

Online tools for planetary sciences



rocks

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Databases and Data Aggregators



We all need data, we all generate data.

- **Databases**

- Websites, CDS, on request
- Mostly static, single bibliographic reference
- Mixture of formats



Databases and Data Aggregators

```
$ ls data/
CAPS      demen2006      lol20002023      sergeyev2021
aast      demen2009      lucas2017        shevchenko2022
akari     devogele2018   lucas2019        smss
astdys    ecaa           mahlike2021      splitzer
astorb    emery2011      mahlike2022      svo
atran     emery_brown2003  meteorites       tholen1984
beck2021  eschrig2021    micronegs        tinout_rapon2024
birlan2007  formater2014   npc              usgs
blanco2023  gaffey1976     nebulae          verma2020B04
burkhardt2017  gals           nux3             vstsmovis
carry2016   gallardo2020   nu6              wong2017
carry_unpublished  gietzen2012    orca             yang_jewitt2007
classy     hat            perna2018        yang_jewitt2011
clowits2011  kaplan2020     popescu2011      zellner1905
dmlt       lant2017       relab
delon2018  lant2018       smss4mc
```

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Data Aggregators

- Collection of data **with processing**
- Dynamic, large number of bibliography references
- Uniform output



Databases and Data Aggregators

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astorb    emery2011      mahlik2022       svo
atran     emery_brown2003  mteorites        tholen1984
becks2021 eschrig2021    wicrowega        tinout_rapon2024
birlan2007 formaster2014   apc              usgs
blanco2023 gaffey1976     nebulae          verma2020B04
burkhardt2017 gals           nux3             vstsmovis
carry2016 gallardo2020    nu6              wong2017
carry_unpublished gietzen2012    orex             yang_jewitt2007
classy     hat            perna2018        yang_jewitt2011
clovis2011 kaplan2020     popescu2011      zellner1985
dant       lant2017       relab
delon2018  lant2018       smss4mc
```

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Data aggregation takes effort but saves time and energy.



Data Aggregators

NAME	OBJECTS	PARAMETERS	URL
ECOCCEL	Asteroids	Physical, Orbital	http://www.ecocel-database.com/
JPL SBDB	Asteroids, Comets	Physical, Orbital	https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html
Lowell	Asteroids	Physical, Orbital	https://asteroid.lowell.edu/astinfo/
MP3C	Asteroids	Physical, Orbital	https://mp3c.oca.eu/
NEOExchange	Near-Earth Objects	Orbital	https://neoexchange.lco.global/
SiMDA	Asteroids, Comets	Size, Mass, Density	https://astro.kretlow.de/simda/
SsODNet	Asteroids	Physical, Orbital	https://ssp.imcce.fr/forms/ssocard


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Lowell	Asteroids	Physical, Orbital	https://asteroid.lowell.edu/astinfo/
MP3C	Asteroids	Physical, Orbital	https://mp3c.oca.eu/
NEOExchange	Near-Earth Objects	Orbital	https://neoexchange.lco.global/
SiMDA	Asteroids, Comets	Size, Mass, Density	https://astro.kretlow.de/simda/
SsODNet	Asteroids	Physical, Orbital	https://ssp.imcce.fr/forms/ssocard

Demo

The next slides show an outline of the demoed material.

Demo


Lowell Minor Planet Services
 Access to astorbDB and tools

[UpObjects](#)
[CribLists](#)
[AstEph](#)
[AstInfo](#)
[AstObs](#)
[AstFinder](#)
[QueryBuilder](#)
[Comets](#)
[astorb.dat](#)

Asteroid Information

Use this tool to query available orbital and physical properties of asteroids.

Query object by name / number ->

Number	Name	Primary Designation	Alternation Designation(s)	Dynamical Family
221	Eos	Eos	AB82 BA	Eos

Orbital + Physical Parameters

Elements		Albedo/Diameter		Survey		# Obs.	# Bands	Technique	Ref.
Epoch	2823-12-22T00:00:00	Albedo	\pm	Diam. (km)	\pm				
Type	mbs,outer_belt	0.131	± 0.005	187.74	± 1.51	6	2	Mid IR photometry	[icon]
a	3.012	0.14	± 0.01	183.87	± 3.6	15	3	Infrared Astronomical Satellite (IRAS)	[icon]
e	0.182	0.182	± 0.023	91.197	± 2.213	68	4	Mid IR photometry	[icon]
i	10.898	0.166	± 0.013	95.469	± 1.684	24	2	Mid IR photometry	[icon]
M	216.969	0.14	± 0.042	94.925	± 22.238	32	2	Mid IR photometry	[icon]
Peri	192.550	0.151	± 0.002	87.123	± 21.393	31	2	Mid IR photometry	[icon]
Node	141.732								
H	7.780								

Taxonomy

Type	System	Survey	Technique	Ref.
S	Tholen_ECAS	Tholen (1989)	Visible photometry	[icon]
5	Barucci_Gmode	Barucci et al. (1987)	Visible photometry, Mid IR photometry	[icon]
K	Tedesco_Sparameter	Tedesco et al. (1989)	Visible photometry, Mid IR photometry	[icon]
K	Howell_Neural	Howell et al. (1994)	Visible photometry, Near IR spectroscopy	[icon]
K	Bus_SMASSII	SMASSII	Visible spectroscopy	[icon]
K	Bus-DeMao	DeMao et al. (2009)	Near IR spectroscopy	[icon]
K	Bus-DeMao	MITHNEOS	-	[icon]

Orbit

Arc	137.554
First Observed	1885-11-26
Last Observed	2823-06-18
# Apparitions	68
# Obs. Used	3971
Orbit Quality	6.95
T _J	3.2141


Colors

Bibliographic references ->

16:08:10 UTC 09:08 MST 13:08 GMT-3 06:08 HST
 [astorb Citation](#)
 [Status](#)
 [Docs](#)
 [FAQ](#)
 [f](#)
 [t](#)
 [@](#)
 [v](#)

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

Demo


MP3C
[Search](#) - [Plots](#) - [Documentation](#) - [Citations](#) - [Contact](#)

Ceres

Eos

00221, 1882BA, 182B00A

^ Query object by name / number

All data for this body: [vot] <- Static URL to results in VOTable

MPC data

Name (number)	Eos (221)	n_obs	3325
Packed designation	00221	n_app	71
a	3.00997	Years observed	1885-2022
e	0.10228	rms	0.61
i / sin(i)	10.8932 / 0.18898		
q	2.70211		
Q	3.31784		
ω	192.3274		
Node	141.7334		
m	85.1583		
n	0.1887		
Epoch	2459600.5		

Orbital + Physical Parameters

Best values

[raw, vot]

	Value	Standard error		Value	Standard error
Parent	Eos (221)		G	0.150	
a_p	3.013		H	7.800	
e_p	0.074		Mass	1.133e+18	3.650e+17
sin(i_p)	0.172		D	100.15	0.878
			pV	0.147	0.0055

Family data


[raw, vot]

Parent	Parent name	Family ID	Family name	C _J	Author	Reference	Method
221	Eos	606	Eos	-2.3700	Nesvorny	doi.org/10.26033/6cg5-pt13	HCM-2020-08-14

Bibliographic references

<https://mp3c.oca.eu/>

Demo


MP3C

[Search](#)
[Plots](#)
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[Citations](#)
[Contact](#)

Ceres

Plots

This form lets you plot 2- or 3-axis graphs (X, Y and optional marker color) from the MP3C data by selecting the axes. It allows for filtering of the data by several criteria.

[Example query](#)

Fast and versatile 2D plots + histograms

Filter rules

Names list (optional): Ceres, Pallas, Juno

Numbers list (optional): 4, 220-255, 704

Parents (families) list (optional): 3, 8-10, 15

Include "0" to match bodies not in any family.

Parent names list (optional): Beagle, Themis

Include "None" to match bodies not in any family.

Constraints on quantities (optional):

0	≤	D	≤	10	Clear
	≤	---	≤		Clear
	≤	---	≤		Clear
	≤	---	≤		Clear
	≤	---	≤		Clear

[More](#)

Axes


X axis: a

Y axis: e

Color axis (optional): pV

<https://mp3c.oca.eu/xyz-plot/>


Demo

 Formulaires de calcul d'éphémérides

SsoCard

This form allows to display the best estimates of the dynamical and physical properties of the small bodies of the solar system, namely *ssoCard*, compiled by the SsODNet service.

[DOCUMENTATION](#)

 Solar system objects : Eos (Asteroid) ^

Asteroids and dwarf planets

Eos (Asteroid) <- Query objects by name / number

✓ Désignation officielle du corps

SEARCH

Orbital + physical parameters, references, static URL to JSON format

(221) Eos

COPY LINK

EXPORT

Dynamical parameters ^

<https://ssp.imcce.fr/forms/ssocard>

Demo

[Home](#)

[About](#)
[Orbits & Ephemerides](#)
[Planets](#)
[Planetary Satellites](#)
[Small Bodies](#)
[Tools](#)
[Extras](#)

[Home](#) / [Tools](#) / Small-Body Database Lookup

67P/Churyumov-Gerasimenko

Classification: Jupiter-family Comet [NEO]
 SPKID: 1000012
 Related Links: [Ephemeris](#)

[Orbit Viewer](#) [\[show\]](#)

[Orbit Parameters](#) [\[hide\]](#)

Select Orbit:

Osculating Orbital Elements

Epoch 2457305.5 (2015-Oct-10.0) TDB
 Reference: [\[J2000\]](#) (heliocentric IAU76/J2000 ecliptic)

Element	Value	Uncertainty (1-sigma)	Units
e	0.6409081297452731	2.7466E-8	
a	3.462249488233078	1.5491E-7	au
q	1.243265644018067	9.8838E-8	au
i	7.040295031286642	2.7143E-6	deg
node	50.13557349079007	2.2796E-5	deg
peri	12.79825003360463	2.3023E-5	deg
M	8.859927433499202	2.7804E-6	deg
tp	2457247.588657805554	1.7755E-5	TDB
	2015-Aug-13.08865781		
period	2353.076065970291	.00015792	d
	6.442371159398469	4.3236e-7	y
n	0.1529912293130881	1.0268E-8	deg/d
Q	5.68123332448069	2.5419E-7	au

Miscellaneous Details

solution date	2023-May-04 10:48:55
# obs. used (total)	8608
data-arc span	5442 days (14.90 years)
first obs. used	2008-06-01
last obs. used	2023-04-26
planetary ephem.	DE441
SB-pert. ephem.	SB441-N16
condition code	0
norm. resid. RMS	.55098
source	JPL
producer	Davide Farnocchia
Earth MOID	.256932 au
Jupiter MOID	.0837763 au
T_jup	2.746

Model Parameters

Parameter	Value	Uncertainty (1-sigma)	Units
A1	1.042492137165642E-9	1.321E-11	au/d^2
A2	-6.739448129852418E-11	2.918E-12	au/d^2
A3	2.957443603656012E-10	1.147E-11	au/d^2
DT	45.6855341067259	1.18	d

Physical Parameters [\[hide\]](#)

Parameter	Value	Units	Sigma	Reference	Notes
[M1] comet total magnitude	12.9		0.8	K213/5	2 parameter fit from 3526 observations, ...
[K1] comet total magnitude slope	7.5			K213/5	autocomd 3.0e
diameter	3.4	km	0.1	Sierks et al., Science 34...	
GM	662.2e-9	km^3/s^2	0.2e-9	Patzold et al., Nature 53...	

https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html

The N-Body Problem

• Graphical User Interfaces do not scale

- Many bodies → Many clicks
- Repeated queries to update data
- Bibliography management

→ Data aggregators need programmatic APIs

• Different degrees of simplification

- Static URLs pointing to text files
- Common service such as the *Table Access Protocol*
- Secondary client such as python packages

```
$ ls data/
CAPS      demo2006      lolzeau2023      sergayev2021
aars      demo2009      lucas2017        shavchenko2022
akari     devogele2018  lucas2019        smass
astdyn    ecar         mahlke2021       spitzer
astorb    emery2011     mahlke2022       svo
atran     emery_brown2003  meteorites       tholen1984
beck2021  eschrig2021   micromega        timeout_runo2024
bislap2007  formasier2014  mpc              usps
bishop2021  gaffey1976    newwise          vernazza2014
burkhardt2017  gala         nls3             vistanovis
carry2016  gallardo2020  nup              wong1937
carry_unpublished  gietzen2012  orex             yano_jewitt2007
classy     hst           perna2018        yano_jewitt2011
clovis2011  kaplan2020    popescu2011      zellner1985
datt       lant2017      rel30
deleon2010  lant201X     sdss4mc
```

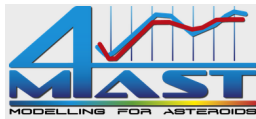


Tutorial

[20min] Tutorial notebook on data access

- Basic: Programmatic data access with `astroquery` and `rocks`
- Advanced: Analysis of catalogue data with `rocks`
- Expert: Building our own `meteorite`-classification lookup tool

Spectra Access



cLassy

- **Spectra are complex data products**
 - Wavelength, Reflectance, Irradiance, ...
 - Instrument Metadata
 - Sample Metadata
- **Spectra Databases for Ast./Comets/Met.**
 - PDS, CDS, RELAB
 - SMASS, MITHNEOS
- **Spectra Aggregators for Asteroids and Meteorites**
 - SSHADE, M4AST, cLassy
 - Processing required
 - Few updates

Demo

The next slides show an outline of the demoed material.

M4AST

Home

Home Start Analysis Database Login

M4AST
MODELLING FOR ASTEROIDS

M4AST (Modelling for Asteroids) is a free on-line tool for modeling reflectance visible and near-ir spectra of atmosphereless bodies.

The old version of M4AST is available [here](#).

M4AST allows to analyse visible and near-infrared spectra of planetary surfaces. There are two ways of using it:

- 1) analyse a spectrum from the database;
- 2) upload your own spectrum (anonymous file submission).

M4AST offers several routines for spectral analysis:

- plotting the data;
- merging spectra;
- taxonomy comparison;
- comparison with laboratory spectra (RELAB database);
- mineralogical modelling.

Acknowledge M4AST tool by citing:
M4AST - A Tool for Asteroid Modelling, American Astronomical Society, DPS meeting #48, id.325.17
Bibliographic code [here](#).
Modeling of asteroid spectra - M4AST, Astronomy and Astrophysics, Volume 544.
Bibliographic code [here](#).

imco

<https://spectre.imcce.fr/m4ast/index.php/index/home>

classy

classy

[GitHub](#) · [ReadTheDocs](#)

In Short

1. Upload your spectra
2. Add literature spectra
3. Classify spectra
4. Export classifications

Development of `classy` and the web interface are on-going.

Last update: 2024-01-09

classy

Welcome to the web interface of `classy`, a tool for the analysis of asteroid reflectance spectra. This interface provides basic functionality. For the full feature set, you can have a look at the `python` package [here](#).

This interface allows to visualise, classify, and export reflectance spectra and their metadata. You can provide your own data, use literature data, or a combination of the two. To get started, just keep scrolling.

Optional: Upload Your Spectra

Upload CSV files

Optional: Add literature spectra

Here you can select spectra from the literature to include in your analysis. Write a query and select the spectra to add by marking it in the `select` column.

Query and select from 66572 Spectra

Classify

Classify

Either upload your spectra or select literature spectra to continue.

← Manage app

<https://classy.streamlit.app/>

RELAB

PDS Geosciences Node Spectral Library

Home Search Cart Contribute Data Help

NASA Planetary Data System
GEOSCIENCES
Washington University in St. Louis

Search Filters

[Reset All](#)

Spectral Database

☒ RELAB 21,379

RELAB Note: Purity or composition of samples sent by users to the NASA RELAB facility are not independently verified by the RELAB spectroscopy facility.

☐ XAS Synthesized Glasses 130

Keyword Search

Chemical Composition

Specimen Type

Specimen Origin

Material State

Material Type

Material Sub Type

Specimen Size

Mineral Type

Rock Type

Measurement Type

Reflectance Measurement Range

Result List - Filters Applied

Specimens: 13,708/11,733 Measurements: 21,379/21,509

[RELAB](#)

[Add All Results to Cart](#) [Remove All Results to Cart](#)

Legend: Chemistry Image Thin Section Sample

Page 1 of 235, Items 1 to 90 of 11708

Specimen	Specimen Name	Specimen Description	Measurements
AA-A1S-001	Ammonium anrite (4.001)	Synthesis and characterization of K-free NH ₄ -anrite (Astrobiology)	2
AA-A1S-002	Ammonium anrite (4.002)	Synthesis and characterization of K-free NH ₄ -anrite (Astrobiology)	2
AA-A1S-003	Ammonium anrite (4.004)	Synthesis and characterization of K-free NH ₄ -anrite (Astrobiology)	2
AA-A1S-004	Ni-bearing ammonium anrite (4.005)	Synthesis and characterization of K-free NH ₄ -anrite (Astrobiology)	2
AB-DTB-003	Pathfinder Airbag (Kevlar)	Mars Pathfinder airbag material: Kevlar. About eight layers over one another.	1
AB-EAC-001	Albite: ALB101 0 - 45 μ m	From Minerals Unlimited	3
AB-EAC-001-E	Albite: ALB101E	From Minerals Unlimited	1
AC-PCP-001	Basalt: BaG1 0 - 70 μ m	A fresh unaltered basalt, with some phenocrysts of olivine, pyroxene and plagioclase	6
AC-PCP-002	Basalt: BaG2 70 - 250 μ m	A fresh unaltered basalt, with some phenocrysts of olivine, pyroxene and plagioclase	1

Quick View

Compare measurement plots from search results

Expand specimens and click the measurement thumbnails to view plots in the quick view graph. Click the thumbnail a second time to remove it from the quick view.

Current Plot

Wavelength (nm)

Reflectance

AA-A1S-001

Move cursor over spectrum to display values

Download Graph Download Measurements

X Min: X Max: Update Graph Reset

Y Min: Y Max: Clear Graph Contents

Display as Wavenumber

<https://sites.brown.edu/relab/relab-spectral-database/>

SSHADE

[Help](#) [Log in / Register](#)

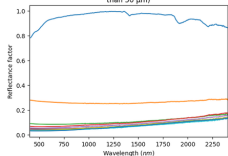
Solid Spectroscopy Hosting Architecture of Databases and Expertise

[Search spectra](#)[Search band lists](#)[Search bands](#)[Search publications](#)[Latest spectra dataset](#)1 / 5 [←](#) [→](#)

EXPERIMENT_CF_20200813_000 : VIS-NIR reflectance spectra of binary mixtures of silicon dioxide (SiO₂) particles (0.5 - 10 μ m) and Juniper charcoal particles (less than 50 μ m) | BYPASS database

2023-12-07

VIS-NIR reflectance spectra of binary mixtures of silicon dioxide (SiO₂) particles (0.5 - 10 μ m) and Juniper charcoal particles (less than 50 μ m)



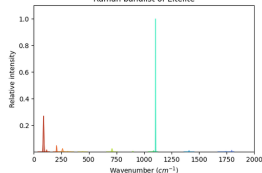
— VIS-NIR reflectance spectrum of pure silicon dioxide (SiO₂, 0.5 - 10 μ m)
— VIS-NIR reflectance spectrum of a binary mixture of silicon dioxide and Juniper charcoal (10 wt.%)
— VIS-NIR reflectance spectrum of a binary mixture of silicon dioxide and Juniper charcoal (20 wt.%)

[Latest bandlists dataset](#)1 / 5 [←](#) [→](#)

BANDLIST_RAMAN_Eitelite : Raman bandlist of Eitelite

2023-12-27

Raman bandlist of Eitelite



<https://www.sshade.eu>

SSHADÉ

The screenshot displays the SSHADÉ software interface. The top menu bar includes 'Window', 'TAP', 'Registry', 'Edit', 'Interop', and 'Help'. Below the menu is a toolbar with icons for file operations and execution. The main window is divided into several panes:

- Metadata:** A table listing various metadata fields. The table has columns for Name, Schema, Type, Unit, Indexed, Description, UCD, UType, xtype, and Flags. The 'Name' column lists fields like 'granule_id', 'dataproduct_type', 'target_name', 'target_class', 'time_min', 'time_max', 'time_sampling_step_min', 'time_sampling_step_max', 'time_exp_min', 'time_exp_max', 'spectral_range_min', 'spectral_range_max', 'spectral_sampling_step_min', 'spectral_sampling_step_max', 'spectral_resolution_min', 'spectral_resolution_max', 'c1_min', 'c1_max', 'c2_min', 'c2_max', 'c3_min', 'c3_max', 's_region', 'c1_resol_min', 'c1_resol_max', 'c2_resol_min', 'c2_resol_max', 'c3_resol_min', 'c3_resol_max', and 'spatial frame type'.
- Service Capabilities:** A section below the metadata table with a dropdown for 'Query Language' (set to ADQL-2.0), a 'Max Rows' dropdown (set to 20000), and an 'Uploads' field (set to 2048).
- ADQL Text:** A text area containing a SQL query: `SELECT * FROM sshade_spectra.apn_core`.
- Examples:** A section at the bottom with a 'Run Query' button.

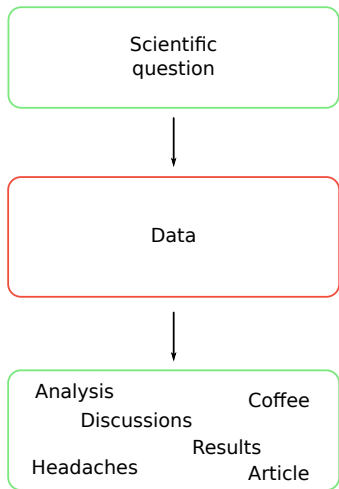
TOPCAT → TAP Query → “SSHADÉ”

Tutorial

[20min] Tutorial notebook on spectra access with SSHADE and TAP

- Basic: Access of SSHADE database using TAP
- Advanced: Creating an astroquery module for SSHADE

Re: 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

Online resources in a nutshell

- A suite of pages, libraries, and services
 - **Providers:** data archives, catalogs, online codes
 - **Clients:** GUI, CLI, analysis tools
 - Check IVOA: <http://ivoa.net/astronomers/applications.html>

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 - Common interface I/O: VOTable, json, Protocols: TAP, cone-search
 - Registries → phone book
 - Homogeneity of interface in APIs and in python modules

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 - Homogeneisation of interface in APIs and in python modules
- It is **not** a master software
- Resources are made **by us**, and **for us**
 - Powerful libraries and tools
 - Good practice to release data/codes Consider CDS at the very least
 - Contribute to open-source projects: `astroquery`, `sbpy`, `rocks`, ...