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sbpy Overview
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Why Python?

Ubiquitous programming language with a rich standard library.

> *Readability counts.*
>
> - Zen of Python

In 2017, when `sbpy` was proposed, Python had already taken flight within the astronomical community.

> `astropy` v0.1 released June 2012 and v2.0 July 2017

Why Python?

A great default for astro students and early career researchers.

→ See "Ubiquitous programming language."

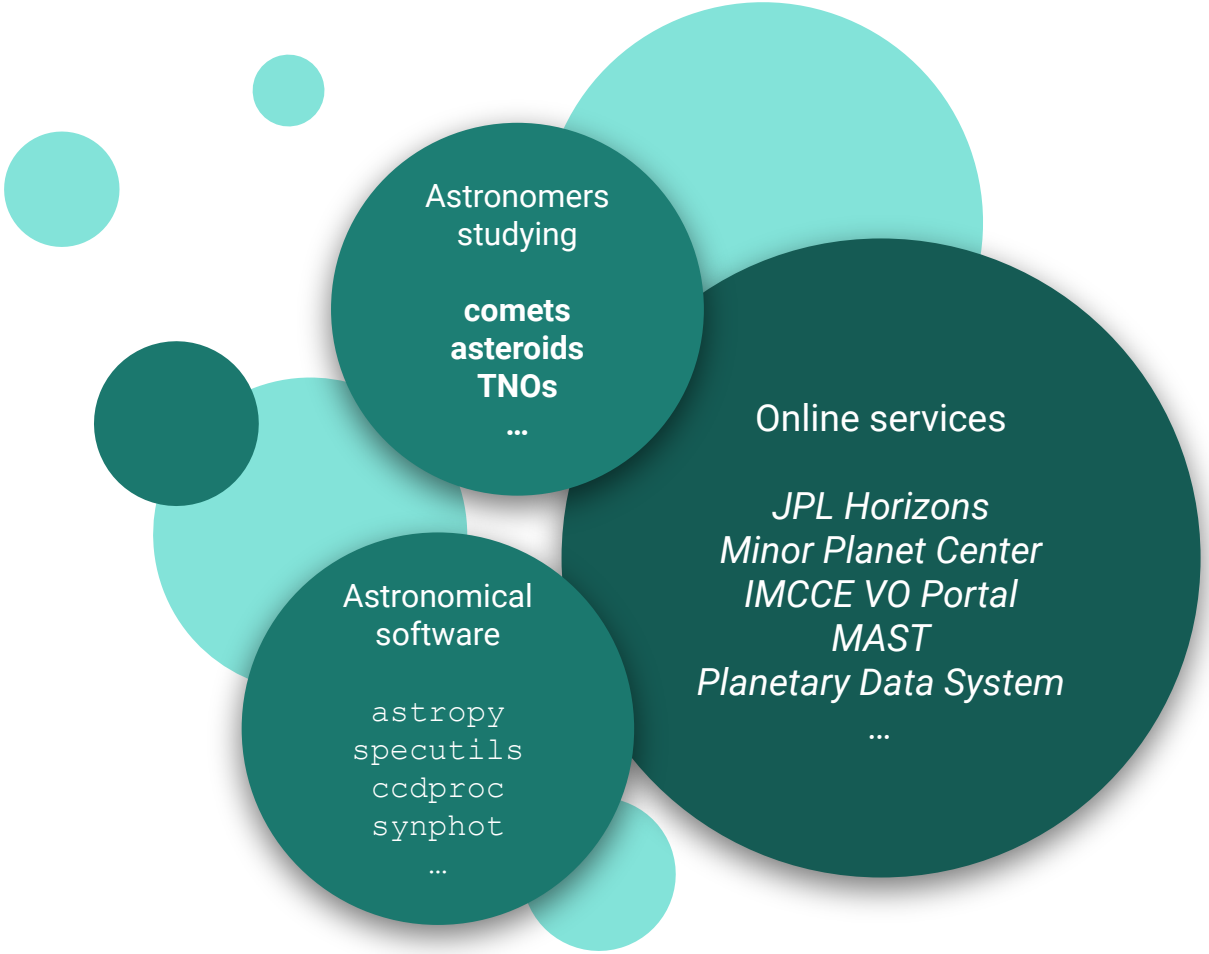
Python and astropy communities promote open source philosophies.

→ Also benefits mid- and late-career scientists (Gordon 2018, PDF/video).

Goals

The sbpy project aims to provide small-body astronomers with domain specific tools that interface with common astronomical tools and datasets.

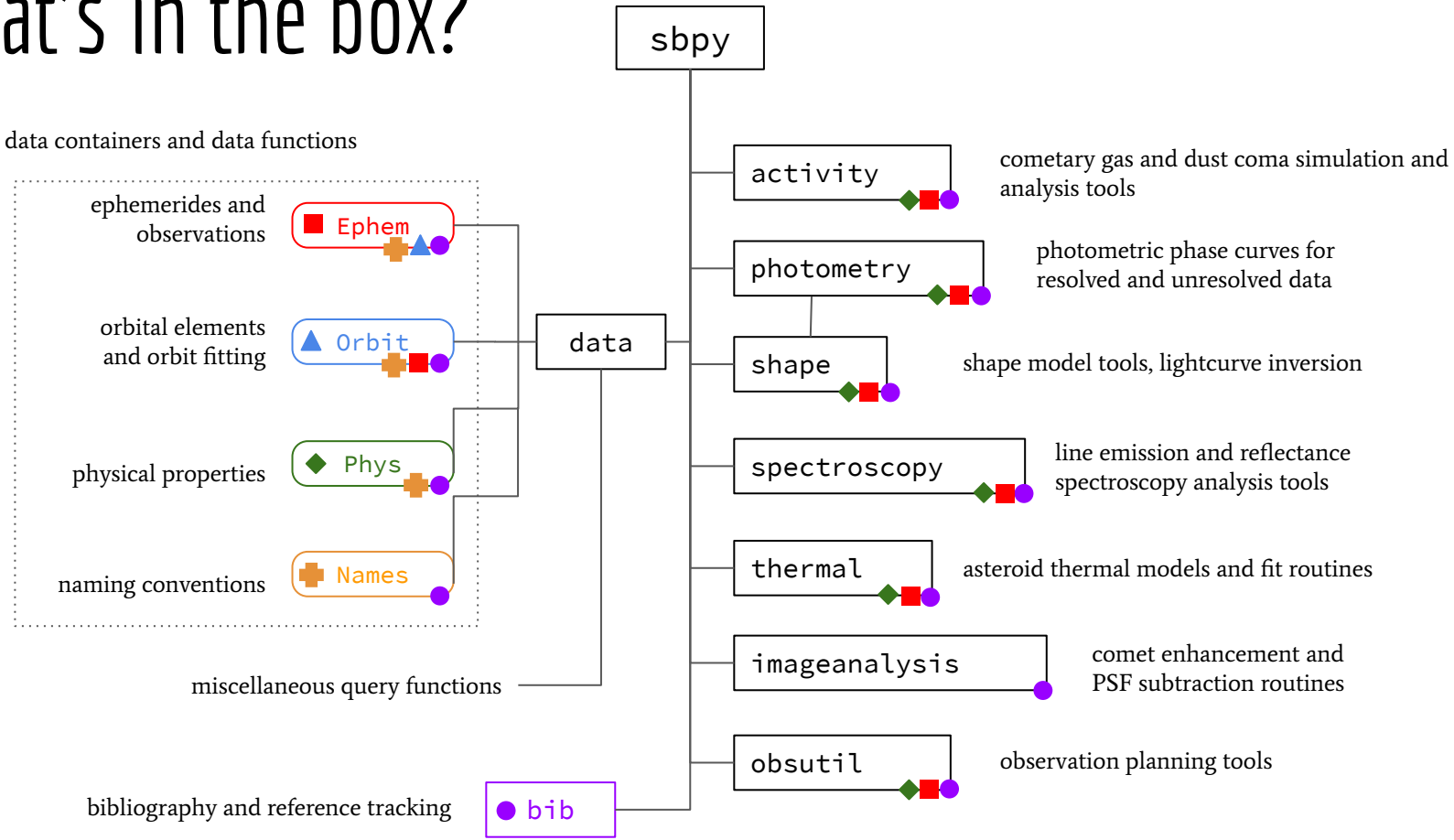
No need to develop a spectroscopy library for asteroid taxonomy, when it already exists.



Goals

OS	**Open source, with a test suite.**	• Critical for reproducibility. • Improves reliability. • Community driven.
AA	**An `astropy` affiliated module.**	• Facilitates code reuse. • Improve interoperability. • Follow interface standards.
Ex	**Extend `astropy`, `astroquery`, ...**	• Wherever appropriate, our efforts feed back into other projects.
LM	**`sbpy` is a living module.**	• Kick-started with NASA funding. • It should grow beyond our baseline package. • Version control preserves old behavior.

What's in the box?



sbpy.data: Where is 2P/Encke today?

```
In [1]: from sbpy.data import Ephem
In [2]: eph = Ephem.from_horizons('2P', id_type='designation', closest_apparition=True)
In [3]: print(eph['date', 'ra', 'dec', 'rh', 'delta', 'phase'])
<QTable length=1>
     epoch            RA       DEC           r              delta         alpha
                     deg       deg           AU              AU           deg
     object        float64   float64      float64         float64       float64
---------------- --------- -------- -------------- ---------------- -------
2459023.40490978 104.94399 23.46338 0.346145942653 1.26710086497057 37.8857

In [4]: print(eph['rh'].to('km'))
[51782695.97233311] km
```

sbpy.data: What is 2P/Encke's orbit?

```
In [1]: from sbpy.data import Orbit, Ephem
In [2]: orb = Orbit.from_mpc('2P', target_type='comet')
In [3]: print(orb['q', 'e', 'i'])
<QTable length=1>
    q          e         i
    AU                  deg
 float64    float64   float64
--------- --------- --------
0.3367202 0.8479982 11.76466
```

sbpy.data: Orbits ⟶ Ephemerides

```
In [4]: # add openorb required parameters
In [5]: orb['H'], orb['G'] = 15, 0.15
In [6]: eph = Ephem.from_oo(orb)
In [7]: print(eph['rh', 'delta', 'phase'])
<QTable length=1>
         r                Delta              alpha
         AU                 AU                deg
      float64            float64            float64
------------------ ------------------ ------------------
0.34609967304037237 1.2669227780766985 37.924127308801715
```

sbpy.calib: Built-in solar spectra

```
In [1]: from sbpy.calib import Sun

In [2]: Sun.show_builtin()
    name                                  description
------------ ------------------------------------------------------------
Castelli1996      Castelli model, scaled and presented by Colina et al. (1996)
   E490_2014                E490-00a (2014) reference solar spectrum (Table 3)
 E490_2014LR E490-00a (2014) low resolution reference solar spectrum (Table 4)
  Kurucz1993               Kurucz (1993) model, scaled by Colina et al. (1996)

In [3]: sun = Sun.from_default()

In [4]: print(sun)
<Sun: E490-00a (2014) reference solar spectrum (Table 3)>
```

sbpy.calib: Apparent brightness of the Sun

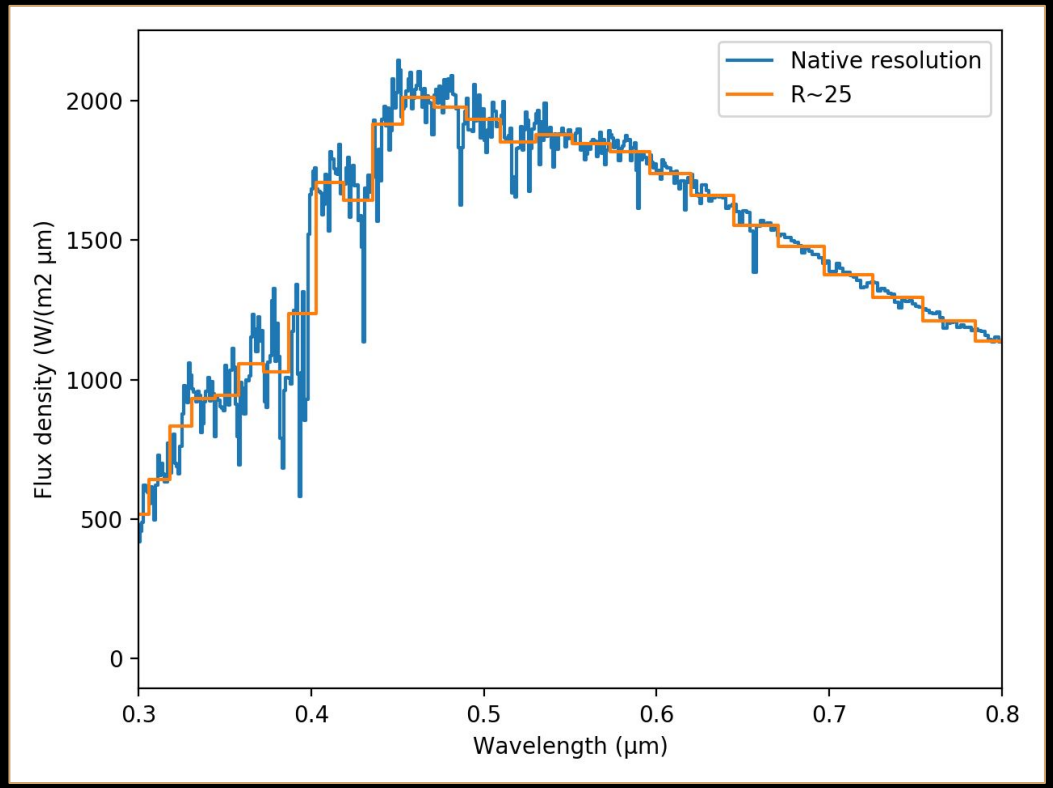
```
In [5]: from sbpy.photometry import bandpass
In [6]: import sbpy.units as sbu

In [7]: bp = bandpass('Johnson V')

In [8]: fluxd = sun.observe(bp, unit=sbu.VEGAmag)
In [9]: print(fluxd)
-26.774715028702648 mag(VEGA)
```

sbpy.calib: Solar spectra

Solar spectra can be plotted at the native resolution of the data, or rebinned. Plot the solar spectrum at the native resolution, and at a resolution of ~25...

See full example in the sbpy documentation:

https://sbpy.readthedocs.io/en/latest/sbpy/calib.html#plot-solar-spectra

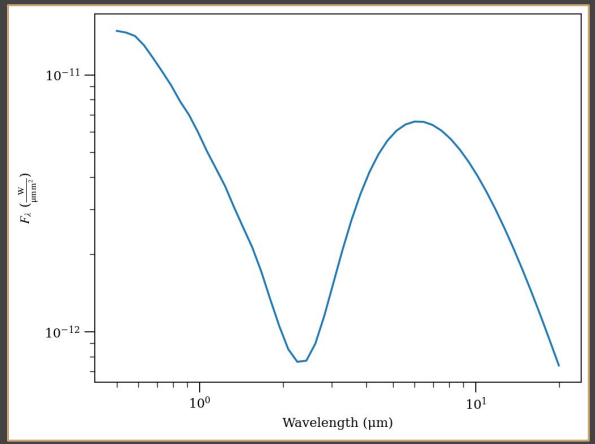


sbpy.photometry: Apparent brightness of Ceres

```
In [1]: import numpy as np
In [2]: import astropy.units as u
In [3]: from sbpy.photometry import HG
In [4]: from sbpy.data import Ephem

In [5]: ceres = HG(3.34 * u.mag, 0.12, radius = 480 * u.km, wfb = 'V')

In [6]: eph = Ephem.from_mpc('Ceres')
In [7]: print(ceres(eph['phase']))
[4.33661803] mag
In [8]: print(ceres(eph['phase']) + 5 * np.log10(eph['rh'] / u.au * eph['delta'] / u.au) *
u.mag)
[8.6749947] mag

In [9]: print(eph['V'])
[8.7] mag
```

sbpy.activity: Dust coma spectrum

```
In [1]: import numpy as np
In [2]: import astropy.units as u
In [3]: import matplotlib.pyplot as plt
In [4]: from sbpy.activity import Afrho, Efrho
In [5]: from sbpy.data import Ephem

In [6]: eph = Ephem.from_mpc('C/2020 F3')
In [7]: w = np.logspace(-0.3, 1.3) * u.um
In [8]: aper = 5 * u.arcsec

In [9]: fsca = Afrho(5000 * u.cm).to_fluxd(w, aper, eph)
In [10]: ftherm = Efrho(20000 * u.cm).to_fluxd(w, aper, eph)

In [11]: plt.plot(w, fsca + ftherm)
```



sbpy.activity: OH coma column density

```
In [1]: import astropy.units as u
In [2]: from sbpy.activity import gas
In [3]: import numpy as np

In [4]: Q = 1e28 / u.s          # production rate
In [5]: v = 0.8 * u.km / u.s    # expansion speed
In [6]: parent = gas.photo_lengthscale('H2O')
In [7]: daughter = gas.photo_lengthscale('OH')
In [8]: coma = gas.Haser(Q, v, parent, daughter)

In [9]: rho = [10, 100, 1000, 10000] * u.km
In [10]: print(coma.column_density(rho))
[7.09928015e+17 5.19060330e+17 3.28255692e+17 1.40606742e+17] 1 / m2
```

sbpy.bib: Reference tracking

```
In [1]: from sbpy import bib
In [2]: bib.track()
...  # repeat previous slide
In [12]: print(bib.to_text())
sbpy:
  software: sbpy:
      Mommert, Kelley, de Val-Borro, Li et al. 2019, The Journal of Open Source Software, Vol 4,
38, 1426
sbpy.activity.gas.core.photo_lengthscale:
  H2O photodissociation lengthscale:
      Cochran & Schleicher 1993, Icarus, Vol 105, 1, 235
  OH photodissociation lengthscale:
      Cochran & Schleicher 1993, Icarus, Vol 105, 1, 235
sbpy.activity.gas.core.Haser.__init__:
  model:
      Haser 1957, Bulletin de la Societe Royale des Sciences de Liege, Vol 43, 740
sbpy.activity.gas.core.Haser._column_density:
  model:
      Newburn & Johnson 1978, Icarus, Vol 35, 3, 360
```

What is planned?

When effort is restored this fall, on our horizons are:

- Comets: dust syndynes and synchrones, gas vectorial model, ice sublimation.
- Disk resolved photometric functions.
- NAIF Spice integration (via `spiceypy`).
- Lowell asteroid database, IMCCE tools.
- Observational tools: when to observe, finder charts.

What is planned?

Anything of general interest to astronomers studying small solar system objects.

Contributions are welcome!

File a GitHub issue to introduce your idea.

Find out more

Documentation and examples:

sbpy.readthedocs.io

Class and module docstrings →

GitHub tutorial repository.

```
In [1]: from sbpy.activity import Afrho
In [2]: Afrho?
Init signature: Afrho(value, unit=None, dtype=None, copy=None)
Docstring:
Coma dust quantity for scattered light.

``Afrho`` objects behave like `~astropy.units.Quantity`
objects
with units of length.


Parameters
----------
value : number, `~astropy.units.Quantity`
    The value(s).

unit : string, `~astropy.units.Unit`, optional
    The unit of the input value.  Strings must be parseable by
    :mod:`~astropy.units` package.

...
```

#sbpy channel in the astropy Slack workspace.

`sbpy` needs your help

- Use it, test it, break it! Then give us your feedback.
- What would you like to see/have in the future? For LSST?
- Spread the word. More users and contributions leads to better code.
- If you use it in your work, please cite it: `10.21105/joss.01426`.

Thanks