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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

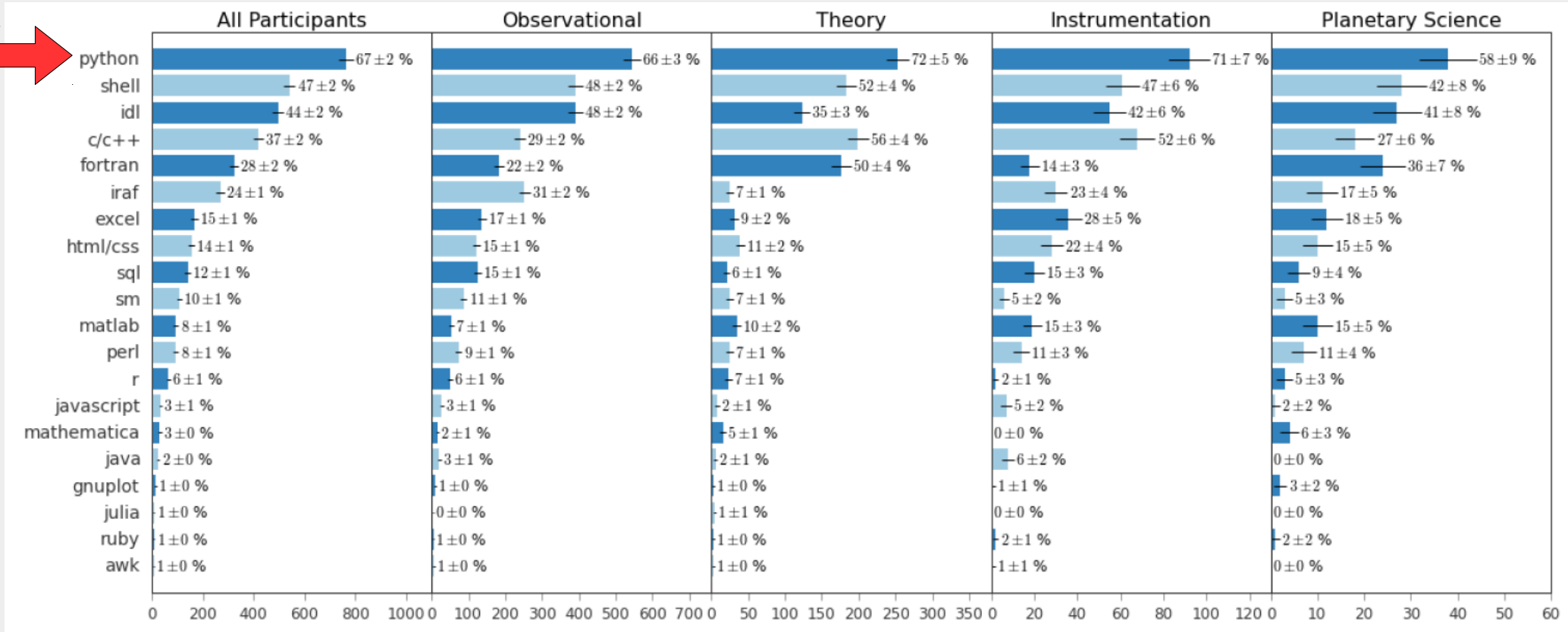
sbpy.org

Motivation

- Imagine... you need some code to solve a problem...
 - Write the code from scratch (time intensive)
 - Use somebody else's code (is it reliable?)
 - Re-write somebody else'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



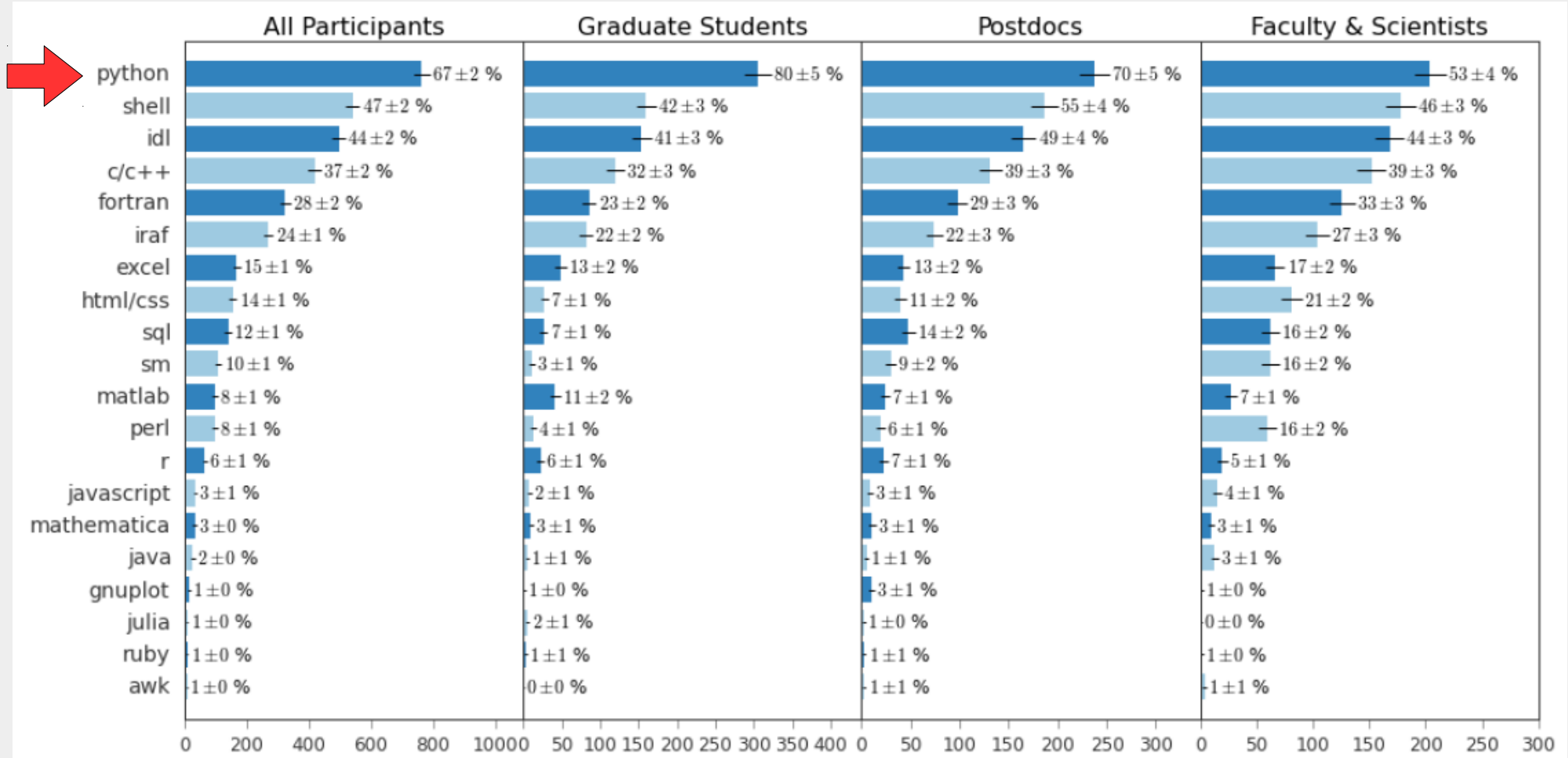
Why Python?



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

Momcheva and Tollerud (2015)

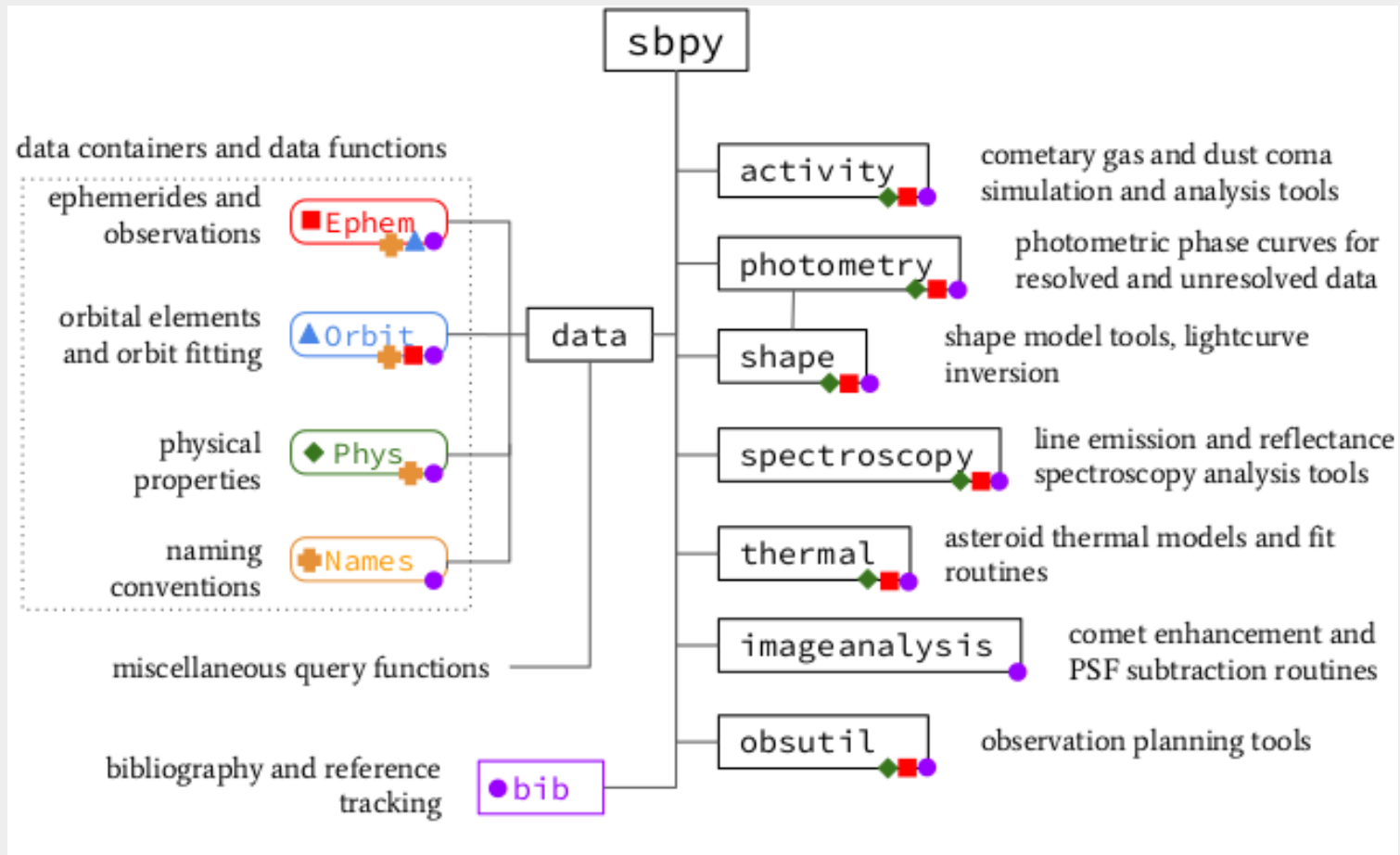
Why Python?



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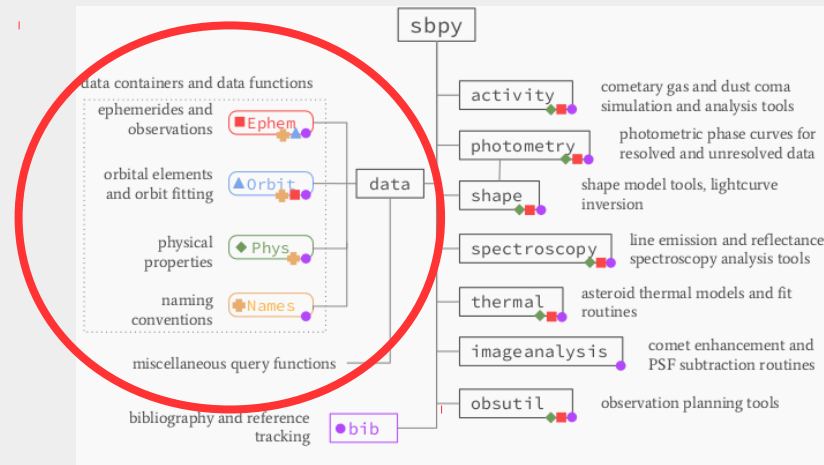
Momcheva and Tollerud (2015)

sbpy – Inventory



sbpy.data

- A collection of data containers:
 - **Orbit**: orbital elements [notebook](#)
 - **Ephem**: ephemerides and observational data [notebook](#)
 - **Phys**: physical properties
 - **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

- Different ways to generate data objects:

- from a list or array:

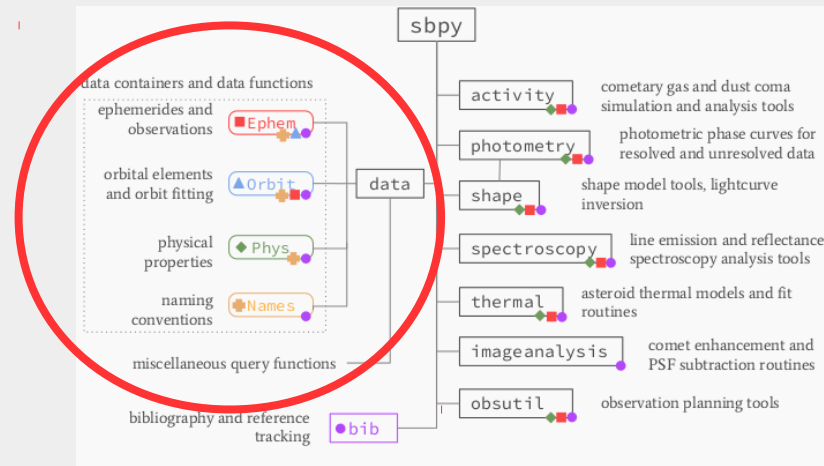
```
>>> eph = Ephem.from_array([[10.2234, 10.233453]*u.deg,  
...                          [-12.42123, -12.42562]*u.deg,  
...                          [2451234.1234, 2451234.2345]*u.d],  
...                          names=['ra', 'dec', 't'])
```

- from a dictionary:

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

- from an online resource:

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



notebook

sbpy.data - Examples

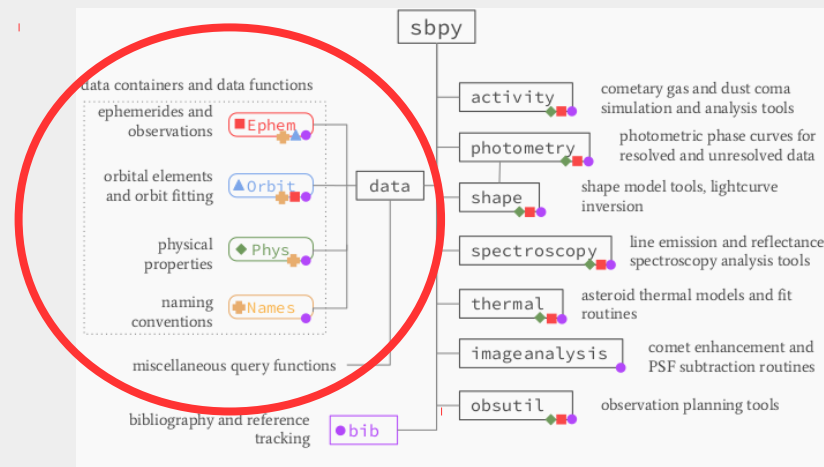
- Using sbpy.data objects:

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

```
>>> eph['ra', 'dec']  
<QTable length=10>
```

RA deg	DEC 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`)

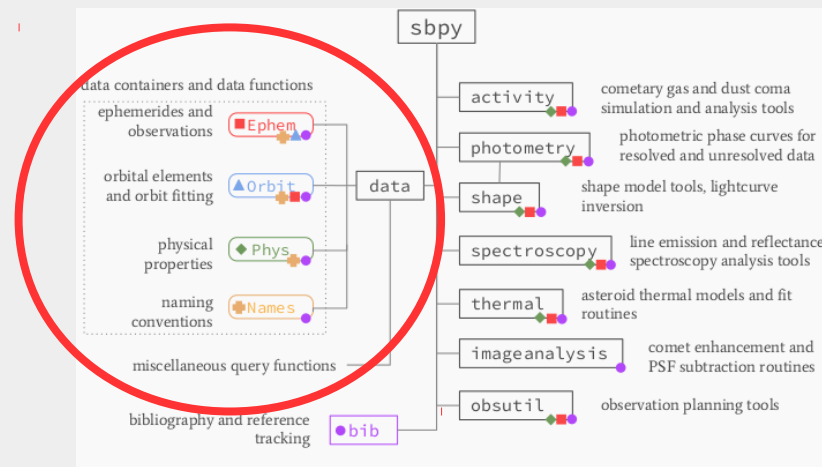
```
Ephem.from_horizons('ceres')
```

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):

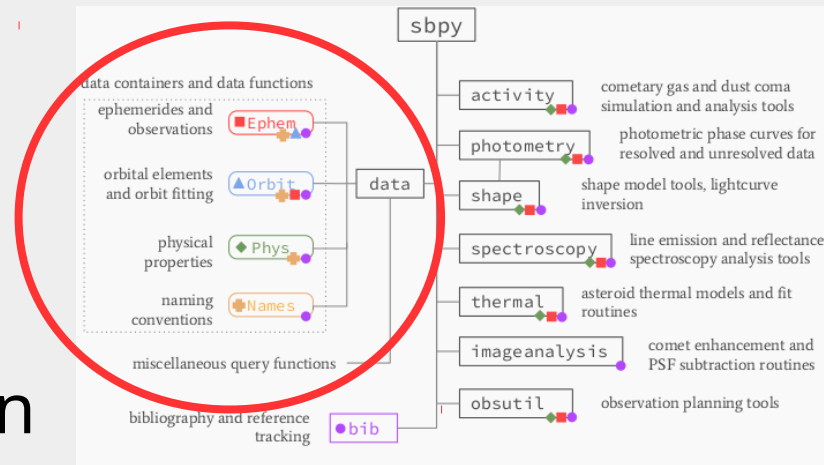
- IMCCE (orbits, ephemerides)
- Lowell Observatory (ephemerides, physical properties)



sbpy.data

- Interoperability with other Python modules:

- **Pyoorb**: a Python interface to OpenOrb
 - 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

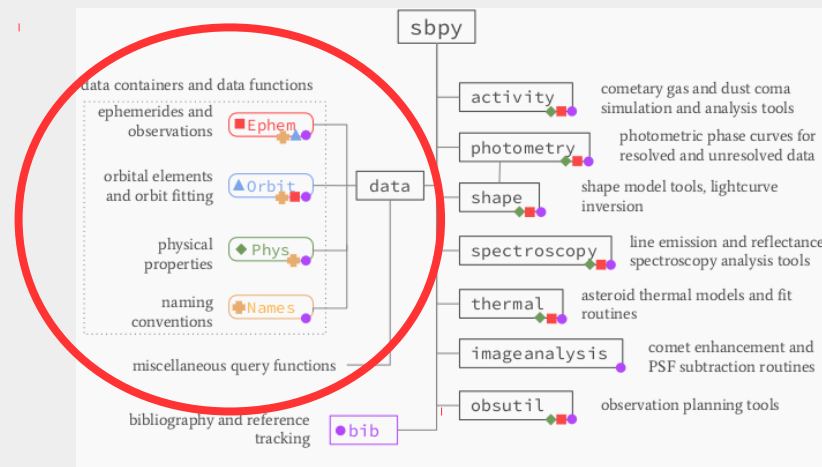
- Name resolving functionality

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

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

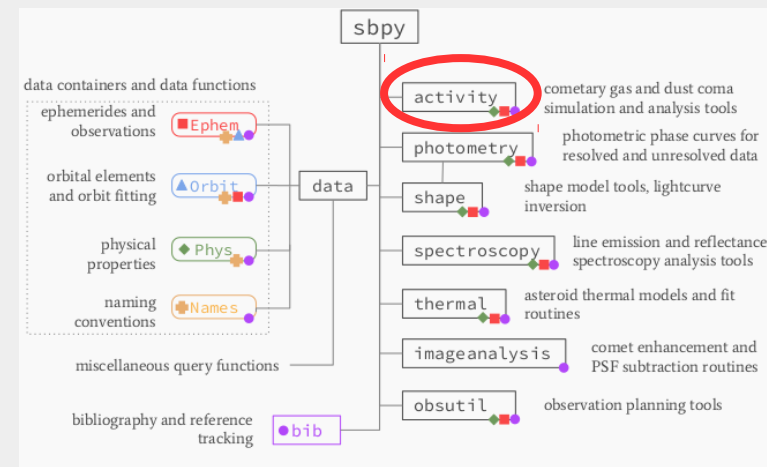
```
>>> Names.parse_comet('72P/Denning-Fujikawa')
{'type': 'P', 'number': 72, 'name': 'Denning-Fujikawa'}
```

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



notebook

sbpy.activity



- Modeling of cometary comae:

- Dust activity: Afp (basic functionality implemented)

[notebook](#)

- Gas activity:

- Haser Model (basic functionality implemented)

[notebook](#)

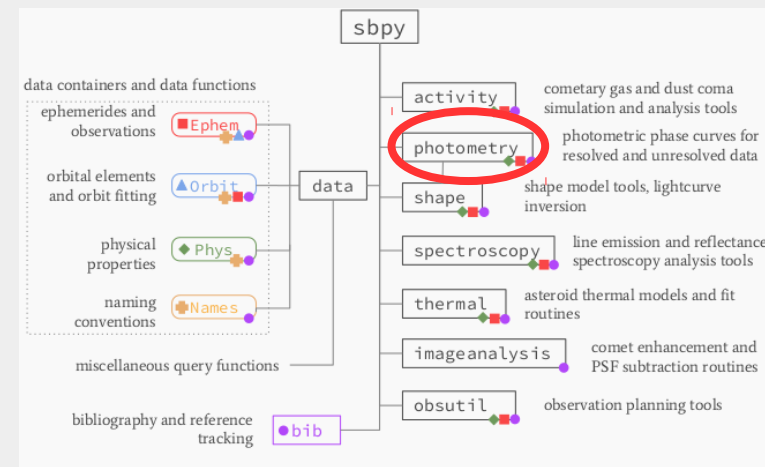
- Vectorial Model (tbd)

- Syndyne/Synchrone Model (tbd)

- Ice sublimation Model (tbd)

sbpy.photometry

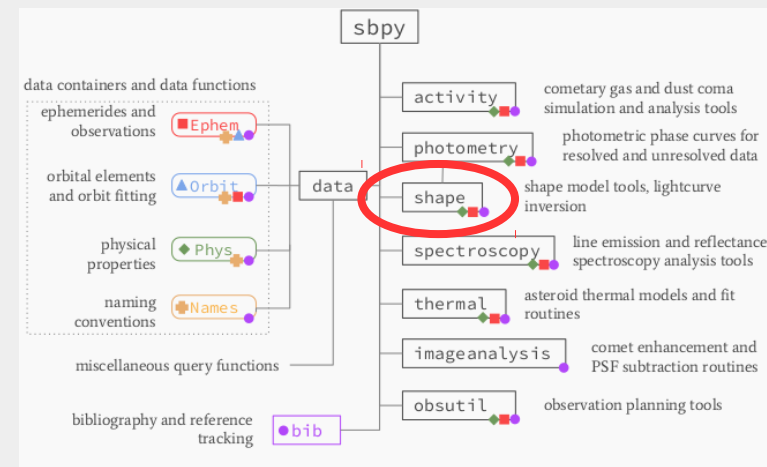
- Implementation of different light-scattering models:
 - HG asteroid phase curve model (basic)
 - HG1G2 asteroid phase curve model (basic)
 - HG12 asteroid phase curve model (basic)
 - Linear phase curve model (basic)
 - Lunar, Lommel-Seeliger, Lunar Lambert, ROLO (basic)
 - Hapke (5-parameter version,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



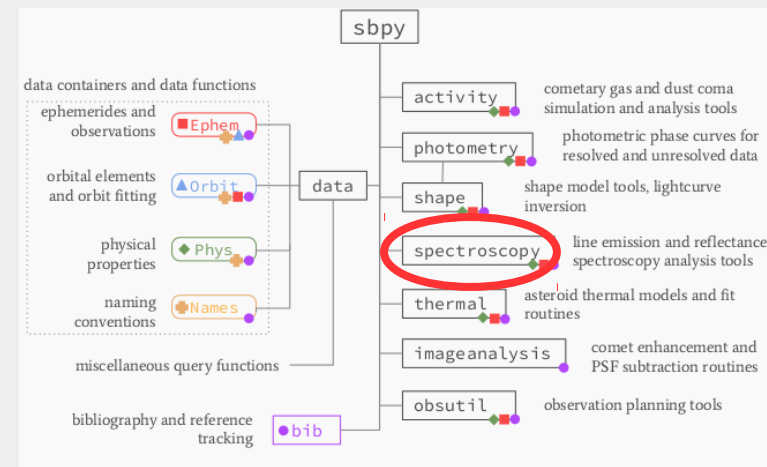
notebook

sbpy.shape

- Lightcurve fitting tools (tbd)
- Kaasalainen shape modeling tools ([Durech code](#), tbd)
- Lightcurve modeling based on shape models (tbd)



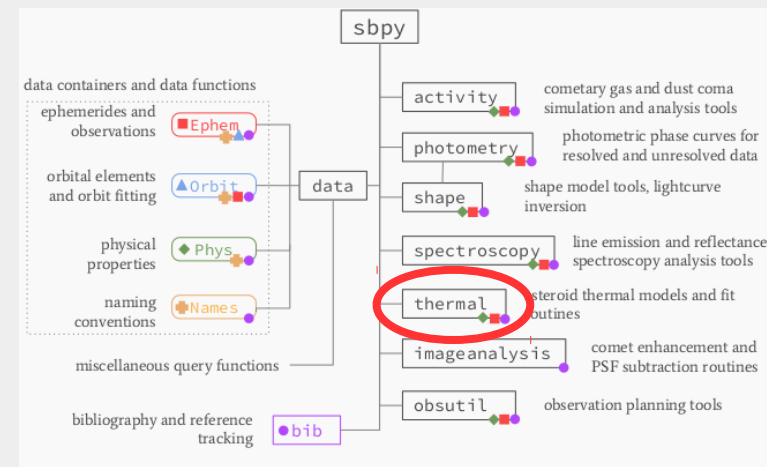
sbpy.spectroscopy



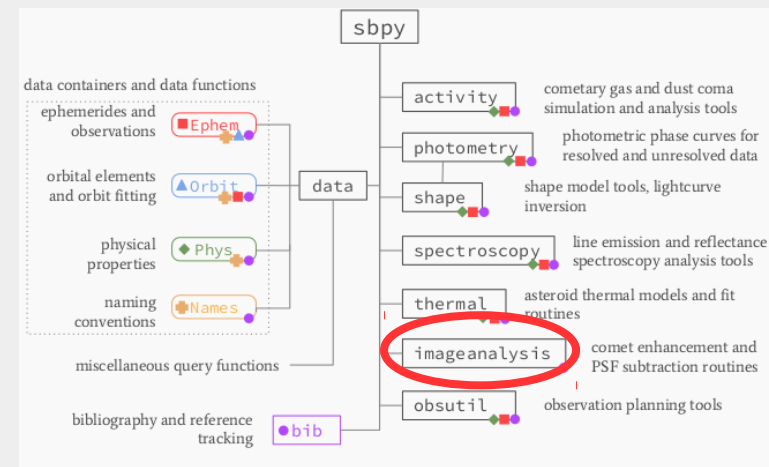
- Tools for querying spectral libraries (e.g., JPL using `astroquery.jplspec`) [notebook](#)
- Tools for fitting emission line and reflectance spectra (tbd)
- LTE and non-LTE radiative transfer models (tbd)
- Determination of production rates and excitation parameters (tbd)
- Spectrophotometry and spectrum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

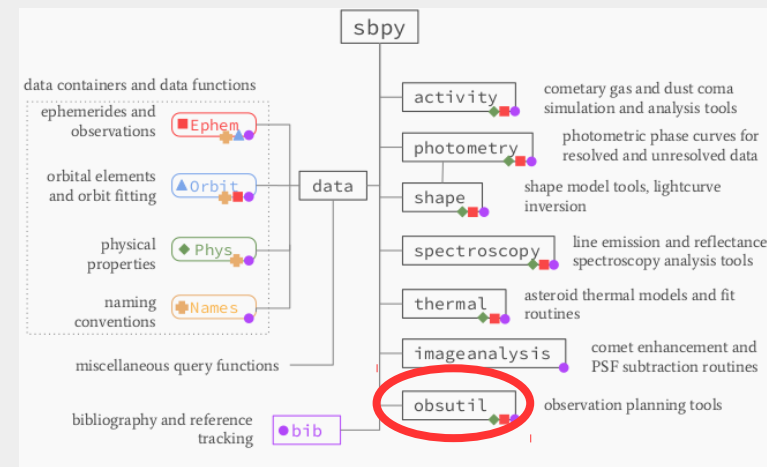


sbpy.imageanalysis



- 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

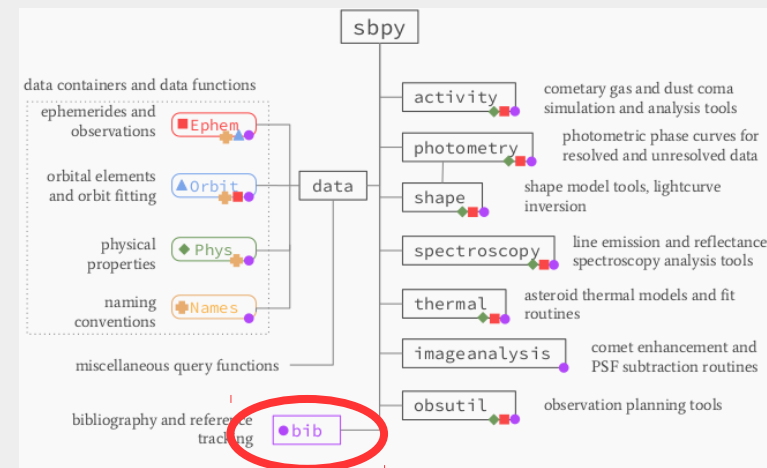
- Reference tracking throughout sbpy (basic implementation)

```
>>> 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?

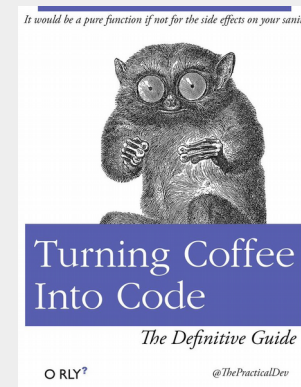
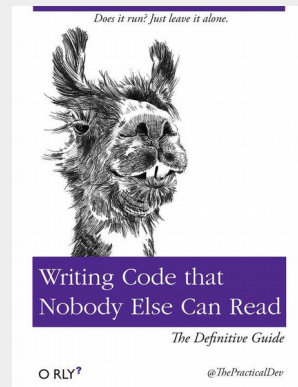
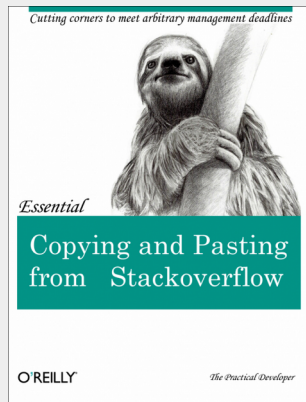
- Give us your **feedback**!
- Bugs? Create **issues**!
- What would you like to see/have in the future?
- Do you have code that might be useful to others?
Consider donating it!
- Spread the word!
- Use it!

Resources

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

sbpy.readthedocs.io

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



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