Online tools for planetary sciences

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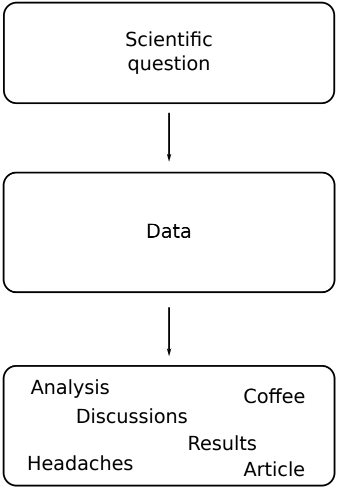
A typical research project



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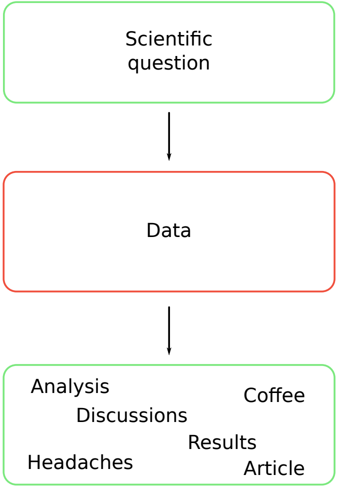

Repetitive (and tedious) tasks!

- **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 expertize 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

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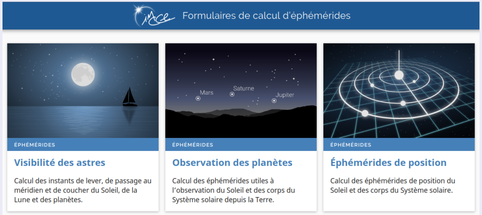
Where do I point the telescope from the name of a target?

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



Visibility of targets

Example

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

Visibility of targets

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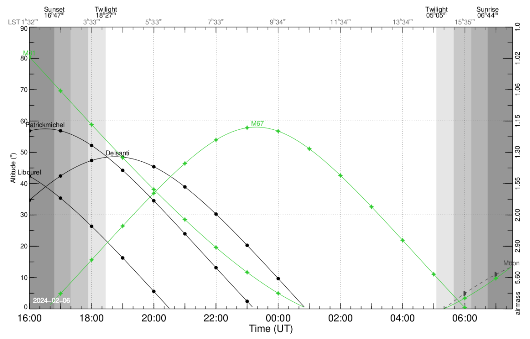
Can I observe asteroids Raymond, Delsanti, 7561 and 10281? And M31 and M67?

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

EXPORT

Type: Asteroid
Class: MB>Outer
Parent body: Sun
Dynamical system: Sun

Dynamical parameters

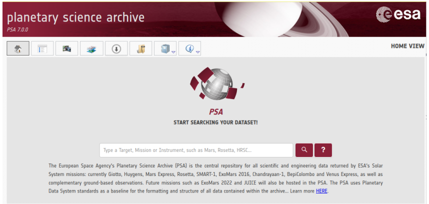
Physical parameters

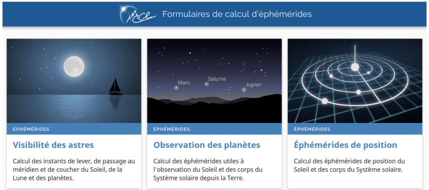
Absolute magnitude	$H = 13.03^{+0.2}_{-0.2}$ mag
Diameter	$D = 15.049^{+0.24}_{-0.24}$ km
Albedo	$p_V = 0.047\,9^{+0.008\,9}_{-0.008\,9}$
Taxonomy	Class = B
	Complex = B
	Wavelength range = VIS
	Scheme = Bus-DeMeo

```
$ 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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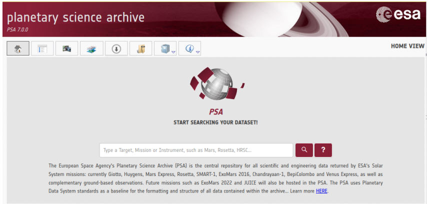

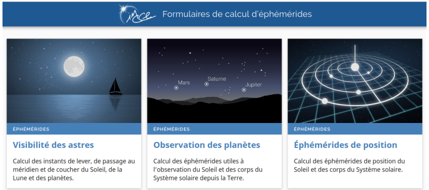

Broz (Astéroïde)

Date	α h	δ deg	d_{obs} au	m_V mag	Phase deg	Elong. deg	Δαcosδ arcsec/min	Δδ arcsec/min	v_r km/s
2024-02-06T21:00:00.000	9:20:29.0387	20°50'03.305"	1.452625003759	17.83	2.095	174.8183	-0.6516374	0.2428699	4.9870915

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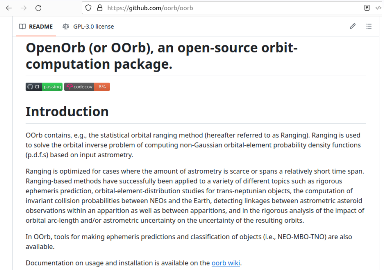

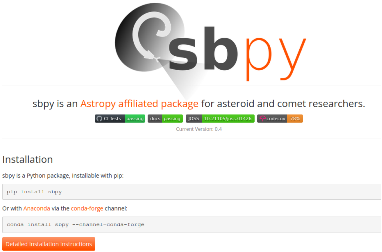

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Reddened solar spectrum

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
```

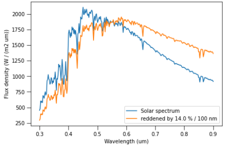
In [2]:
```
sun = Sun.from_builtin('E490_2014LR')
wave = np.linspace(0.3, 0.9, 300) * u.um
fluxd = sun.observe(wave)
S = SpectralGradient(14 * u.percent / hundred_nm, wave0=0.55 * u.um)
print(S)
```

```
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']
('Guilbertlepoutre', 3.2)

>>> result
[{'absolute_magnitude': '14.22',
  'aphelion_distance': '3.566',
  'arc_length': 9428,
  'argument_of_perihelion': '92.1275',
  'ascending_node': '317.2229202',
  'critical_list_numbered_object': False,
  'delta_v': 10.5,
  [...]
  'updated_at': '2024-01-16T13:32:14Z',
  'uranus_moid': 15.1713,
  'venus_moid': 1.77253}]
```

https://ssp.imcce.fr/webservices/miriade/api/ephemcc.php?-name=a:bonal

```
# Flag: 1
# Ticket: 178835392827186609
##########################################################################################
# Solar system object ephemeris by IMCCE/OBSPM/CNRS
# Asteroid : 41927 Bonal
# Source: ASTORB
# Author: L.H. Wasserman
# Reference epoch: 2460300.5
# Number of observations: 1082
# Orbit arc covered: 9812 jours
# RMS or maximum residual: 0.280E-01 " 0.9500E-04 "/d
# Diameter:    0.00 km
# Absolute magnitude H: 15.100
# Slope parameter G:  0.150
# Orbital period:  1.97579452E+03 jours
# System mass: 0.0000E+00 kg
# Dynamical class: MB>Outer
# Taxonomic class: ? , ? , ?
# Planetary theory: INPOP19A
# Frame: J2000 astrometric
# Coordinates: equatorial
# Frame center: geocenter
# Precession/nutation model: IAU2000
# Relativistic perturbations: yes
# PPN coordinate system: beta=gamma=1, alpha=0
##########################################################################################
#         Date UTC        |       RA        |      DEC        |     Dobs     | VMag  | Phase | Elong. |   dRAcosDEC    |     dDEC      |    RV
#              h  m  s    |  h  m  s        |  o  '  "        |      au      |  mag  |  deg  |  deg   |  arcsec/min    |  arcsec/min   |   km/s
  2024-02-06T00:00:00.000  +09 54 20.85936  +14 07 36.4221   2.614580816    20.24    2.63   170.38    -0.4511E+00    0.1880E+00   -4.36531
  2024-02-07T00:00:00.000  +09 53 36.01275  +14 12  7.5592   2.612214127    20.22    2.31   171.57    -0.4547E+00    0.1885E+00   -3.82987
  2024-02-08T00:00:00.000  +09 52 50.82038  +14 16 39.3248   2.610157487    20.20    1.98   172.76    -0.4578E+00    0.1889E+00   -3.29170
  2024-02-09T00:00:00.000  +09 52  5.32512  +14 21 11.4627   2.608412351    20.17    1.66   173.95    -0.4605E+00    0.1891E+00   -2.75124
  2024-02-10T00:00:00.000  +09 51 19.57089  +14 25 43.7138   2.606979891    20.14    1.34   175.12    -0.4627E+00    0.1890E+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 phyiscal 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?` : Lsit all SSOs visible from a location

Lowell Observatory services

- https://asteroid.lowell.edu/

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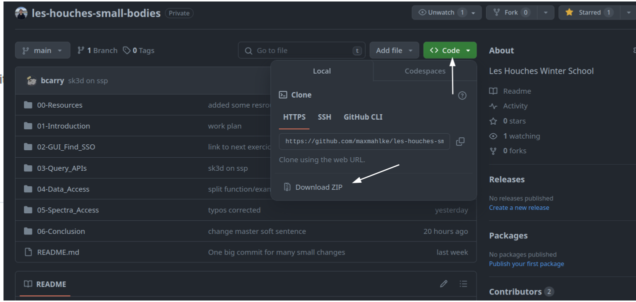

https://github.com/maxmahlke/les-houches-small-bodies

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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 exerices on ephemerides Preparing observation, locating objects
   - More advanced exercices 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