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Surviving guide for young astronomers in the era of Virtual Observatories

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ADS

The SAO/NASA Astrophysics Data System (ADS) is a Digital Library portal for researchers in Astronomy and Physics, operated by the Smithsonian Astrophysical Observatory (SAO) under a NASA grant. The ADS maintains three bibliographic databases containing more than 13.9 million records covering publications in Astronomy and Astrophysics, Physics, and the arXiv e-prints. Abstracts and full-text of major astronomy and physics publications are indexed and searchable through the new ADS interface as well as the traditional "Classic" search forms. A set of browsable legacy interfaces are also available.

Please note that all abstracts and articles in the ADS are copyrighted by the publisher, and their use is free for personal use only. In general, books are not accessible through ADS, only few books are available in this link.

The URL main webpage is:

http://adsabs.harvard.edu/

It is recommend to create an account in both ADS “Classic” and “New”. Both accounts are independent one from another.

Classic ADS form

The Classic form is available since 1994:

http://adsabs.harvard.edu/abstract_service.html

Explore: sort options, list of links (each letter), output format.

New ADS

This version was released in May 2018:

https://ui.adsabs.harvard.edu/

Please, explore the Help Pages, Tutorial "Become a power User", and Blog.

Examples, search by:

Object `object:"HD 5980"` it is not the same as `object:HD 5980`

Author `author:"Koenigsberger"`

`author:("Koenigsberger" "Barba")`

works like `Koenigsberger and Barba`

`author:("Koenigsber" or "Barba")` for "or" connect

`author:("Smith, N.") database:astronomy` to restrict only astronomy

`author:("^Smith, N.") database:astronomy` as first author

Doctype `doctype:software python` search papers using Python code

`doctype:software cmb` search papers with software applied to CMB

`doctype:phdthesis agn` search PhD thesis about AGNs

`doctype:phdthesis agn data:(XMM)` ... and using XMM data.

`(doctype:phdthesis agn abstract:"HST") year:2010-2018` search

Thesis about AGNs with HST in the abstract published between 2010 and 2018.

Smart searches

ADS provide four operators which modify the query results by performing second-order operations on the original query. To invoke the operators, enter the corresponding operator before your search terms (enclosing your search terms in parentheses) in the search box.

`trending(term), reviews(term), useful(term), topn(n,term,sort)`

Examples:

`trending(agn)`

`reviews(agn)`

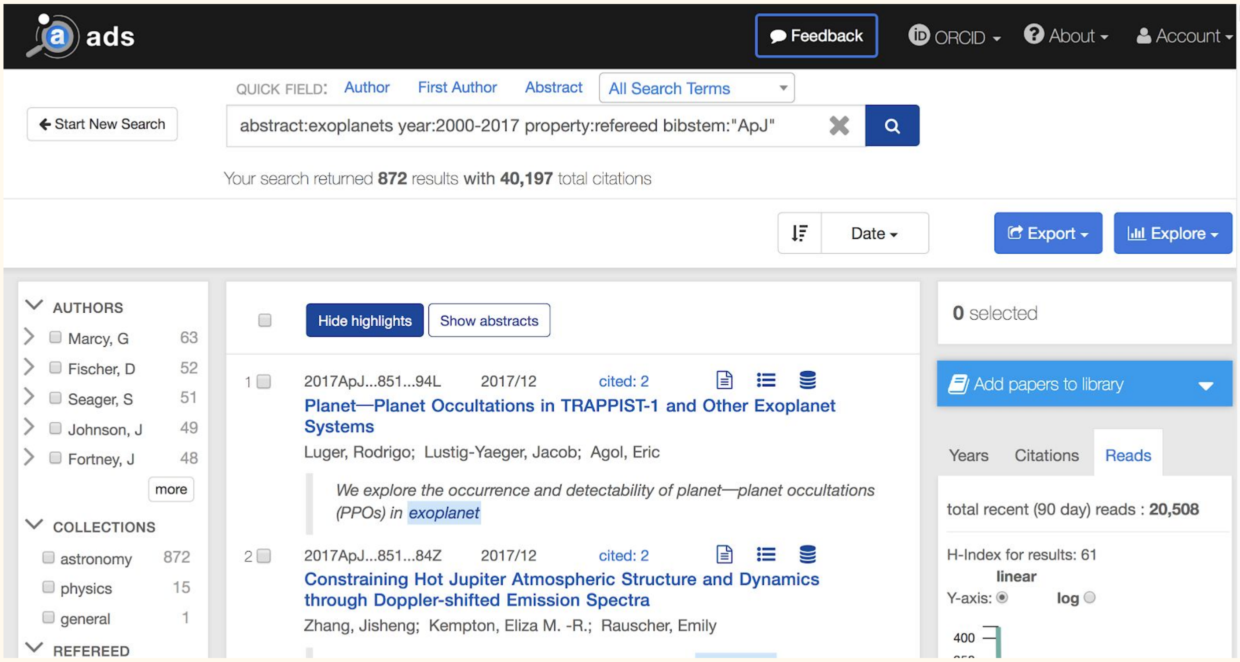
`useful(agn)`

`topn(100, keyword:agn, citation_count desc)`

Exercises

1. How many papers in Astronomy are registered in ADS?
2. How many published in 2017? How many refereed?
3. Which is the most productive Journal in papers? Which is the most cited? Adopt the following list of Journals: ApJ, ApJS, MNRAS, A&A, AJ.
4. What has happened to AN (Astronomische Nachrichten) over the years? This question is important in order to understand the language shift in Astronomy.
5. Which topic (stars, galaxies, cosmology) has the largest impact in readers (reads)? Compare during periods 1988-1997, 1998-2007, 2008-2017.
6. Which topic is the most cited (same periods)?
7. When was introduced the concept *Astrophysics* (Journal, Author)? Check the answer in Wikipedia (not before!).
8. "Only" four papers about exoplanet are retrieved from in ApJ during 2000-2017, using the search keyword:exoplanet, What do you think? Is the result realistic?

Export Box, and Explore Box

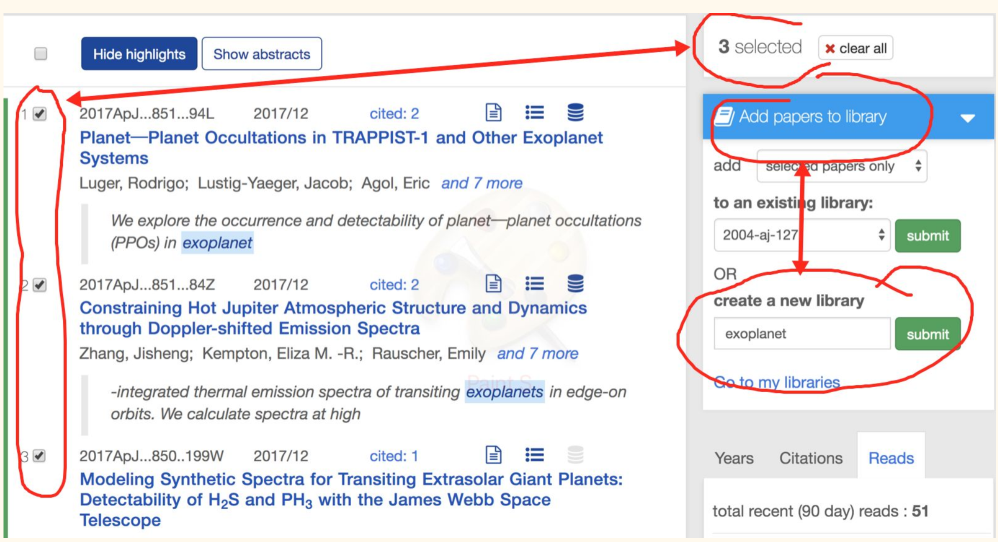


User ADS libraries

Selected papers can be saved as a "library". There are two methods:

a) Do a [search on the new ADS](), select your relevant papers, and select the **Add papers to library** button. Fill in a library name and press submit.

b) Go the **My Account** drop down and select **ADS Libraries**. Press the **Create a library** button.



CDS

Centre de Données astronomiques de Strasbourg (Strasbourg Astronomical Data Center)

http://cds.u-strasbg.fr/

Basic helps: http://cds.u-strasbg.fr/help

Developer's corner (software download): http://cds.u-strasbg.fr/resources/doku.php

Publication support: http://cdsweb.u-strasbg.fr/publication-support

MyCDS: http://cdsweb.u-strasbg.fr/myCDS

DATA FORMAT

ASCII: American Standard Code for Information Interchange, https://en.wikipedia.org/wiki/ASCII

CSV: comma-separated values, https://en.wikipedia.org/wiki/Comma-separated_values

TSV: tab-separated values, https://en.wikipedia.org/wiki/Tab-separated_values

FITS: Flexible Image Transport System, https://en.wikipedia.org/wiki/FITS

Version 4.0, see https://fits.gsfc.nasa.gov/fits_standard.html

JSON: Javascript Object Notation, is an open-standard file format that uses human-readable text to transmit data objects consisting of attribute–value pairs and array data types.

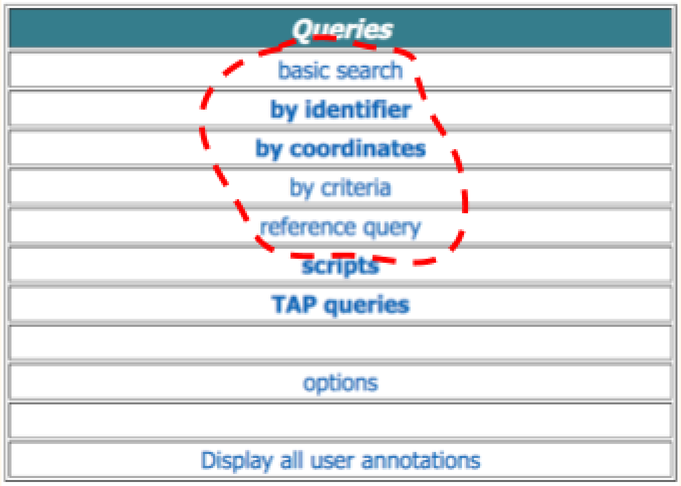
XML: Extensible Markup Language is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable

VOTable: Virtual Observatory Table is an XML standard for the interchange of data represented as a set of tables. In this context, a table is an unordered set of rows, each of a uniform structure, as specified in the table description (the table *metadata*). Each row in a table is a sequence of table cells, and each of these contains either a primitive data type, or an array of such primitives. VOTable is derived from the Astrores format [1], itself modeled on the FITS Table format [2]; VOTable was designed to be close to the FITS Binary Table format.

http://www.ivoa.net/documents/VOTable/20130920/REC-VOTable-1.3-20130920.html

SIMBAD

Classic Simbad Astronomical Database: http://simbad.u-strasbg.fr/simbad/



Direct access to SIMBAD with small number of options. Check in options the different possibilities for the output.

By ***Criteria Query*** is possible to do more sophisticated queries using a simple logic in a large number of parameters. For example:

Search expression:

```
radvel > 1000 & maintype = "Star" & Vmag < 14

maintype = "**" & Vmag < 14  (case of 61 Cyg, and
A-B)

maintypes = "Sy2" & Vmag <= 15.0
```

In the script mode, you can perform any kind of queries defined in a script file and get the result in ascii format. You can either define your own format for displaying the data or get the result in a votable, specifying the data fields you are interested in.

The scripting language accepts commands described here. You can define several formats and use them to display data. Votable definitions can be specified and used for output. Example:

```
echo ISYA41 Simbad4 script

format object form1 "%IDLIST(1) : %COO(A , D), RadVel= %RV(V
Q), Plx= %PLX "

query id HD 93129A
```

```
goto lab1
query id hd 3
query id hd 4
lab1:
# three last queries
query id hdx 997
query id hd 998
query id hd 999
echo Tienen hambre?
format display
```

Another example with VOTABLE (pay attention use of ~ character before ID):

```
votable vot-isya41 {MAIN_ID RA(d) DEC(d) PMRA PMDEC FLUX(V)}
votable open vot-isya41
set radius 3m
~HD 93129A
12 30 +10 20
13 40 +11 21
15:00-10:10 radius=10m
votable close
```

Simbad TAP Services.

TAP is an IVOA protocol which describes a way to query data tables. Queries are by default written in ADQL and results are returned by default in VOTable. Contrary to usual web-services, TAP lets query the service on all its exposed data with customized conditions. Thus you can get only the data which interest you in the format of your choice.

Simbad offers a TAP service where you can write your script, obtain results in different formats or even keep the results for future downloads or cross-matching. Also, you can upload your table and join them with Simbad ones.

Examples.

Pairing the Hipparcos stars with the main identification in Simbad, with coordinates. First, we must select columns from two different tables `basic` and `ident`, joined by `oidref` and `oid` parameters. Then select the output parameters `basic.oid` (internal identification in Simbad), `id` (Hipparcos number), `main_id` (the main identifier) and coordinates `ra`, `dec`:

```
SELECT basic.OID, id, main_id AS "Main identifier", RA, DEC

FROM basic JOIN ident ON oidref = oid

WHERE id like 'HIP%';
```

A more complex query: retrieve all stars brighter than V=12 around the star HDE 303308 in a radius of 30’, and print the output OID, MAIN_ID, RA, DEC, OTYPE, OTYPES, V, SP_TYPE, PARALLAX, PLX ERROR, PM_RA, PM_DE, PM_ERR_AXIS, PM_ERR_ANG, RADIAL VELOCITY, RADIAL VELOCITY ERROR, DISTANCE FROM THE STAR.

First, we select the output columns labeling them, and also including the `distance` operator respect the position of the reference star. The next step is to join the `basic` table with `allfluxes` and `alltypes` tables pairing the internal identification, with the conditions of `V <= 12` and the "*" character in the `alltypes` columns, and finally inside the circle of 0.5 degrees centered in HDE 303308. The last step is sorting by `distance`.

```
SELECT basic.oid, main_id AS "Main identifier",

      ra as "RA", dec as "DEC", otype_txt AS "Main Type",

      Alltypes.otypes as "Other Types", V, sp_type as "Sp Type",

      plx_value as "Plx", plx_err as "Plx Err", pmra as "PM RA",

      pmdec as "PM DE", pm_err_maj as "PM Err Axis",

      pm_err_angle as "PM Err Ang", rvz_radvel as "RV",

      rvz_err as "RV Err",

      distance(point('ICRS',RA,DEC), point('ICRS', 161.2746441839713,
-59.6683119054036)) as "distance"

FROM basic JOIN allfluxes ON allfluxes.oidref = oid

           JOIN alltypes  ON alltypes.oidref = oid

WHERE V <= 12 AND alltypes.otypes LIKE '%*%' AND
CONTAINS(POINT('ICRS', RA, DEC), CIRCLE('ICRS', 161.274644183971,
-59.6683119054036, 0.5)) = 1

ORDER BY "distance";
```

ADQL Cheat-sheets.

ADQL means **A**stronomical **D**ata **Q**uery **L**anguage. This language is used by the IVOA to represent astronomy queries posted to VO services. It is based on SQL (**S**tructured **Q**uery **L**anguage) and enriched with geometrical functions such as CONTAINS and INTERSECTS. But contrary to SQL, ADQL is only designed to interrogate a database.

All information about ADQL are available at this IVOA Document. This page gathers minimal ADQL features required to interrogate Simbad-TAP.

http://simbad.u-strasbg.fr/simbad/tap/help/adqlHelp.html

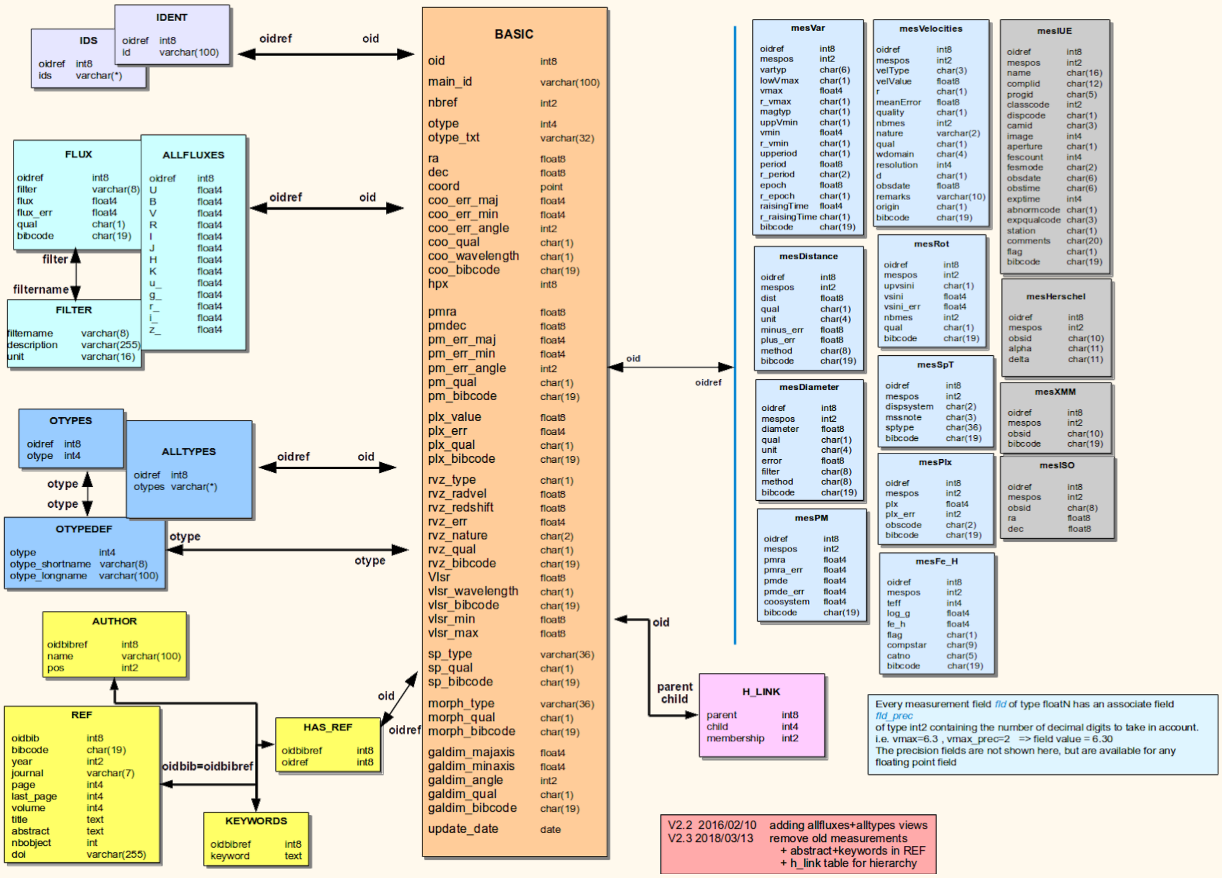
SIMBAD tables

Currently, there are 46 SIMBAD tables for queries. You can perform a keyword search to get the name of suggested columns using names of observables or parameters. For example to get the columns related with *radial velocities*, the result is:

`Keyword search:` *`radial velocity`*

`Suggested columns :`

- `basic.rvz_bibcode`
- `basic.rvz_err`
- `basic.rvz_err_prec`
- `basic.rvz_qual`
- `basic.rvz_radvel`
- `basic.rvz_radvel_prec`
- `basic.rvz_type`
- `mesGcrv.radvel`
- `mesVelocities.nature`
- `mesVelocities.origin`
- `mesVelocities.velType`
- `mesVelocities.velValue`
- `mesVelocities.wdomain`



Examples

http://wiki.ivoa.net/internal/IVOA/InterOpJune2015Apps/SIMBAD-TAP.pdf

TAP and Python: Astroquery and PyVO

Astroquery is a set of tools for querying astronomical web forms and databases, please take a look the large list of database and images services which can be accessed. There are two other packages with complimentary functionality as Astroquery: PyVO is an Astropy affiliated package, and Simple-Cone-Search-Creator to generate a cone search service complying with the IVOA standard. They are more oriented to general virtual observatory discovery and queries, whereas Astroquery has web service specific interfaces. Check out the A Gallery of Queries for some nice examples. For Simbad queries examples, here.

Example:

a) Query Simbad for a particular object.

```
>>> from astroquery.simbad import Simbad
>>> result_table = Simbad.query_object("m1")
>>> print(result_table)

MAIN_ID      RA        DEC     RA_PREC DEC_PREC COO_ERR_MAJA COO_ERR_MINA
COO_ERR_ANGLE COO_QUAL COO_WAVELENGTH     COO_BIBCODE
------- ----------- ----------- ------- -------- ------------ ------------ ------------ --------
-------------- -------------------
M   1 05 34 31.94 +22 00 52.2      6       6        nan        nan          0       C            R
2011A&A...533A..10L
```

b) Search around a position of an object.

```
>>> from astroquery.simbad import Simbad
>>> import astropy.units as u
>>> result_table = Simbad.query_region("HD93250", radius=0.01 * u.deg)
>>> # another way to specify the radius.
>>> result_table = Simbad.query_region("HD93250", radius='0d0m36s')
>>> print(result_table)
```

c) Search around a coordinate position.

```
>>> from astroquery.simbad import Simbad
>>> import astropy.coordinates as coord
>>> import astropy.units as u
>>> result_table = Simbad.query_region(coord.SkyCoord(31.0087, 14.0627,
...                             unit=(u.deg, u.deg), frame='galactic'),
...                             radius='0d0m2s')
>>> print(result_table)

         MAIN_ID           RA      ... COO_WAVELENGTH     COO_BIBCODE
------------------- ------------- ... -------------- -------------------
NAME Barnard's star 17 57 48.4980 ...              O 2007A&A...474..653V
```

d) Search based on criteria, for example extract all Seyfert 2 AGNs in a circle of 10º around the Northern Galactic Pole.

```
>>> from astroquery.simbad import Simbad
>>> result = Simbad.query_criteria('region(circle, GAL, 0 +90, 10d)', otype='Sy2')
>>> print(result)
```

e) Saving result of the previous example in a VOTable.

```
>>> from astroquery.simbad import Simbad
>>> result = Simbad.query_criteria('region(circle, GAL, 0 +90, 10d)', otype='Sy2')
>>> result.write('my_sy2_table.xml', format='votable')
```

f) As example (b), search around a position of an object, and adding columns to the output, for example MK type and Radial Velocity. Get the list of field to add in the VOTable using Simbad.list_votable_fields():

```
>>> from astroquery.simbad import Simbad
>>> import astropy.units as u
>>> Simbad.add_votable_fields('sp', 'rvz_radvel')
>>> result_table = Simbad.query_region("HD93250", radius='0d0m36s')
>>> result_table('HD93250.xml',format='votable')
```

Exercises

a) Please, try to reproduce the examples and exercises of TAP Simbad services section as Python scripts.
b) Get the bibliographic information for the star HD 93250
c) Save in a VOTable the complete list of Seyfert 2 galaxies, including photometric information.

Dictionary of nomenclature.

Designations of astronomical objects are often confusing. Astronomical designations (also called Object *Identifiers*) have been collected and published by Lortet and collaborators in *Dictionaries of Nomenclature of Celestial Objects outside the solar system* (**B**iblio). This *Info service* is the electronic look-up version of the *Dictionary* which is updated on a regular basis; it provides full references and usages about 23776 different acronyms.

http://cds.u-strasbg.fr/cgi-bin/Dic-Simbad

Object Classification in SIMBAD

The Object Type in Simbad is defined as a hierarchical classification, which emphasizes the physical nature of the object rather than a peculiar emission in some region of the electromagnetic spectrum or the location in peculiar clusters or external galaxies. Therefore objects are classified as peculiar emitters (Radio, IR, Red, Blue, UV, X or gamma) only if nothing more about the nature of the object is known, i.e. it cannot be decided whether the object is a star, a multiple system, a nebula or a galaxy.

Each class has normally a standard designation, a condensed one (used in tables) and an extended explanation. Examples:

```
14.00.00.00       Star                  *         Star
```

14.01.00.00	·	*inCl	*iC	Star in Cluster
14.02.00.00	·	*inNeb	*iN	Star in Nebula
14.03.00.00	·	*inAssoc	*iA	Star in Association
14.04.00.00	·	*in**	*i*	Star in double system
14.05.00.00	·	V*?	V*?	Star suspected of Variability

SimWatch

The SimWatch tool lists the latest references of your preferred objects. They will be saved in your profile and you will receive a notification by email for new references (at most one message per day).

http://simbad.u-strasbg.fr/tools/SimWatch/manage/

CDS Portal

New interface with interactive capabilities. Object oriented. Development also for the use in touching dispositives (cell-phone, tablets, etc.).

http://cdsportal.u-strasbg.fr/

VizieR

VizieR provides access to the most complete library of published astronomical catalogues and data tables available on line organized in a self-documented database. Query tools allow the user to select relevant data tables and to extract and format records matching given criteria. Currently, 17,489 catalogues are available.

VizieR is a joint effort of CDS (Centre de Données astronomiques de Strasbourg) and ESA-ESRIN (Information Systems Division). VizieR has been available since 1996, and was described in a paper published in A&AS 143, 23 (2000).

Note that VizieR does not contain all available online catalogues; some catalogues are not suitable and some less frequently used catalogues have not yet been incorporated into the VizieR database. These last ones can be accessed by FTP from the Astronomer's Bazaar.

Astronomer's Bazaar

http://cdsarc.u-strasbg.fr/viz-bin/Cat?menu=on

- **18571** catalogues available from CDS … (updated in July 2018)
- … of which **17893** are available on-line (as full ASCII or FITS files) …
- … of which **17602** are also available through the VizieR browser.

VizieR tutorials

Basic: http://cds.u-strasbg.fr/tutorial/vizier/viziertutorial.pdf

Advanced: http://cds.u-strasbg.fr/tutorial/vizier/advancedviziertutorial.pdf

Rules of usage

The VizieR Information System provides a standardized description of astronomical catalogs, and generally a free access to the data contained therein, essentially dedicated to a scientific usage. The data retrieved with VizieR are **free of usage in a scientific context**; however, as it is the usage in scientific publication, the original authors and publication references including the publisher have to be explicitly cited (see section Code of conduct of scientific research).

An acknowledgment of the usage of VizieR, as described here, and it would be appreciated.

The **commercial usage** of the data is subject to rules depending of the origin (see section How to search Copyright information).

The Information system including the metadata is private and reserved to the CDS.

Important: **Code of conduct of scientific research**

Proper acknowledgement of the work of others should always be given, and complete referencing is an essential part of any astronomical research publication. Authors have an obligation to their colleagues and the scientific community to include a set of references that communicates the precedents, sources, and context of the reported work. ***Deliberate omission of a pertinent author or reference is unacceptable.*** Data provided by others must be cited appropriately, even if obtained from a public database.

All authors are responsible for providing prompt corrections or retractions if errors are found in published works with the first author bearing primary responsibility.

Plagiarism is the presentation of others' words, ideas or scientific results as if they were one's own. Citations to others' work must be clear, complete, and correct. Plagiarism is unethical behavior and is never acceptable.

These statements apply not only to scholarly journals but to all forms of scientific communication including but not limited to press releases, proposals, websites, popular books, and podcasts.

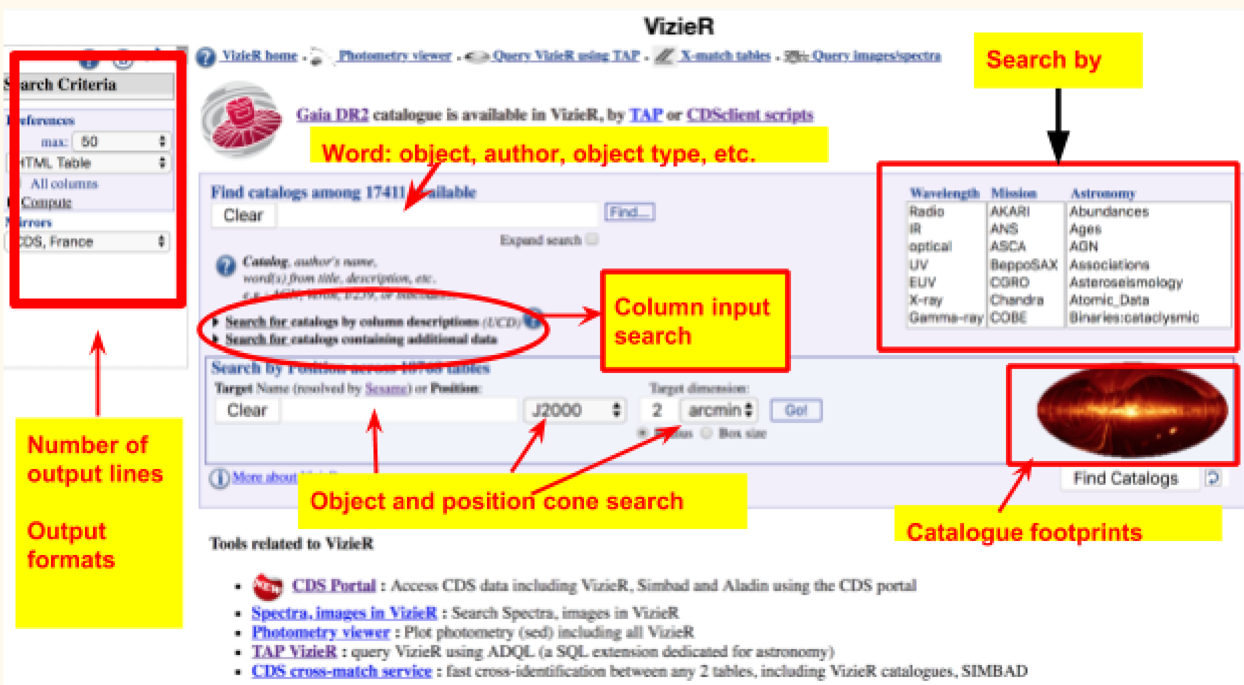
AAS Ethics Statement

More information about ethics in science are in the American Astronomical Society web-page.

https://aas.org/about/policies/aas-ethics-statement

Searching and retrieving information from VizieR

- ★ Free text search
- ★ Position (coordinates or object)
- ★ Classic advanced form



Free text and position searches

Catalogues in VizieR can be searched directly using the web-form by different ways: words, target search, wavelength regime, mission or astronomical keyword. All of them can be combined.

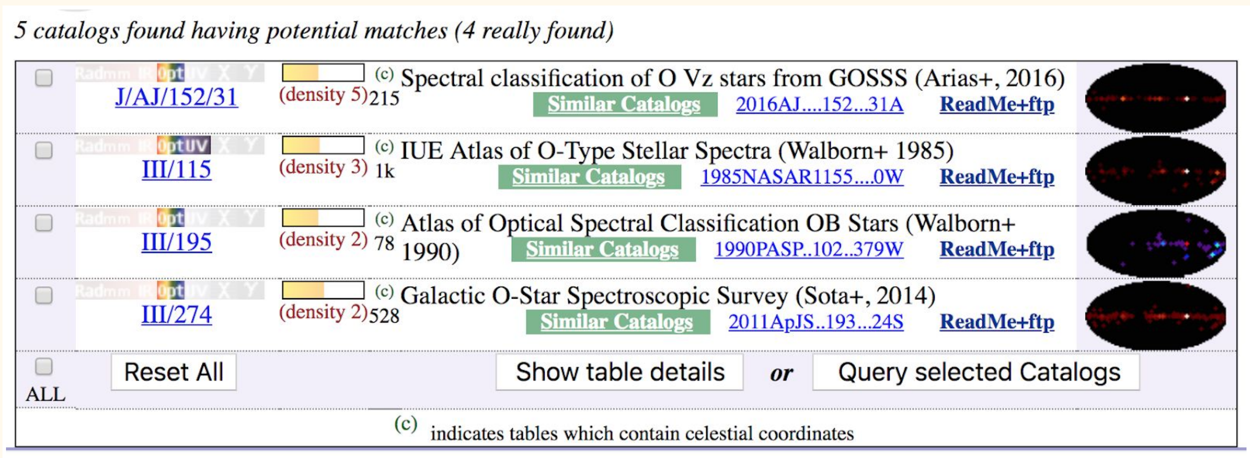
- ★ By **words** using free text or predefined keywords (it includes author, catalog name, title, description, etc.)

★ By **target** name, it is resolved by Sesame or **position**, within a radius or box of a given size.

★ By **contents** to search a type of data inside catalogs, searching catalogs containing a table which have a **column with a given type**, as they are described by the **Unified Content Descriptors** (see UCD). The **UCD** is the vocabulary describing astronomical data quantities and it is controlled by the IVOA. The current version is UCD1+.

All modes can be combined simultaneously and an estimation of number of catalogues.

For example, searching catalogues: **Walborn** as author, checking wavelength: **Optical**, and objects 2' around the star **eta Car**, we can retrieve four catalogues, see Figure.



In the query result there are several features to be remarked:

a) The name of the catalogues, categories as they are stored is here, i.e. J/AJ/152/31 is a catalogue from Astronomical Journal, 152, 31; III/115 is a catalogue about spectroscopic data.
b) A color bar over the name of the catalogue marks the catalogue's wavelength domain.
c) The popularity and density of the catalogues, for example clicking in the first catalogue, you get an histogram with the access to the catalogue.
d) The number of entries in the catalogue, i.e. III/274 has 528 lines.
e) Title of the catalogue, link to the ADS, search of similar catalogues.
f) Readme and FTP direct access to the catalogue.
g) Sky footprint of the catalogue.

Selecting a catalogue, you can query through a web-form, which contains many options and features.

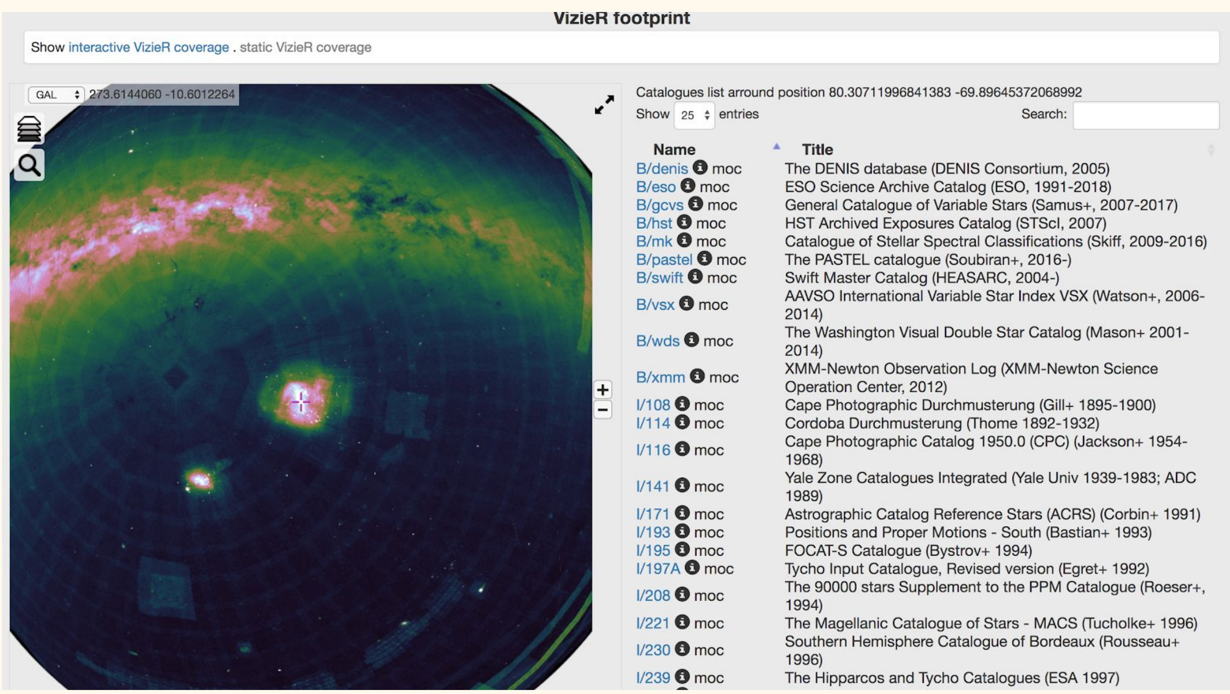
a) Searching by only one target/position or a list (to be uploaded).

b) **Querying by** [simple constraint]() or a list of constraints (to be uploaded). You can select which columns will be **retrieved** and how the data **sorted**.
c) **Preferences box** appears on the left. There, you can select the **output format** (VOTable, ascii, FITS, XML, etc.), the number of lines, and compute different coordinates (Galactic, B1950, distance from the searching position, etc.)

For example, searching the stars **10' around the position of eta Car** in the catalogue **III/274**, and obtaining the results in ASCII format. Also, if you are interested in all stars in that catalogue labeled as triple systems, in the cell "**SB**" fill the character value "**SB3**" (see the note in the table), the result is six entries.

VizieR Mine

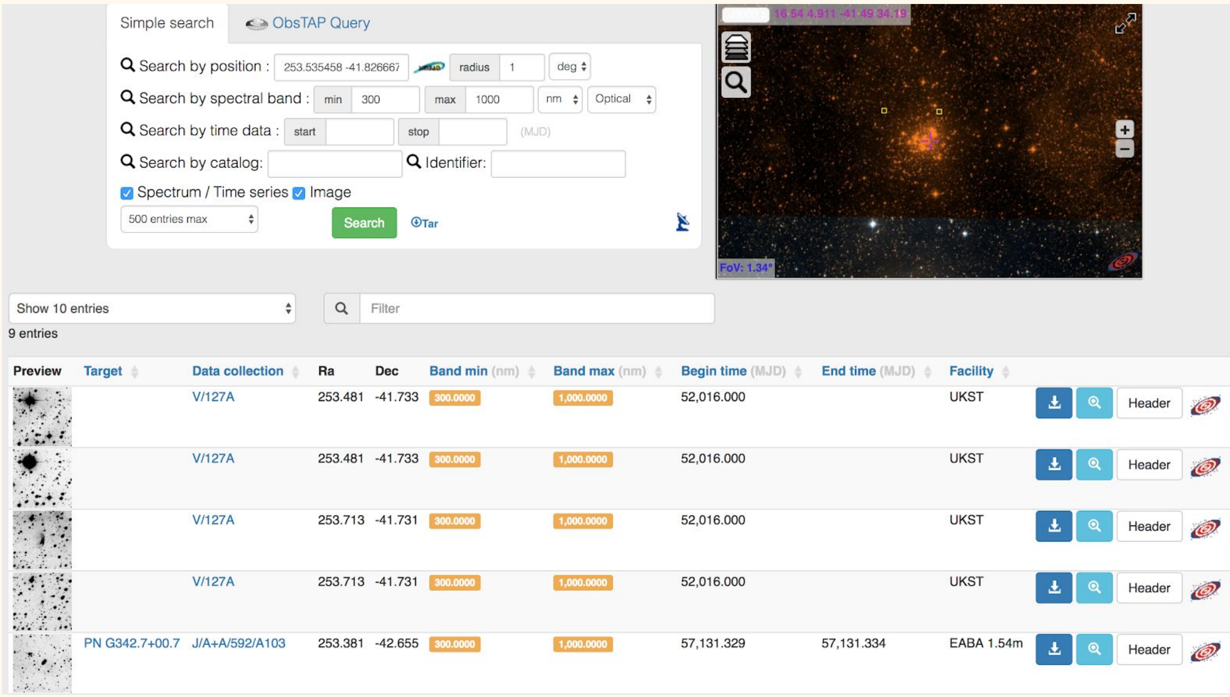
Vizier Mine is a service to explore catalogue footprint directly on the sky.



VizieR images and spectra service

This service is an access to the VizieR Associated data (images, spectra, time-series, SED) which comes from publications. This tool is the results of the documentation assigend by the authors of the catalogues and supervised by the CDS documentalist team (see the Vizier ingestion tool).

The meta-data and the search engine are built according to the VO framework (SIA, SSA, ObsTAP) and can so be queried by VO softwares. The data are gathered with the Saada engines, and the VO data model ObsCore has been chosen for the documentation.



VizieR catalogues having spectra

This service allows you to browse directly through catalogues having associated data as images, spectra, time-series, data cubes (3D images), etc. At the moment, there are about 10,500 catalogues with SEDs, images, cubes, spectra, time-series, etc. For example, a search for LAMOST spectra or data:

Catalogues having associated data

Simple list (weekly updated)

- SED (5799 tables)
- Image (267 tables)
- Cube (88 tables)
- Timeserie (3310 tables)
- Spectrum (1118 tables)

Show 50 entries

Search: lamost

Type	Description	Catalogue
SED	Be stars in LAMOST DR1 (Lin+, 2015)	J/other/RAA/15.1325
SED	Be stars in LAMOST DR1 (Lin+, 2015)	J/other/RAA/15.1325
SED	E+A galaxy candidates in LAMOST DR2 (Yang+, 2015)	J/other/RAA/15.1414
SED	LAMOST luminous infrared galaxies (Lam+, 2015)	J/other/RAA/15.1424
SED	LAMOST new QSOs in M31 and M33 vicinity (Huo+, 2015)	J/other/RAA/15.1438
SED	Infrared photometry of DA white dwarfs from LAMOST (Zhang+, 2013)	J/AJ/146/34
SED	New carbon stars from LAMOST survey (Si+, 2015)	J/other/RAA/15.1671

VizieR photometry viewer

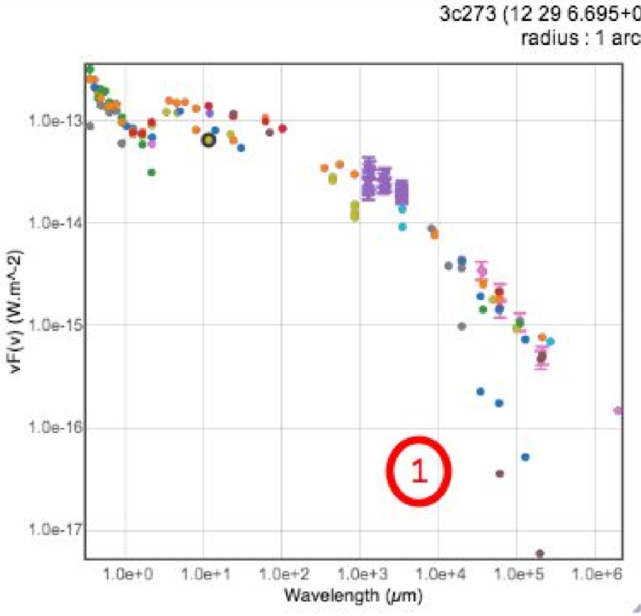
The VizieR photometry viewer is a very interesting tool to build spectral energy distribution in real time. This tool converted automatically into fluxes using photometric system descriptions in the METAfltr VizieR table, assuming some specific conditions and zero-points. There is no correction for reddening applied: unless magnitude values in the original catalogue are already corrected for extinction, values will correspond to the observed reddened flux.

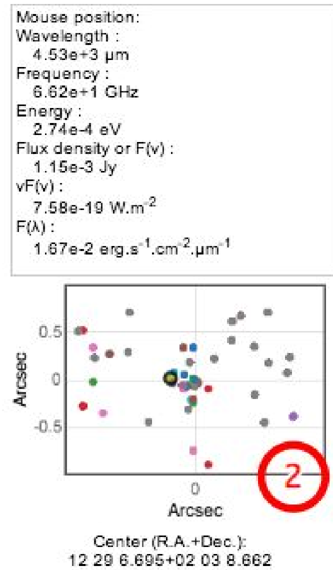
We can start using an object name (resolved by the Sesame service) or a position and a radius (limited to 30''). The user interface is composed by three different panels: 1) the SED builder, 2) the FoV centered in the position, 3) a tabular view of frequencies and flux values for each point in the SED.

These three panels are linked: clicking on a data point in the main plot or in the sky map will highlight the corresponding point in the other plot and in the table. Conversely, clicking on a table row will highlight the corresponding point in the 2 other panels.

The photometric points can be exported (through SAMP) to VO tools like Topcat or Aladin using the dedicated button . They can also be retrieved directly as a VOTable using the following URL pattern: http://vizier.u-strasbg.fr/viz-bin/sed?-c=Target&-c.rs=Radius-in-arcsec

Example: http://vizier.u-strasbg.fr/viz-bin/sed?-c=Vega&-c.rs=1.5 will return the VOTable with photometric points for a 1.5 arcsec region around Vega.





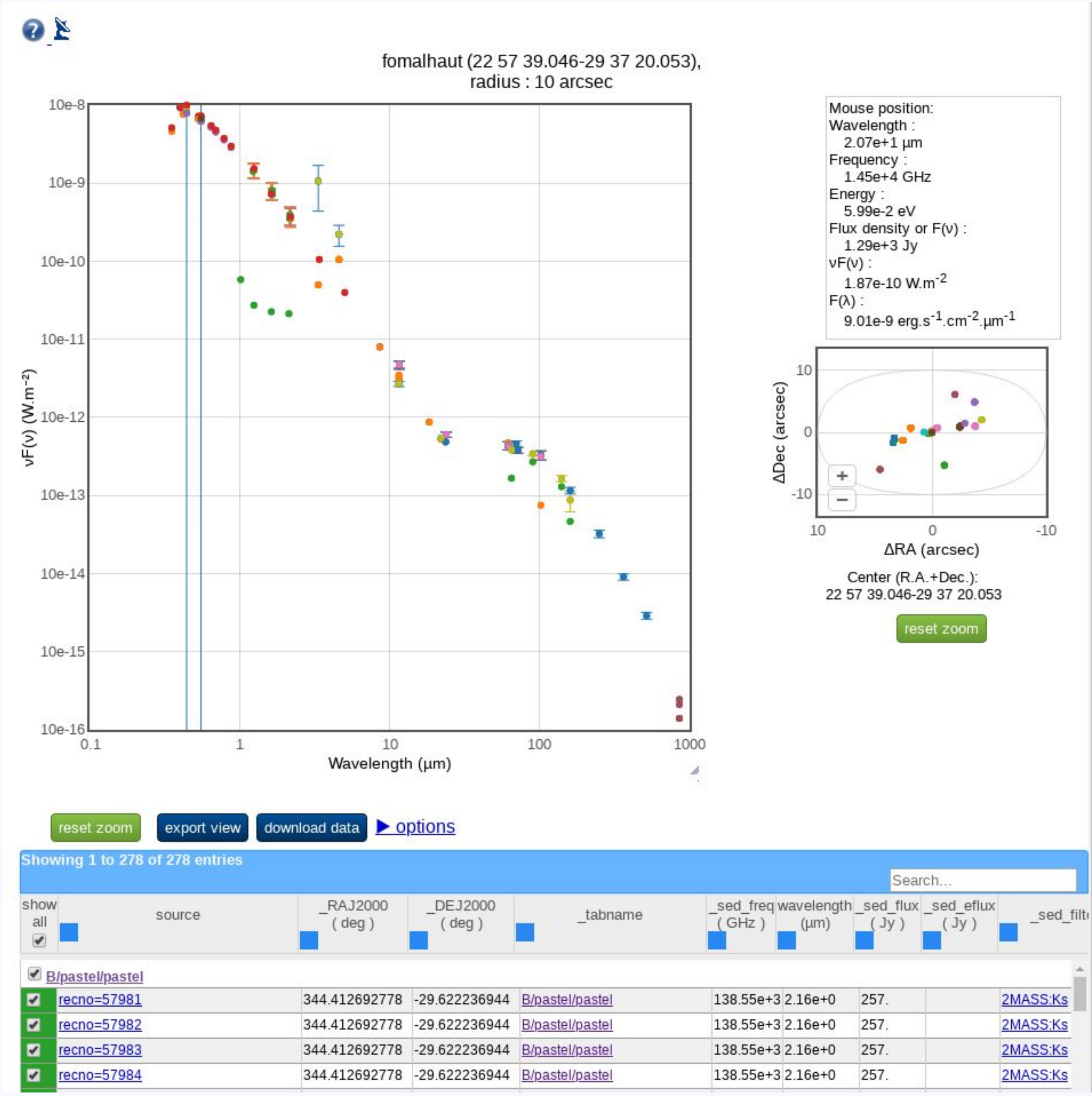
reset zoom

options print reset zoom

Search:

show all	source	_RAJ2000 (deg)	_DEJ2000 (deg)	_tabname	_sed_freq (GHz)	wavelength (μm)	_sed_flux (Jy)	_sed_eflux (Jy)	_sed_filter
✔	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
✔	WISE===J122906.70+020308.6	187.277945	+02.052411	II/311/wise	138.55e+3	2.16e+0	68.0e-3	1.4e-3	2MASS:Ks
✔	WISE===J122906.70+020308.6	187.277945	+02.052411	II/311/wise	181.75e+3	1.65e+0	40.0e-3	1.0e-3	2MASS:H
✔	WISE===J122906.70+020308.6	187.277945	+02.052411	II/311/wise	241.96e+3	1.24e+0	31.0e-3	0.8e-3	2MASS:J
✔	WISE===J122906.70+020308.6	187.277945	+02.052411	II/311/wise	25.934e+3	1.16e+1	0.253	0.003	WISE:W3
✔	WISE===J122906.70+020308.6	187.277945	+02.052411	II/311/wise	65.172e+3	4.60e+0	0.186	0.003	WISE:W2
✔	WISE===J122906.70+020308.6	187.277945	+02.052411	II/311/wise	89.490e+3	3.35e+0	0.138	0.003	WISE:W1
✔ II/314/las8									
✔	-c=\htarg{187.277938+02.052428,eq=J2000}\&-c.rs=0.004	187.277938	+02.052428	II/314/las8	136.21e+3	2.20e+0	51.1e-3	0.0e-3	UKIDSS:K
✔	-c=\htarg{187.277938+02.052428,eq=J2000}\&-c.rs=0.004	187.277938	+02.052428	II/314/las8	183.78e+3	1.63e+0	41.7e-3	0.0e-3	UKIDSS:H
✔ II/319/las9									
✔	recno=53344062	187.277918	+02.052421	II/319/las9	136.21e+3	2.20e+0	51.1e-3	0.0e-3	UKIDSS:K
✔	recno=53344062	187.277918	+02.052421	II/319/las9	183.78e+3	1.63e+0	41.7e-3	0.0e-3	UKIDSS:H

3



TAP VizieR

As Simbad TAP service, the TAP Vizier service provides access to tables and catalogues through ADQL scripts.

The search for catalogues could be done by a free word, author, object name, keyword, etc. The selected catalogues can be queried using ADQL, combining the output. Also, users can upload their tables and combine them.

Examples

Search of proper motion average in the PPMX catalogue around the position of the cluster M44

```
SELECT avg(pmDE), avg(pmRA)

FROM "I/312/sample"

WHERE 1=CONTAINS(POINT('ICRS',"I/312/sample".RAJ2000,"I/312/sample".DEJ2000),
CIRCLE('ICRS', 130.1, 19.6667, 5/60.))
```

Calculate the distance of stars inside the circle of 5’ from Vega in the Carlsberg Meridian Catalogue 15 (CMC15), printing the output also in Galactic coordinates.

```
SELECT cmc15.cmc15,cmc15.RA_ICRS,cmc15.DE_ICRS,POINT('GALACTIC',cmc15.RA_ICRS,
cmc15.DE_ICRS), DISTANCE(POINT('ICRS',279.234734787,
38.783688956),POINT('ICRS',cmc15.RA_ICRS, cmc15.DE_ICRS))

FROM "I/327/cmc15" as cmc15

WHERE 1=CONTAINS(POINT('ICRS',cmc15.RA_ICRS,cmc15.DE_ICRS), CIRCLE('ICRS',
279.234734787, 38.783688956, 5/60.))
```

From Table 2 of the YSO catalogue "J/A+A/542/A66" return positions, identifiers and magnitudes when B - V > 2.0

```
SELECT TOP 10 t2.SAGE, t2.RAJ2000, t2.DEJ2000, t2.Umag, t2.Bmag, t2.Vmag,
t2.Imag, t2.Jmag, t2.Hmag, t2.Kmag, Bmag - Vmag as B_V

FROM "J/A+A/542/A66/table2" as t2

WHERE t2.Bmag - t2.Vmag > 2
```

TAP VizieR and Python Astroquery

As a TAP service, VizieR also can be accessed using astroquery module in Python. For VizieR queries examples, here.

Examples

Table discovery:

```
from astroquery.vizier import Vizier
catalog_list = Vizier.find_catalogs('Sota O-stars')
print("\n".join(" = ".join((str(k),str(v.description))) for k,v in catalog_list.items()))

III/274 = Galactic O-Star Spectroscopic Survey (Sota+, 2014)

J/ApJ/710/L30 = On the multiplicity of the O star Herschel 36 (Arias+, 2010)

J/A+A/546/A92 = Spectra of HD 120678 (Gamen+, 2012)

J/A+A/588/L6 = WASP-12 transit light curves (Maciejewski+ 2016)

J/AJ/152/31 = Spectral classification of O Vz stars from GOSSS (Arias+, 2016)
```

Complete table download, for example the main Table III/274:

```
from astroquery.vizier import Vizier

catalog_list = Vizier.find_catalogs('Sota O-stars')
Vizier.ROW_LIMIT=-1
catalogs=Vizier.get_catalogs(catalog_list.keys())

print(catalogs)

TableList with 10 tables:

    '0:III/274/main' with 14 column(s) and 448 row(s)

    '1:III/274/notes' with 2 column(s) and 31 row(s)

    '2:III/274/refs' with 4 column(s) and 49 row(s)
```

'3:J/ApJ/710/L30/table1' with 9 column(s) and 63 row(s)

'4:J/A+A/546/A92/table2' with 5 column(s) and 30 row(s)

'5:J/A+A/546/A92/spectra' with 5 column(s) and 10 row(s)

'6:J/A+A/588/L6/w12new' with 5 column(s) and 11657 row(s)

'7:J/A+A/588/L6/w12rer' with 5 column(s) and 7038 row(s)

'8:J/AJ/152/31/single' with 13 column(s) and 177 row(s)

'9:J/AJ/152/31/table3' with 13 column(s) and 38 row(s)

```
catalogs[0].write('my_catalog.tex',format='latex')
```

Query by object:

```
from astroquery.vizier import Vizier

result=Vizier.query_object("HD 164019")

print(result)

interesting=result['III/274/main']

print(interesting)
```

```
TableList with 168 tables:

'0:I/108/cpd' with 8 column(s) and 2 row(s)

'1:I/114/cd' with 8 column(s) and 1 row(s)

GOS           Name     HD   m_HD   RAJ2000      DEJ2000    SpT  LCl Qual SpT2 Pap  BS  M
SimbadName

                                        "h:m:s"      "d:m:s"

--------------- --------- ------ ---- ------------ ------------ ---- --- ---- ---- ---
--- --- ----------

001.91-02.62_01 HD 164019 164019       18 00 19.956 -28 37 14.66 O9.5  IV    p      S14
yes   1  HD 164019
```

Query in a region:

```
from astroquery.vizier import Vizier

from astropy.coordinates import Angle
```

```
catalog = 'III/274/main'

result = Vizier.query_region("eta Car", radius=Angle(0.1, "deg"), catalog=catalog)

print(result)

interesting=result[catalog]

print(interesting)
```

Specifying keywords, output columns and constraining columns, for example, a search 5' around eta Car, and printing the sky distance to the star, coordinates and spectral types

```
from astroquery.vizier import Vizier

v = Vizier(columns=['Name','+_r', 'RAJ2000', 'DEJ2000','SpT','LCl','Qual'])

result = v.query_region("eta Car",catalog='III/274/main',radius="5m")

print(result["III/274/main"])
```

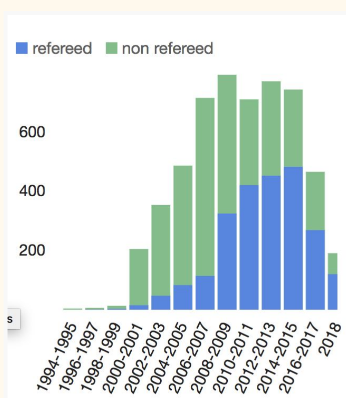
Exercises

a) Search catalogues using LAMOST data (take the option max_catalogs to a large number).
b) More specifically, those LAMOST catalogues with quasars.
c) Download the catalogue published by Huo et al. (2015) about QSO around M31 and M33 in VOTable format.

Open Question: are Virtual Observatories dying?

Search in the new ADS the concept "virtual observatory" in the Astronomy database between 1990-2018.

I've got 2334 entries (try to get that number), for refereed papers, 5463 in total.



Aladin & TopCat

Aladin is an interactive sky atlas allowing the user to visualize digitized astronomical images or full surveys, superimpose entries from astronomical catalogues or databases, and interactively access related data and information from the *Simbad database*, the *VizieR service* and other archives for all known astronomical objects in the field.

TOPCAT is an interactive graphical viewer and editor for tabular data. Its aim is to provide most of the facilities that astronomers need for analysis and manipulation of source catalogues and other tables, though it can be used for non-astronomical data as well. It understands a number of different astronomically important formats (including FITS, VOTable and CDF) and more formats can be added.

It offers a variety of ways to view and analyse tables, including a browser for the cell data themselves, viewers for information about table and column metadata, and facilities for sophisticated interactive 1-, 2-, 3- and higher-dimensional visualisation, calculating statistics and joining tables using flexible matching algorithms. Using a powerful and extensible Java-based expression language new columns can be defined and row subsets selected for separate analysis. Table data and metadata can be edited and the resulting modified table can be written out in a wide range of output formats.

It is a stand-alone application which works quite happily with no network connection. However, because it uses Virtual Observatory (VO) standards, it can cooperate smoothly with other tools, services and datasets in the VO world and beyond.

The program is written in pure Java and available under the GNU General Public Licence, though some of the library code is LGPL. It has been developed mostly in the UK within various UK and Euro-VO projects (Starlink, AstroGrid, VOTech, AIDA, GAVO, GENIUS, DPAC) and under PPARC and STFC grants. Its underlying table processing facilities are provided by the related packages STIL and STILTS.

SAMP applications

Both Aladin and TopCat are SAMP compatible applications. SAMP (Simple Application Messaging Protocol) is a protocol for communication between client-side astronomy applications. Concretely, it allows you to send data to another SAMP compatible application and select some of them and see the corresponding selection into the other application.

SAMP is a three parts mechanism : two applications (or possibly more) and one "hub" for forwarding messages and data from one application to the other. It exists several SAMP hub implementations.

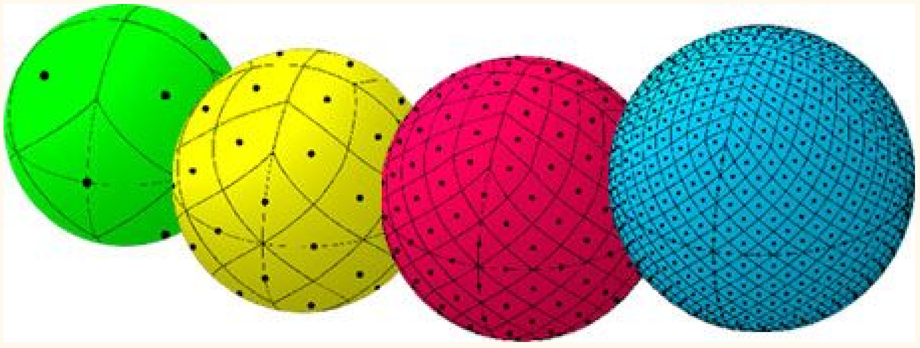
MOCs, HiPS, HEALPix: I'm lost!

New technologies imply new vocabulary!

MOCs and HiPS are based on the same HEALPix sky tesselation (mosaicing). But MOC is used for describing sky coverage, and HiPS is used for accessing data (pixels, catalog sources...).

HEALPix

HEALPix is an acronym for **H**ierarchical **E**qual **A**rea iso**L**atitude **Pix**elization of a sphere. As suggested in the name, this pixelization produces a subdivision of a spherical surface in which each pixel covers the same surface area as every other pixel. The figure below shows the partitioning of a sphere at progressively higher resolutions, from left to right. The green sphere represents the lowest resolution possible with the HEALPix base partitioning of the sphere surface into 12 equal sized pixels. The yellow sphere has a HEALPix grid of 48 pixels, the red sphere has 192 pixels, and the blue sphere has a grid of 768 pixels (~7.3 degree resolution).



Another property of the HEALPix grid is that the pixel centers, represented by the black dots, occur on a discrete number of rings of constant latitude, the number of constant-latitude rings is dependent on the resolution of the HEALPix grid. For the green, yellow, red, and blue spheres shown, there are 3, 7, 15, and 31 constant-latitude rings, respectively. The software is here.

For example to represent a full-sky map with a spatial resolution of about 0.2 arcsecond is needed 13,194,139,533,312 pixels (about 13 billions).

MOC: Multi-order Coverage Map

A Multi-Order Coverage map, also called "MOC", is a method for describing arbitrary sky regions. Its goal is to be able to provide a very fast comparison mechanism between coverage maps. The mechanism is based on the HEALPix sky tessellation algorithm. It is essentially a simple way to map regions of the sky into hierarchically grouped predefined cells. Concretely, a

MOC is a list of HEALPix cell numbers, stored in a FITS binary table. MOC is fully described by an IVOA standard available at this address: http://www.ivoa.net/documents/MOC/

HiPS: Hierarchical Progressive Survey

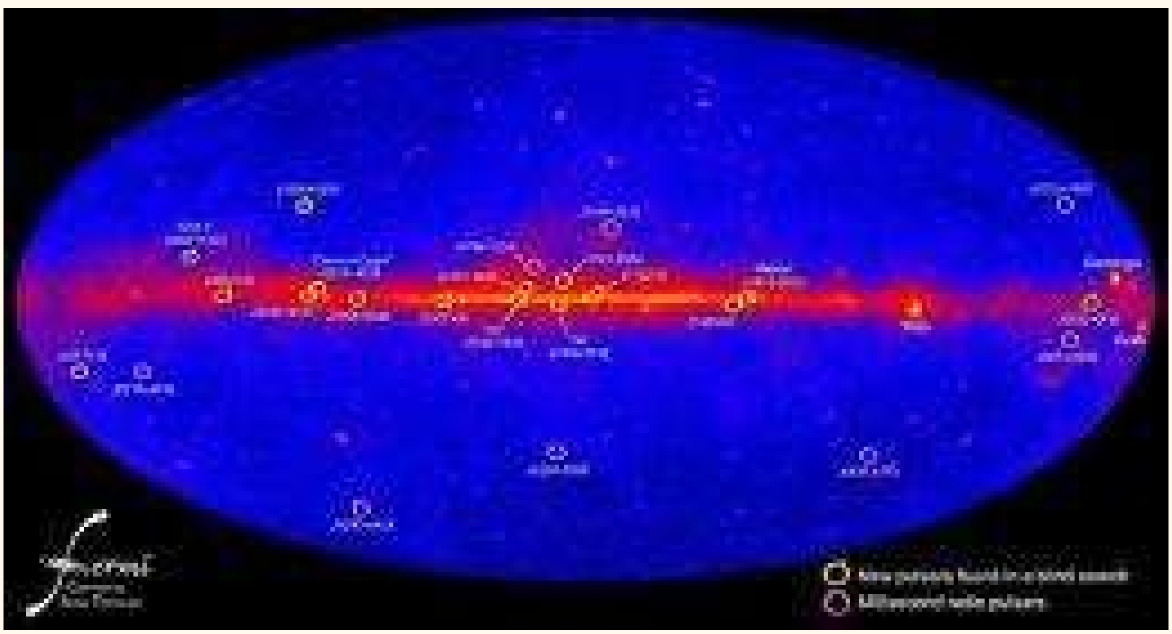
Since version 7, Aladin provides access to progressive sky surveys with the capability to zoom and pan on any regions. This kind of surveys are called "HiPS". This mode allows you see a survey at any scale, even the whole sky. This method can be used for image surveys, but also for catalogs, notably huge catalogs, density maps, etc.

Multifrequency sky

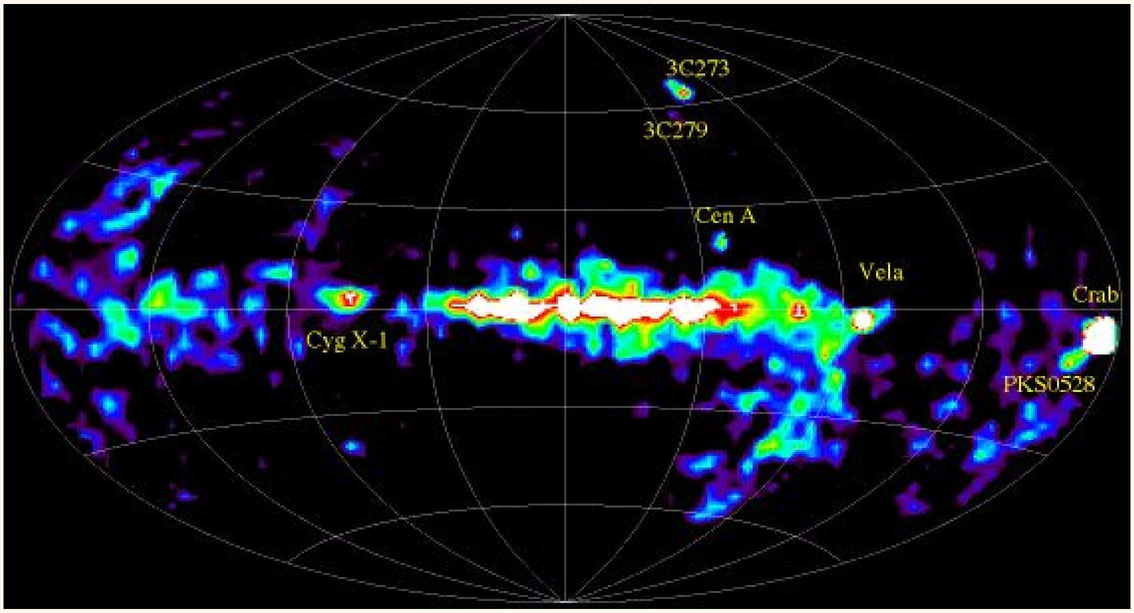
Learn how different astrophysical processes and objects contribute to the radiation observed in the sky.

Learn which missions and surveys have contributed to build our sky-scape.

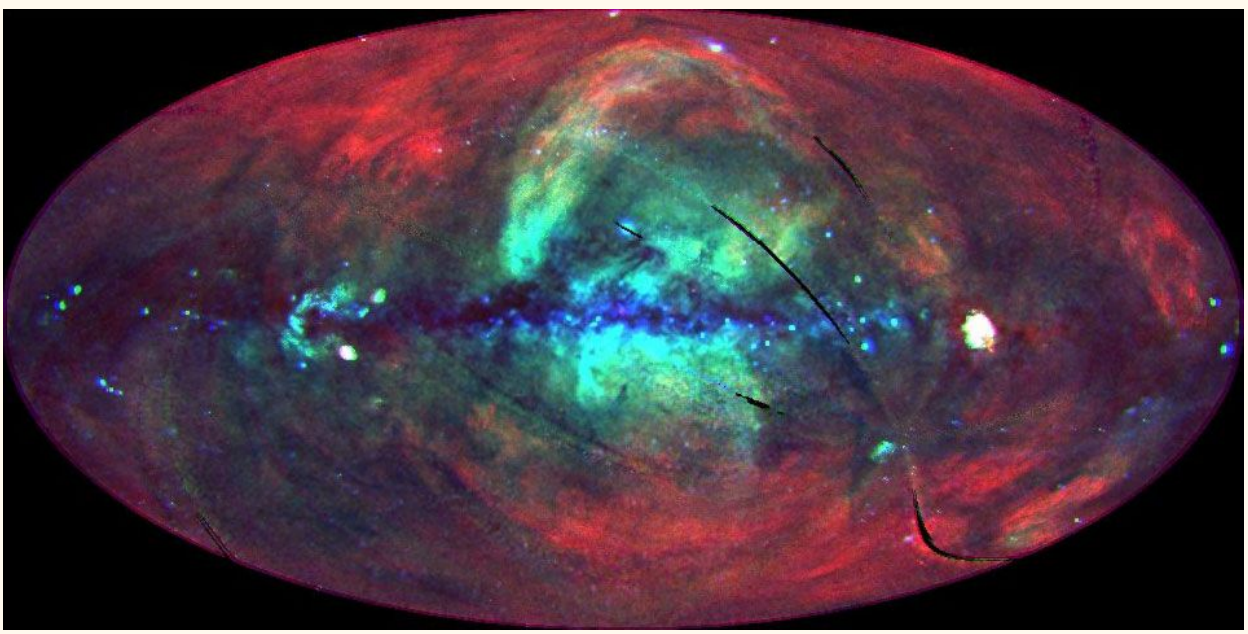
Also, please see the map around your home!! And remember, on your eyes, half is landscape, half is skyscape.



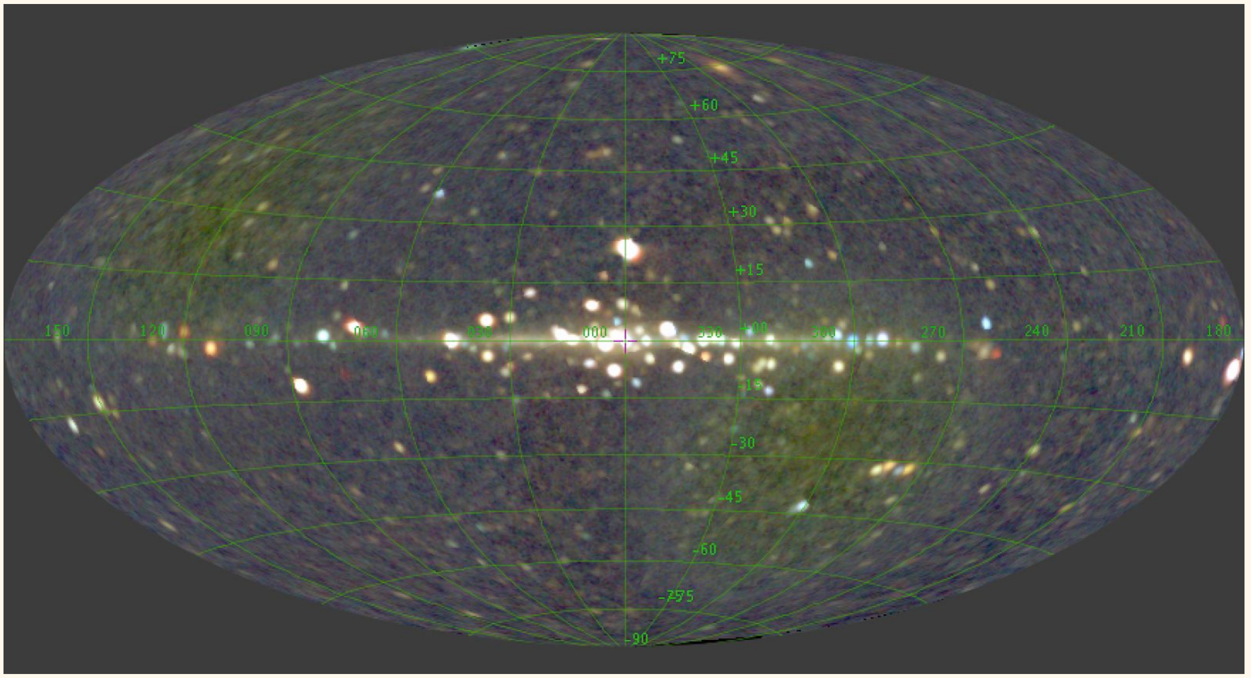
Fermi



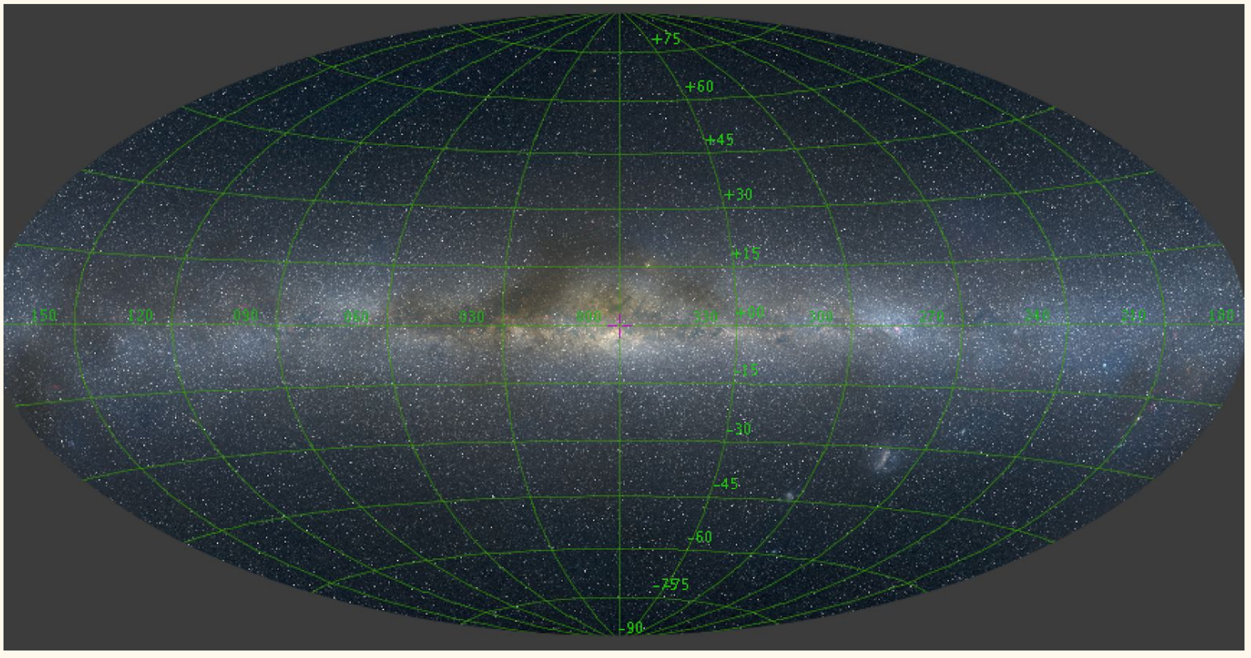
EGRET



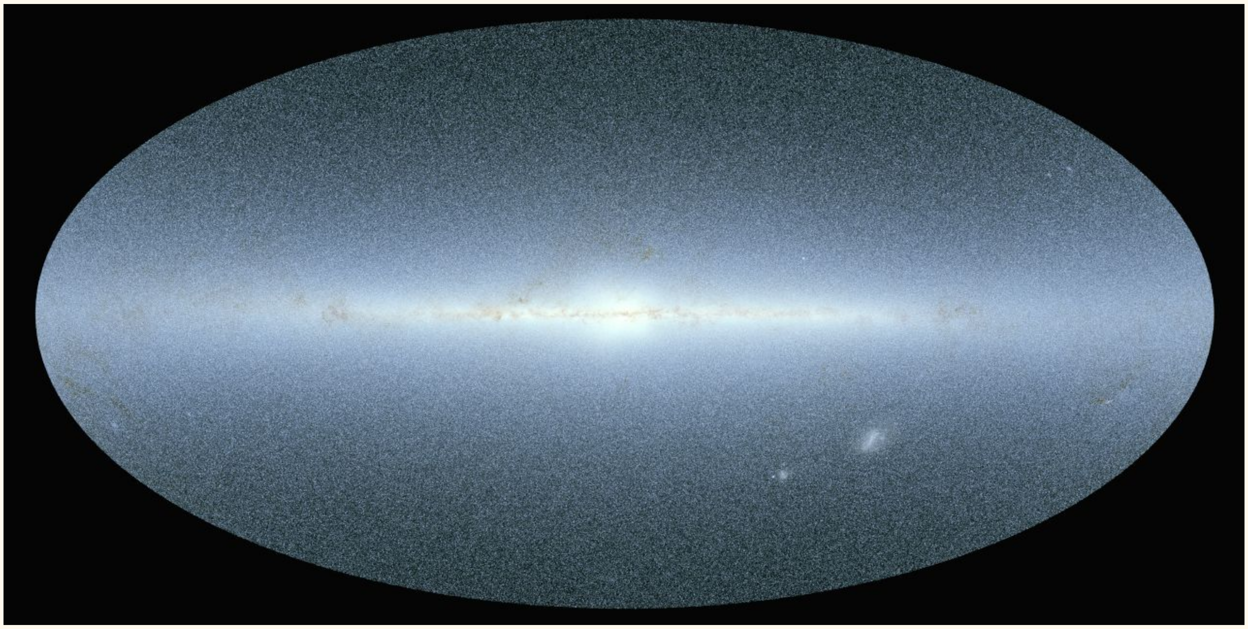
ROSAT



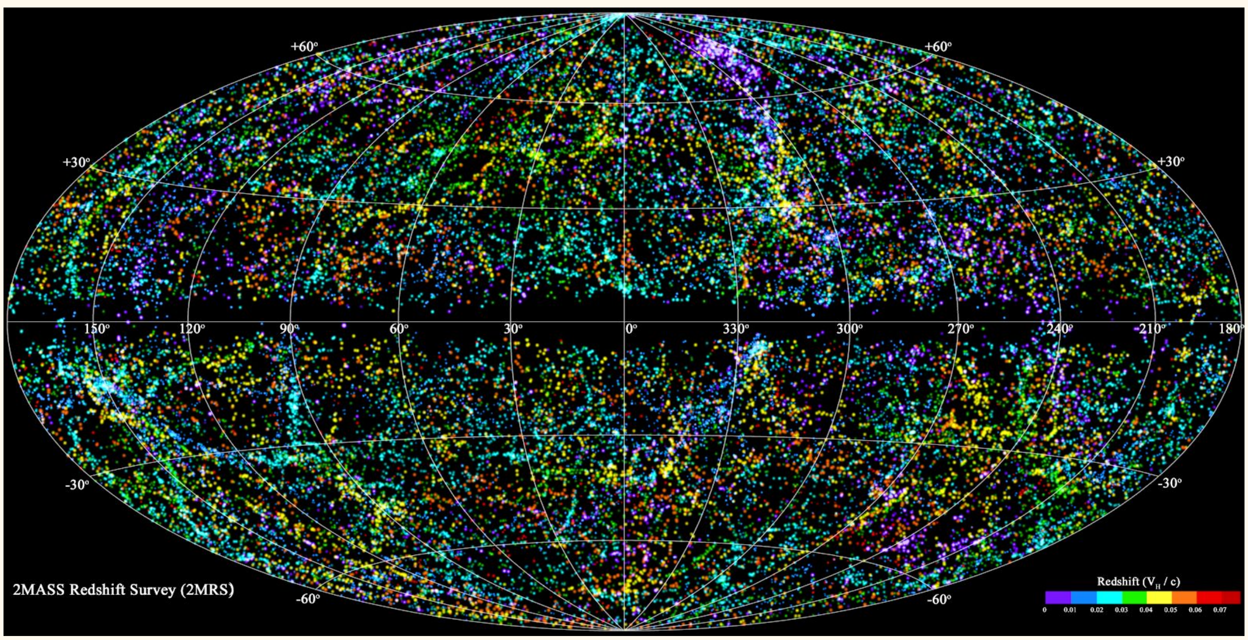
JAXA MAXI



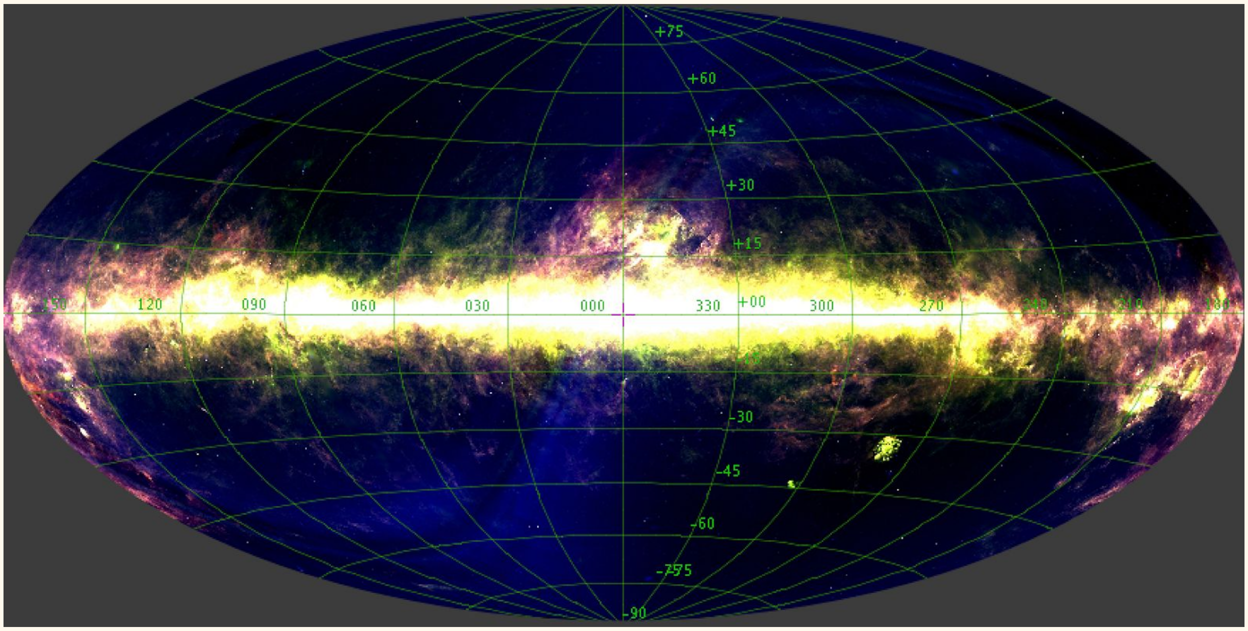
Optical / Mellinger



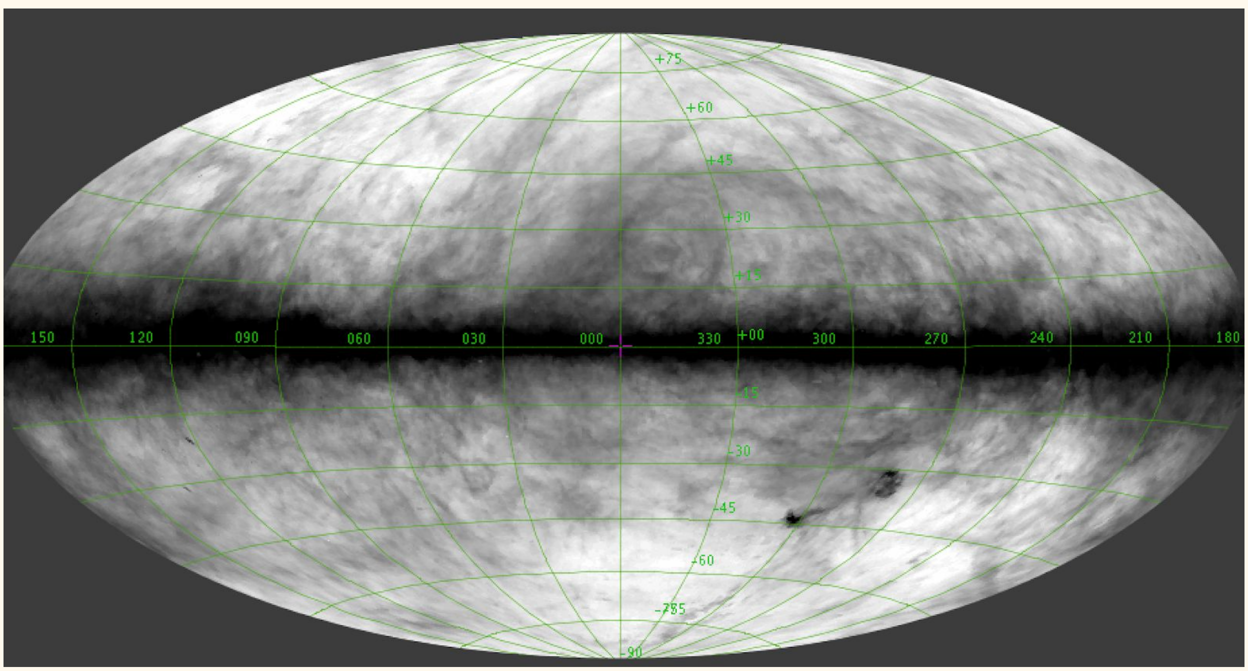
2MASS



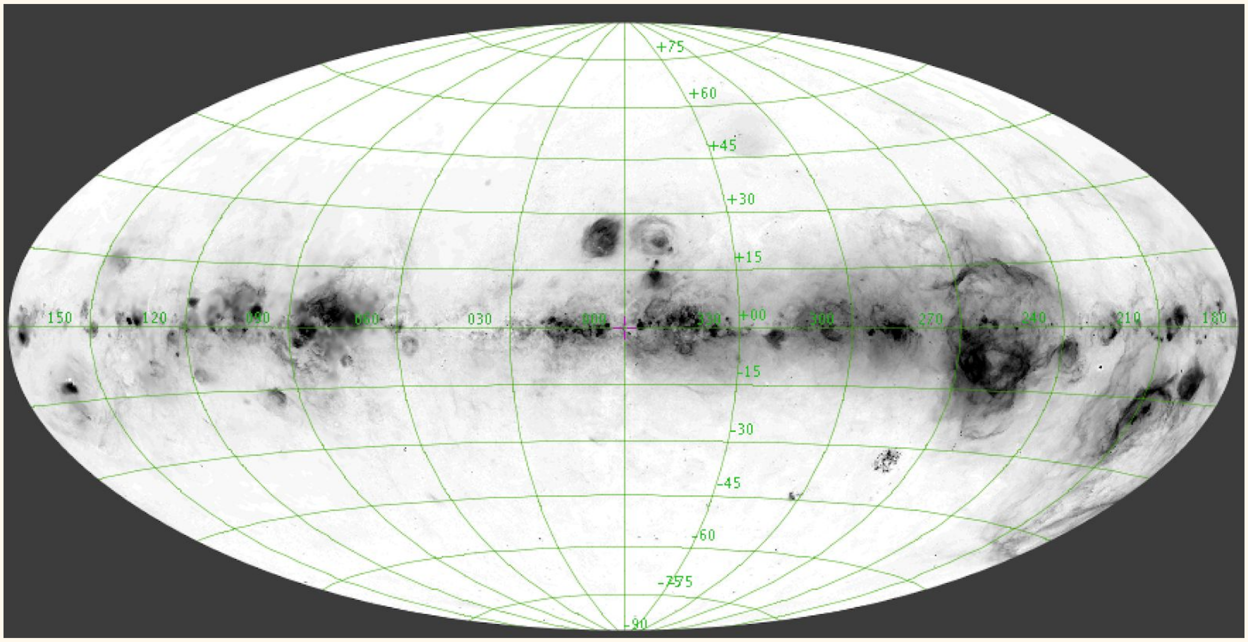
2MASS Galaxy Redshift Map



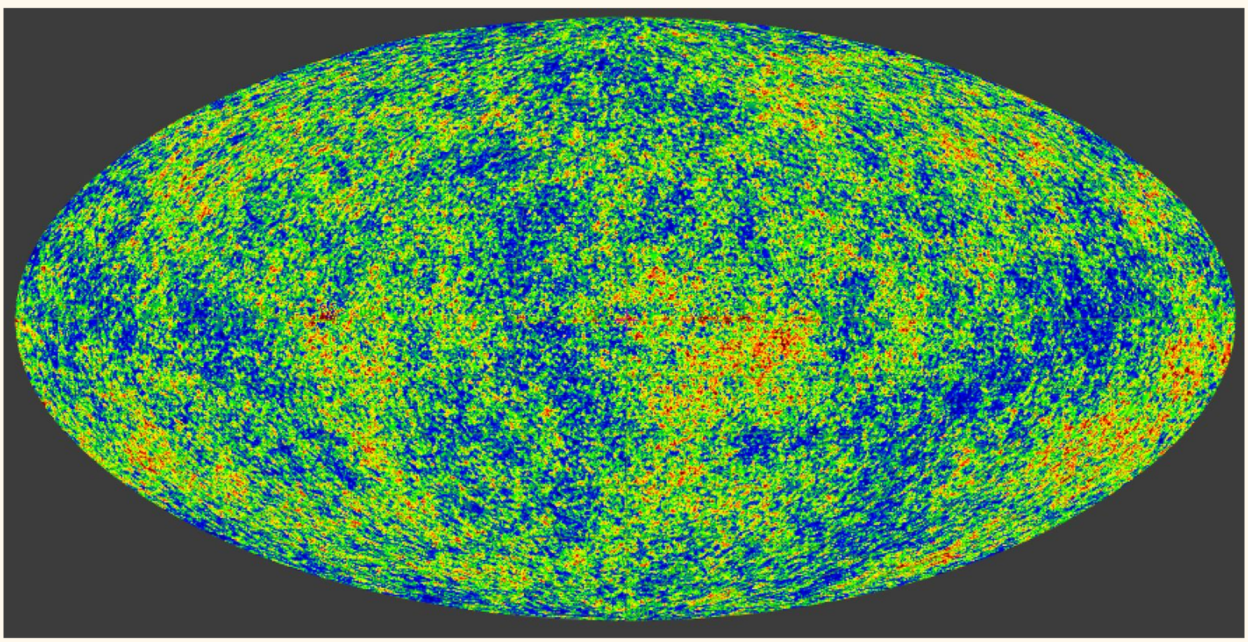
IRAS / IRIS



LAB HI 1420 MHz



Halpha



Planck CMB fluctuations

Examples of VO-like science

New Young Stars and Brown Dwarfs in the Upper Scorpius Association Luhman et al. (2018)

Wide-field Infrared Survey Explorer Catalog of Periodic Variable Stars. Chen et al. (2018)

Radial distribution of stellar motions in Gaia DR2 *Kawata, D. et al. (2018)*

Revisiting hypervelocity stars after Gaia DR2 *Boubert, D. et al. (2018)*

Testing the white dwarf mass-radius relation and comparing optical and far-UV spectroscopic results with Gaia DR2, HST, and FUSE *Joyce, S. R. G. et al. (2018)*

A White Dwarf catalogue from Gaia-DR2 and the Virtual Observatory *Jiménez-Esteban, F. M. et al. (2018)*

Dark Matter in Disequilibrium: The Local Velocity Distribution from SDSS-Gaia *Necib, Lina et al. (2018)*

Three-dimensional interstellar dust reddening maps of the Galactic plane *Chen, B. -Q. Et al. (2018)*

XMMPZCAT: A catalogue of photometric redshifts for X-ray sources

- Ruiz, A. et al. (2018)

2126 Common Proper Motion Pairs so far not WDS Listed

- Knapp, Wilfried (2018)

They Might Be Giants: An Efficient Color-based Selection of Red Giant Stars

- Conroy, Charlie et al. (2018)

Characterising open clusters in the solar neighbourhood with the Tycho-Gaia Astrometric Solution

- Cantat-Gaudin, T. (2018)

Reanalysis of nearby open clusters using Gaia DR1/TGAS and HSOY

- Yen, Steffi X. et al (2018)

The Extremely Luminous Quasar Survey in the SDSS footprint. II. The North Galactic Cap Sample

- Schindler, Jan-Torge et al. (2018)

Distributions of Quasar Hosts on the Galaxy Main Sequence Plane

- Zhang, Zhoujian et al. (2018)

Tomography of the Fermi-LAT γ-Ray Diffuse Extragalactic Signal via Cross Correlations with Galaxy Catalogs

- Xia, Jun-Qing et al. (2018)

Download GAIA DR2 data

First set:

```
SELECT "I/345/gaia2".ra, "I/345/gaia2".ra_error, "I/345/gaia2".dec,
"I/345/gaia2".dec_error, "I/345/gaia2".source_id, "I/345/gaia2".parallax,
"I/345/gaia2".parallax_error, "I/345/gaia2".pmra, "I/345/gaia2".pmra_error,
"I/345/gaia2".pmdec, "I/345/gaia2".pmdec_error, "I/345/gaia2".duplicated_source,
"I/345/gaia2".phot_g_mean_flux, "I/345/gaia2".phot_g_mean_flux_error,
"I/345/gaia2".phot_g_mean_mag, "I/345/gaia2".phot_g_mean_mag_error,
"I/345/gaia2".phot_bp_mean_flux, "I/345/gaia2".phot_bp_mean_flux_error,
"I/345/gaia2".phot_bp_mean_mag, "I/345/gaia2".phot_bp_mean_mag_error,
"I/345/gaia2".phot_rp_mean_flux, "I/345/gaia2".phot_rp_mean_flux_error,
"I/345/gaia2".phot_rp_mean_mag, "I/345/gaia2".phot_rp_mean_mag_error,
"I/345/gaia2".bp_rp, "I/345/gaia2".radial_velocity,
"I/345/gaia2".radial_velocity_error, "I/345/gaia2".teff_val,
"I/345/gaia2".a_g_val, "I/345/gaia2".e_bp_min_rp_val, "I/345/gaia2".radius_val,
"I/345/gaia2".lum_val
FROM "I/345/gaia2" WHERE "I/345/gaia2".parallax > 5.0
AND ("I/345/gaia2".parallax_error / "I/345/gaia2".parallax) < 0.1
AND (ABS("I/345/gaia2".pmra)) > 1.0
AND (ABS("I/345/gaia2".pmdec)) > 1.0
```

http://xeneize.dfuls.cl/~rbarba/result-gaia-example-t2.xml

Second set:

```
SELECT "I/345/gaia2".ra, "I/345/gaia2".ra_error, "I/345/gaia2".dec,
"I/345/gaia2".dec_error, "I/345/gaia2".source_id, "I/345/gaia2".parallax,
"I/345/gaia2".parallax_error, "I/345/gaia2".pmra, "I/345/gaia2".pmra_error,
"I/345/gaia2".pmdec, "I/345/gaia2".pmdec_error, "I/345/gaia2".duplicated_source,
"I/345/gaia2".phot_g_mean_flux, "I/345/gaia2".phot_g_mean_flux_error,
"I/345/gaia2".phot_g_mean_mag, "I/345/gaia2".phot_g_mean_mag_error,
"I/345/gaia2".phot_bp_mean_flux, "I/345/gaia2".phot_bp_mean_flux_error,
"I/345/gaia2".phot_bp_mean_mag, "I/345/gaia2".phot_bp_mean_mag_error,
"I/345/gaia2".phot_rp_mean_flux, "I/345/gaia2".phot_rp_mean_flux_error,
"I/345/gaia2".phot_rp_mean_mag, "I/345/gaia2".phot_rp_mean_mag_error,
"I/345/gaia2".bp_rp, "I/345/gaia2".radial_velocity,
"I/345/gaia2".radial_velocity_error, "I/345/gaia2".teff_val,
"I/345/gaia2".a_g_val, "I/345/gaia2".e_bp_min_rp_val, "I/345/gaia2".radius_val,
"I/345/gaia2".lum_val
```

```
FROM "I/345/gaia2" WHERE "I/345/gaia2".parallax > 3.0
AND ("I/345/gaia2".parallax_error / "I/345/gaia2".parallax) < 0.1
AND (ABS("I/345/gaia2".pmra)) > 1.0
AND (ABS("I/345/gaia2".pmdec)) > 1.0
AND "I/345/gaia2".phot_g_mean_mag < 16.0
```

http://xeneize.dfuls.cl/~rbarba/result-gaia-example-t4.xml

Mg = g - 5 * log10 (1000. / Parallax - 1.)
Parallax is in milli-arcsecond

Aladin filters to select stars in 2MASS catalogues

http://xeneize.dfuls.cl/~rbarba/hot-all.ajs
http://xeneize.dfuls.cl/~rbarba/cool-all.ajs