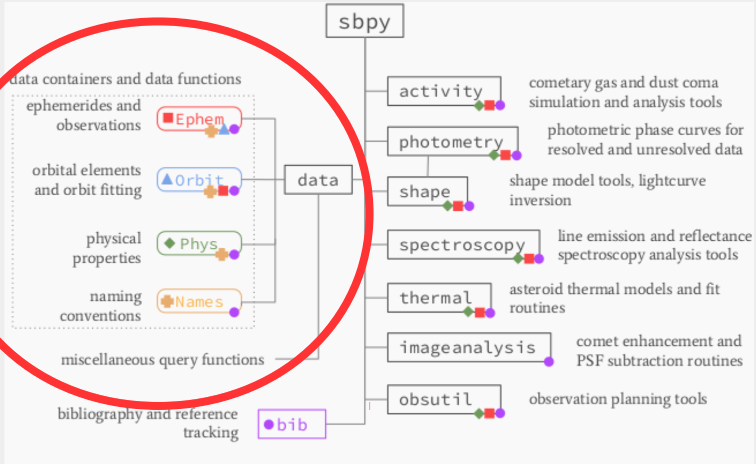
```
>>> eph = Ephem.from_array([[10.2234, 10.233453]*u.deg,
...                          [-12.42123, -12.42562]*u.deg,
...                          [2451234.1234,2451234.2345]*u.d],
...                         names=['ra', 'dec', 't'])
```

  - from a dictionary:

```
>>> ceres = Phys.from_dict({'d':986*u.km, 'pv':0.09})
```

  - from an online resource:

```
>>> eph = Ephem.from_horizons('ceres')
```

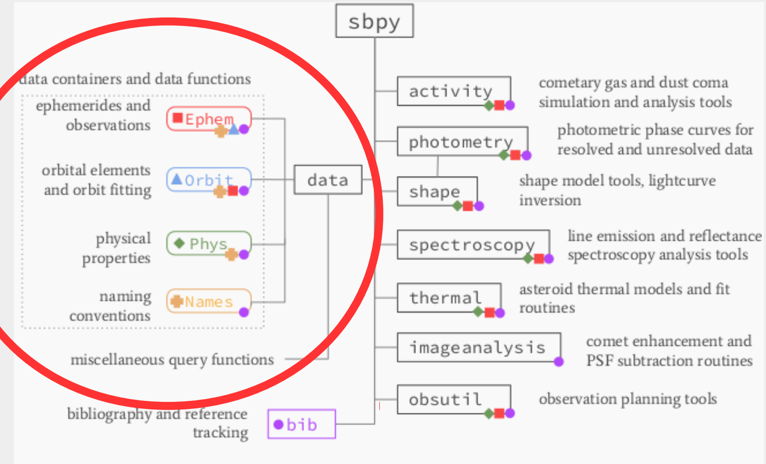


sbpy.data - Examples

- Using sbpy.data objects:

```
>>> eph.column_names
<TableColumns names=('targetname','RA','DEC', … )>

>>> eph['ra', 'dec']
<QTable length=10>
    RA       DEC
   deg       deg
--------- --------
139.60684 26.72378
140.20138 26.46513
 142.0532 25.66408
    ...      ...

>>> eph['RA_rate'].to('arcsec/s')
<Quantity [0.01218538, 0.01244878, ...] arcsec / s>
```

sbpy.data

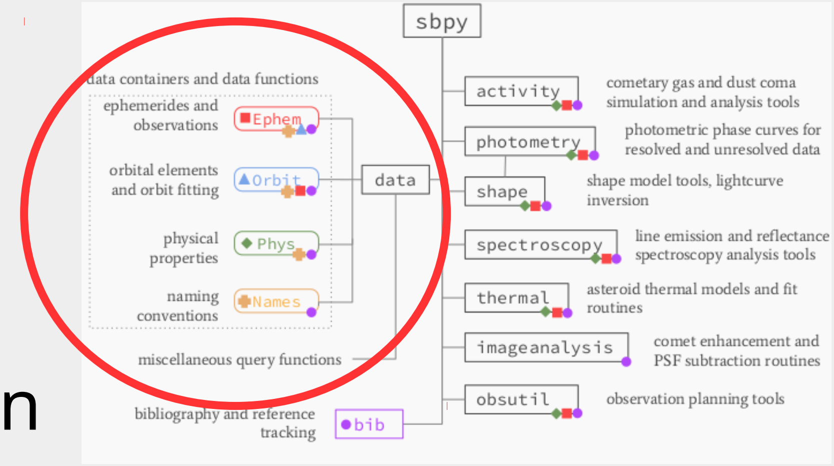


- Home to query functions:
  - JPL Horizons: ephemerides, orbital elements, and state vectors (using astroquery.jplhorizons)

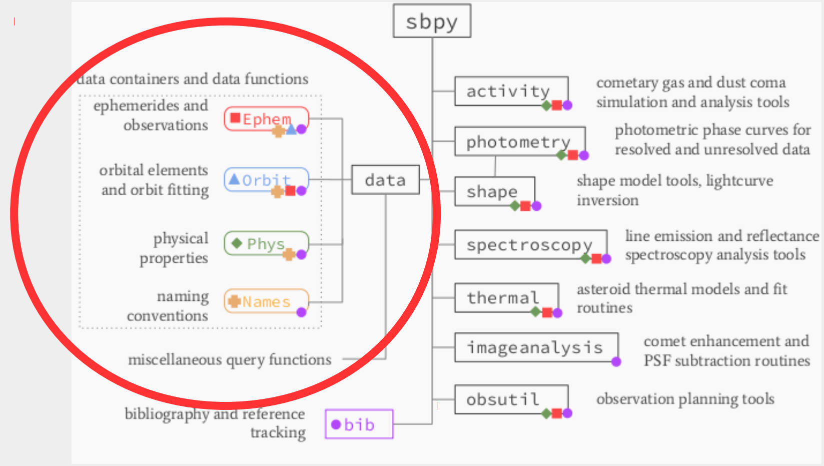
    `Ephem.from_horizons('ceres')`

    notebook
  - JPL SBDB: physical properties (using astroquery.jplsbdb)
  - Minor Planet Center (orbits, ephemerides, observations, using astroquery.mpc)
- Future query functions (mostly as part of astroquery):
  - IMCCE (orbits, ephemerides)
  - Lowell Observatory (ephemerides, physical properties)

sbpy.data



- Interoperability with other Python modules:
  - **Pyoorb**: a Python interface to OpenOrb   notebook
    - implemented: element transformations, orbit propagation, ephemeris computation
    - Future functions: ranging, orbit fitting
  - **PyEphem** (tbd): ephemeris calculation
  - **Rebound** (tbd): n-body simulation
  - **SpiceyPy** (tbd): SPICE interface



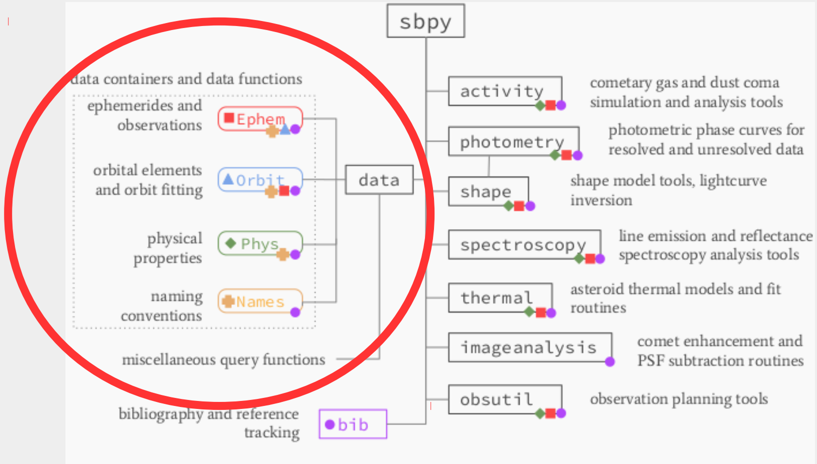
sbpy.data

- Name resolving functionality

```
>>> from sbpy.data import Names

>>> Names.parse_asteroid('3552 Don Quixote (1983 SA)')
{'number': 3552, 'name': 'Don Quixote', 'desig': '1983 SA'}

>>> Names.parse_comet('72P/Denning-Fujikawa')
{'type': 'P', 'number': 72, 'name': 'Denning-Fujikawa'}

>>> Names.asteroid_or_comet('72P/Denning-Fujikawa')
'comet'
```

notebook

sbpy.data



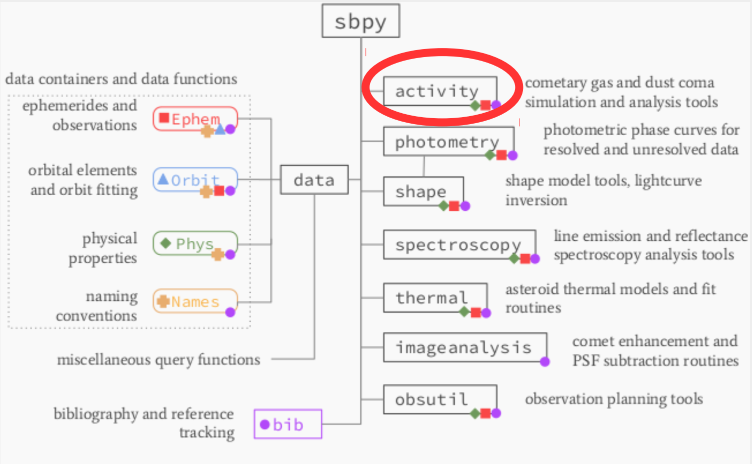
- Field name translation

```
>>> from sbpy.data import Phys
>>> import astropy.units as u

>>> data = Phys.from_dict({‘d’: 10*u.km})
>>> data[‘d’]
<Quantity [10.] km>

>>> data[‘diameter’]
<Quantity [10.] km>
```

- Field conversion

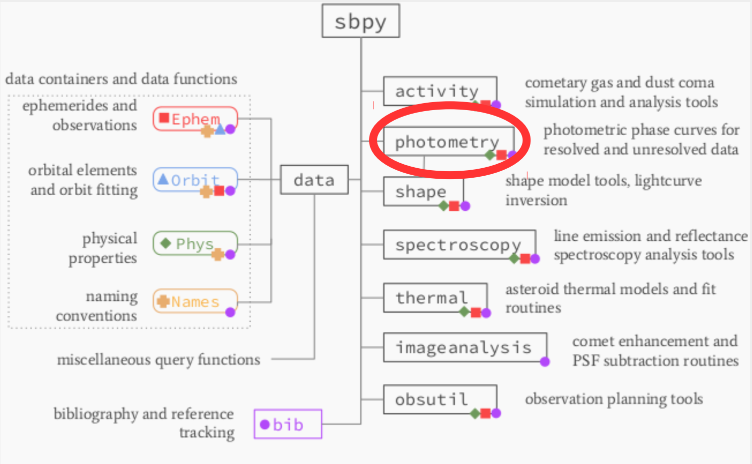
```
>>> data[‘radius’]
<Quantity [5.] km>
```

sbpy.activity



- Modeling of cometary comae:
  - Dust activity: Afρ (basic functionality implemented) notebook
  - Gas activity:
    - Haser Model (basic functionality implemented) notebook
    - Vectorial Model (tbd)
    - Syndyne/Synchrone Model (tbd)
    - Ice sublimation Model (tbd)

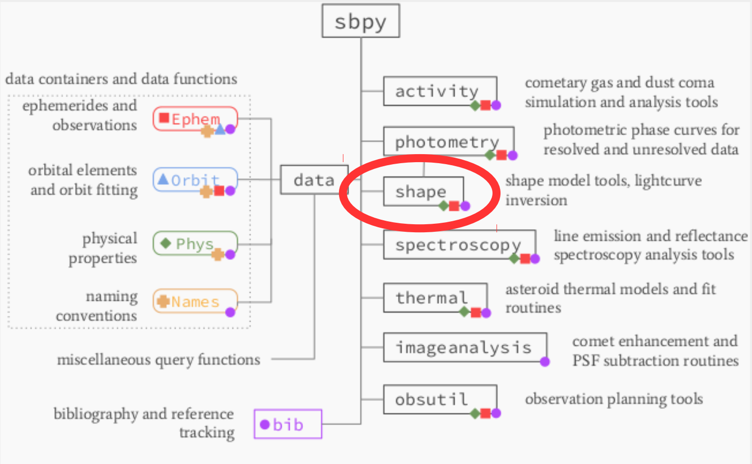
sbpy.photometry



- Implementation of different light-scattering models:
  - HG asteroid phase curve model (basic)
  - HG1G2 asteroid phase curve model (basic)
  - HG12 asteroid phase curve model (basic)
  - Linear phase curve model (basic)
  - Lunar, Lommel-Seeliger, Lunar Lambert, ROLO (basic)
  - Hapke (5-parameter version, spectral mixing, tbd)

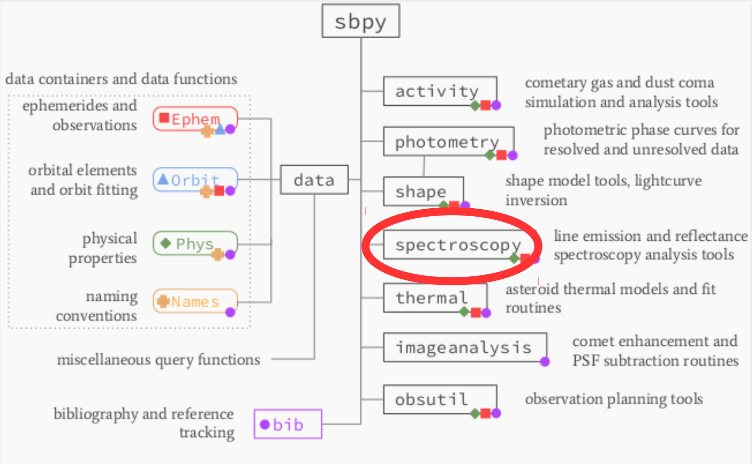
notebook

sbpy.shape

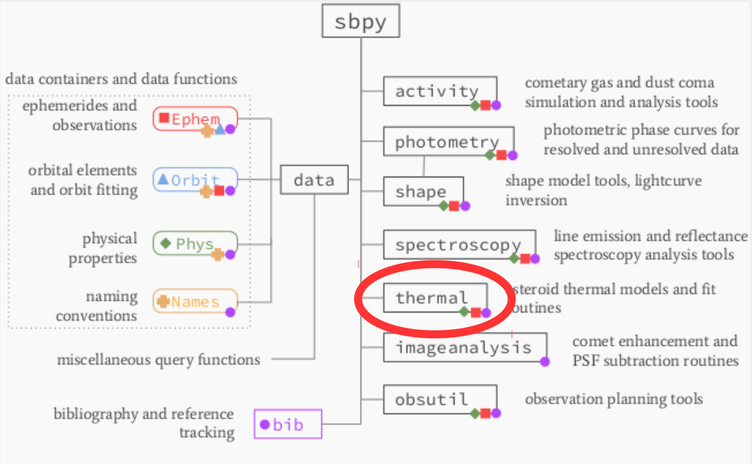


- Lightcurve fitting tools (tbd)
- Kaasalainen shape modeling tools (Ďurech code, tbd)
- Lightcurve modeling based on shape models (tbd)

sbpy.spectroscopy



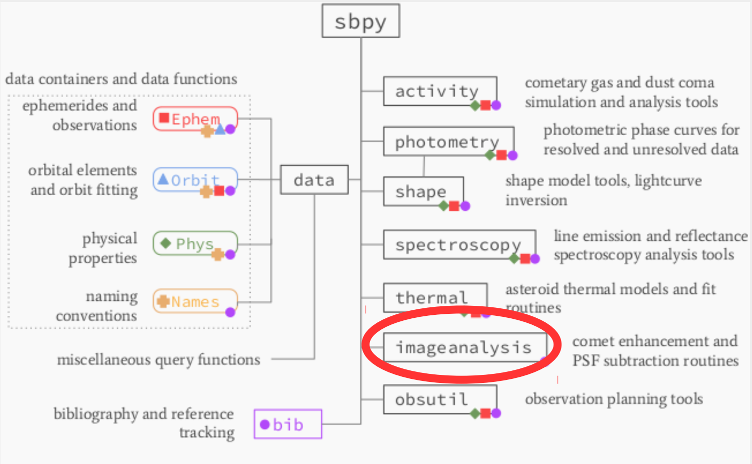
- Tools for querying spectral libraries (e.g., JPL using astroquery.jplspec) notebook
- Tools for fitting emission line and reflectance spectra (tbd)
- LTE and non-LTE radiative transfer models (tbd)
- Determination of production rates and excitation parameters (tbd)
- Spectrophotometry and spectrum convolution (tbd)



sbpy.thermal

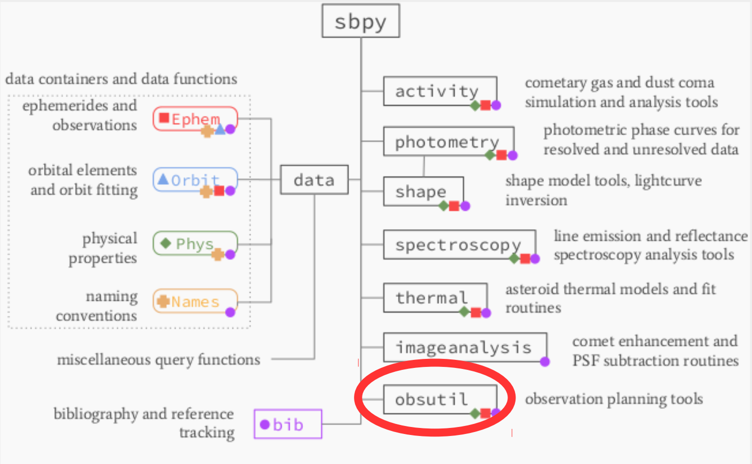
- Thermal modeling capabilities for estimating fluxes and fitting thermal-infrared observations: (tbd)
  - Standard Thermal Model
  - Fast-Rotating Model
  - Near-Earth Asteroid Thermal Model

sbpy.imageanalysis



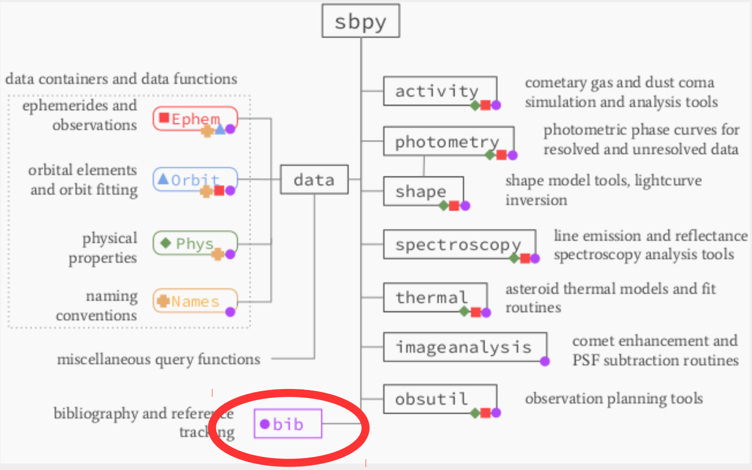
- Cometary coma image enhancement methods (tbd)
- PSF-subtraction tools (tbd)

sbpy.obsutil



- Tools for the planning of asteroid and comet observations (tbd)
  - Identify peak observability
  - Create observing scripts
  - Create finder charts

sbpy.bib



- Reference tracking throughout sbpy (basic implementation)

```
>>> from sbpy.data import Ephem
>>> from sbpy import bib

>>> with bib.Tracking():
...     eph = Ephem.from_horizons('Ceres')

>>> print(bib.to_text())
sbpy.data.Ephem.from_horizons:
  data service: Giorgini, Yeomans, Chamberlin et al. 1996,
AAS/Division for Planetary Sciences Meeting Abstracts #28,
25.04
```

- Will generate references for publications
  - clear text, BibTeX, AASTeX, Icarus, MNRAS...

sbpy – Current Status

- **sbpy.data**: mostly functional, more query functions to be implemented in the future
- **sbpy.spectroscopy**: some functionality implemented
- **sbpy.activity**: some functionality implemented
- **sbpy.photometry**: some phase function models implemented
- All other modules currently only skeletons

Full functionality will be established by Summer 2021.

sbpy – How can I help?

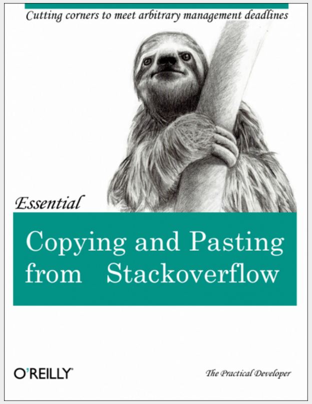
- Give us your feedback!
- Bugs? Create issues!
- What would you like to see/have in the future?
- Do you have code that might be useful to others? Consider donating it!
- Spread the word!
- Use it!

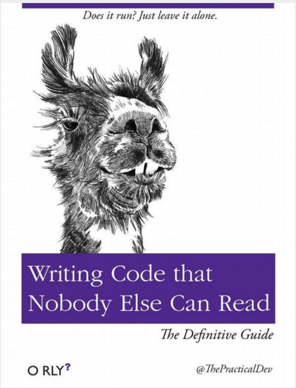
Resources

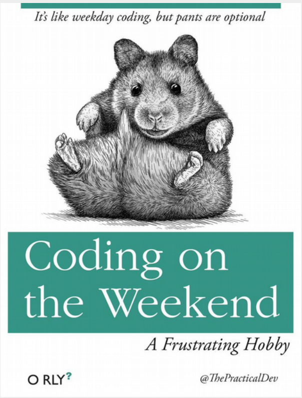
sbpy.org   github.com/NASA-Planetary-Science/sbpy

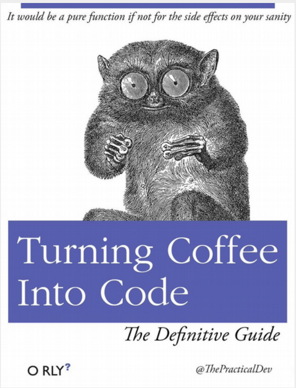
sbpy.readthedocs.io

github.com/NASA-Planetary-Science/sbpy-tutorial









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