

Online tools for planetary sciences



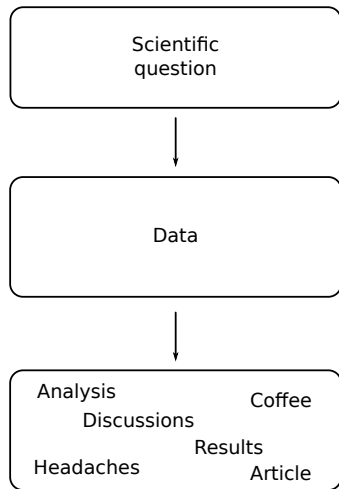
rocks

B. Carry¹ & M. Mahlke²

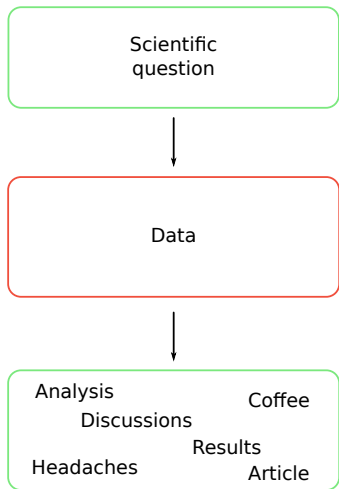
¹Lagrange, Observatoire de la Côte d'Azur, Nice

¹Institut d'Astrophysique Spatiale, Orsay

A typical research project



A typical research project



Repetitive (and tedious) tasks!

- **Planning and conduction of observations**
 - Observations already exist?
 - Target/sample available? visible?
- **Gathering ancillary data for the analysis**
 - Complementary information diameter, fall/find, ...
 - Context for research another population
- **Repetitive low-level analysis**
 - Spectral classification
 - Cross-matches & merges

Shared resources save community time

- **Tedious tasks? Share the load!**

- Many agencies have the mission to support the community
ESO/ESA/NASA, JPL/MPC/IMCCE, ...
- The expertise is in the community → individual initiatives
SSHADE, Meteoretical Bulletin, SMASS
- ▶ More time for your research

- **Tedious tasks? Automatize them!**

- Click, click, click... copy-paste, click...
- Or code some processes to work for you
- ▶ Virtual Observatory & Community librairies

- **Community services are less prone to errors!**

- One user → one α -, β -tester, user...
- Many users → bug reports! and community solutions & patches!
- ▶ Robustness of analysis → results

Pointing a telescope

Example

Where do I point the telescope from the name of a target?

Pointing a telescope

Example

Where do I point the telescope from the name of a target?

Answer: CDS, IMCCE Miriade, JPL SSD, MPC, Lowell AstEph

CDS Centre de Données astronomiques de Strasbourg
Strasbourg astronomical Data Center

Entry point to all services | Object database | Catalogue database | Interactive sky atlas

Object position | Object name/label | Keywords, target... | Object position

Formulaires de calcul d'éphémérides

- ÉPHÉMÉRIDES**
Visibilité des astres
Calcul des instants de lever, de passage au méridien et de coucher du Soleil, de la Lune et des planètes.
- ÉPHÉMÉRIDES**
Observation des planètes
Calcul des éphémérides utiles à l'observation du Soleil et des corps du Système solaire depuis la Terre.
- ÉPHÉMÉRIDES**
Éphémérides de position
Calcul des éphémérides de position du Soleil et des corps du Système solaire.

Visibility of targets

Example

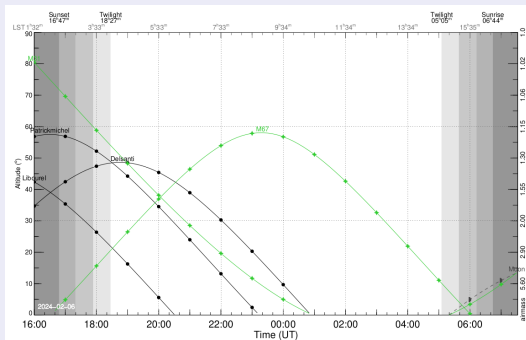
Can I observe asteroids Raymond, Delsanti, 7561 and 10281? And M31 and M67?

Visibility of targets

Example

Can I observe asteroids Raymond, Delsanti, 7561 and 10281? And M31 and M67?

Answer: IMCCE ViSiON, Lowell AstObs, airmass.org



Accessing data

Example

What is the taxonomy of Vernazza? the diameter of Groussin?

Accessing data

Example

What is the taxonomy of Vernazza? the diameter of Groussin?

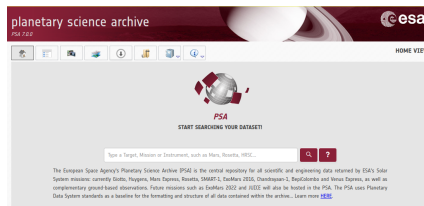
Answer: IMCCE SsODNet, JPL sbdb, OCA MP3C, Lowell AstInfo, SiMDA

(20607) Vernazza		COPY LINK	
Type:	Asteroid	EXPORT	
Class:	MB>Outer		
Parent body:	Sun		
Dynamical system:	Sun		
Dynamical parameters		^	
Physical parameters		v	
Absolute magnitude	$H = 13.03^{+0.1}_{-0.2} \text{ mag}$		
Diameter	$D = 15.049^{+0.24}_{-0.24} \text{ km}$		
Albedo	$p_V = 0.0479^{+0.0089}_{-0.0089}$		
Taxonomy	Class	= B	
	Complex	= B	
	Wavelength range	= VIS	
	Scheme	= Bus-DeMeo	

```
$ rocks diameters groussin
(16280) Groussin
+-----+-----+-----+-----+-----+
| | diameter | err_diameter_up | err_diameter_down | method | shortbib |
+-----+-----+-----+-----+-----+
| 1 | 3.081 | 0.105 | -0.105 | NEATM | Masiero+2011 |
| 2 | 3.19 | 0.84 | -0.84 | NEATM | Masiero+2012 |
+-----+-----+-----+-----+-----+
```

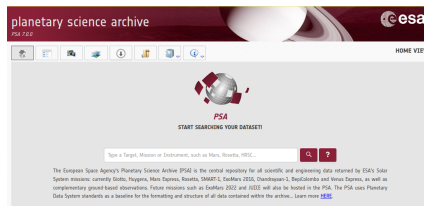
Pimp my processing

- **Web forms** Access at human-scale
 - Reprocess archival observations
 - Need to contextualize and complement
 - Perform operations beyond our confort zone
- **Shared libraries** Automatize and rationalize
 - Local installation & calls
 - Part of codes, scripts → repeatability
- **Web services and APIs** Use remote resources
 - Send query & get answer
 - Maintenance on the provider side



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Broz (Astéroïde)

date	a	h	G	deg	R _{obs}	R _{pl}	Phase	Elong	Δ	Δ ₀	V ₀
					au	mag	mag	deg	deg	arcsec	km/s
2024-02-06T21:00:00.000	9:20:29.0387	20°50'05.305"	1.452625893759	17.85	2.095	174.8183	-0.6516374	0.2428899	4.9870915		

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← → 🔍 <https://github.com/orb/orb>

README GPL-3.0 license

OpenOrb (or OOrb), an open-source orbit-computation package.

📄 README 📄 LICENSE 📄 CODES

Introduction

OOrb contains, e.g., the statistical orbital ranging method (hereafter referred to as Ranging). Ranging is used to solve the orbital inverse problem of computing non-Gaussian orbital-element probability density functions (p.d.f.s) based on input astrometry.

Ranging is optimized for cases where the amount of astrometry is scarce or spans a relatively short time span. Ranging-based methods have successfully been applied to a variety of different topics such as rigorous ephemeris prediction, orbital-elements-distribution studies for trans-neptunian objects, the computation of invariant collision probabilities between NEOs and the Earth, detecting linkages between astrometric asteroid observations within an apparition as well as between apparitions, and in the rigorous analysis of the impact of orbital arc-length and/or astrometric uncertainty on the uncertainty of the resulting orbits.

In OOrb, tools for making ephemeris predictions and classification of objects (i.e., NEO-MBO-TNO) are also available.

Documentation on usage and installation is available on the [oorb wiki](#).

sbpy

sbpy is an **Astropy affiliated package** for asteroid and comet researchers.

📄 README 📄 LICENSE 📄 CODES 📄 CITATIONS 📄 BLOG

Current version: 0.4

Installation

sbpy is a Python package, installable with pip:

```
pip install sbpy
```

Or with **Anaconda** via the **conda-forge** channel:

```
conda install sbpy --channel=conda-forge
```

[Detailed installation instructions](#)

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Reddened solar spectrum

sbpy's `sbpy.spectroscopy.SpectralGradient` can be used to redden a solar spectrum, although this approach may be revised with future sbpy capabilities.

```
In [1]: import numpy as np
import matplotlib.pyplot as plt
import astropy.units as u
from sbpy.spectroscopy import SpectralGradient
from sbpy.units import hundred_nm
from sbpy.calib import Sun

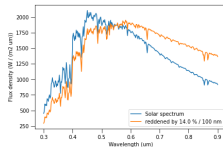
In [2]: sun = Sun.from_builtin('G490_2014LR')
wave = np.linspace(0.3, 0.9, 300) * u.um
fluxd = sun.observe(wave)
S = SpectralGradient(14 * u.percent / hundred_nm, wave@=0.55 * u.um)
print(S)
```

WARNING: Source spectrum is tapered. [synphot.observation]
 WARNING:astropy:Source spectrum is tapered.
 14.0 % / 100 nm

`SpectralGradient` works with two-band photometry expressed as magnitudes. To use it for a spectrum, the function `to_color()` must be repeatedly called:

```
In [3]: color_index = u.Quantity([S.to_color(0.55 * u.um, w) for w in wave])
# express in linear units (reflectance)
r = 10**(0.4 * color_index.value)
```

```
In [4]: ax = plt.gca()
ax.plot(wave, fluxd, label='Solar spectrum')
ax.plot(wave, r * fluxd, label='reddened by {}'.format(S))
plt.setp(ax, ylabel='Flux density ({}).format(fluxd.unit)',
xlabel='Wavelength ({}).format(wave.unit)')
plt.legend()
plt.show()
```



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```
>>> from astroquery.mpc import MPC
>>> result = MPC.query_object('asteroid', number=56788)
>>> result[0]['name'], result[0]['tisserand_jupiter']
('Guilbertepoutre', 3.2)

>>> result
[{'absolute_magnitude': '14.22',
 'aphelion_distance': '3.566',
 'arc_length': '9428',
 'argument_of_perihelion': '92.1275',
 'ascending_node': '317.2229282',
 'critical_list_numbered_object': False,
 'delta_v': '18.5',
 '...'}
 'updated_at': '2024-01-16T13:32:14Z',
 'uranus_mold': '15.1713',
 'venus_mold': '1.77253']
```

← → ↻ <https://api.imcce.fr/web/services/miriade/api/ephemcc.php?name=abonoi> 110%

```
# Flags: 1
# Ticket: 170015930207186699
# Solar system object ephemeris by IMCCE/OSPMV/CNRS
# Asteroid: 42927 Bonal
# Source: ASTORB
# Author: L.H. Wasserman
# Reference epoch: 2400300.5
# Number of observations: 1002
# Orbit arc covered: 9812 jours
# RMS or maximum residual: 0.280E-01 * 0.950E-04 */d
# Diameter: 0.08 km
# Absolute magnitude H: 15.100
# Slope parameter G: 0.150
# Orbital period: 1.95794526+03 jours
# System mass: 0.0000E+00 kg
# Dynamical class: H6Outer
# Taxonomic class: ? . ? . ?
# Planetary theory: INPOP18a
# Frame: J2000 astronomical
# Coordinates: equatorial
# Frame center: geocenter
# Precession/nutation model: IAU2000
# Relativistic perturbations: yes
# PPM coordinate system: beta-gamma=1, alpha=0
```

#	Date UTC	RA	DEC	Obs	Mag	Phase	Elong.	dRascDEC	dDEC	BV
	h m s	° ' "	° ' "	au		deg	deg	arcsec/min	arcsec/min	km/s
2024-02-06T00:00:00.000	+09 54 20.85036	+14 07 30.4221	2.634580016	20.24	2.63	170.38	-0.4511E+00	0.1080E+00	-4.30531	
2024-02-07T00:00:00.000	+09 53 36.81275	+14 12 7.5592	2.612234127	20.22	2.31	171.57	-0.4547E+00	0.1085E+00	-3.82967	
2024-02-08T00:00:00.000	+09 52 50.82038	+14 16 39.3248	2.610157407	20.20	1.90	172.76	-0.4570E+00	0.1089E+00	-3.29170	
2024-02-09T00:00:00.000	+09 52 5.32512	+14 21 11.4027	2.608412553	20.17	1.66	173.95	-0.4605E+00	0.1091E+00	-2.75124	
2024-02-10T00:00:00.000	+09 51 19.57609	+14 25 43.7138	2.606979091	20.14	1.34	175.12	-0.4627E+00	0.1094E+00	-2.20901	

Typical tasks and some solutions

IMCCE VOSSP

- Forms: <https://ssp.imcce.fr/forms>
- APIs: <https://ssp.imcce.fr/webservices/>
- Several services for SSOs:
 - SkyBot : cone-search to list SSOs in a field of view
 - SkyBot 3D : get the position of all SSOs at a given epoch
 - Miriade/ephemcc : compute the ephemerides of positions, orientations, rise-transit-set, etc)
 - Miriade/ephemph : compute the physical ephemerides (orientations)
 - Miriade/rts : compute the rise-transit-set times
 - Miriade/vision : tool to plan nights of observations

JPL Solar System Dynamics

- Forms: <https://ssd.jpl.nasa.gov/>
- APIs: <https://ssd-api.jpl.nasa.gov/>
- Several services for SSOs:
 - Horizons : Compute ephemerides
 - Identification : List SSOs in a field of view
 - What's Observable? : List all SSOs visible from a location

Lowell Observatory services

- <https://asteroid.lowell.edu/>

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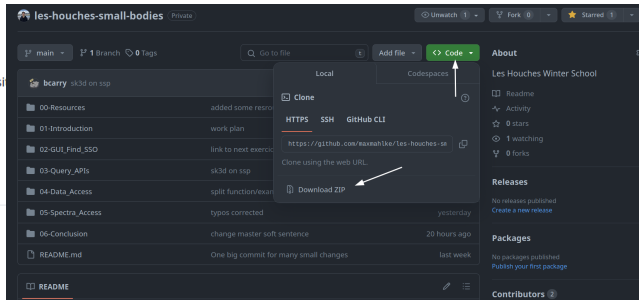
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<https://github.com/maxmahlke/les-houches-small-bodies>

Let's get some hands-on experience

1. Today: **From GUI to scripts**

- Find objects in an image using `aladin` and `SkyBoT`
- The same, with `python`

2. Today: **Getting used to APIs**

- Some exercises on ephemerides Preparing observation, locating objects
- More advanced exercises How is Solar system today? Getting ready for LSST

3. Thursday: **Easy access to data and parameters of objects**

- Common resources for meteorites and Solar System objects
- Efficient data access with APIs

4. Thursday: **Getting and analyzing spectra**

- How to search and obtain spectra?
- Tools for classification