

# The Hitchhiker's Guide to Astronomical Databases

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# Overview

## ■ Simbad and VizieR catalogs

- Basic handling, searching the catalogs
- Export of tables

## ■ TopCat

- Basic handling
- Processing tables and creating plots
- Cross-matching tables
- TAP queries

## ■ Useful Python libraries

- Astroquery
- PyStilts
- Pandas

Simbad and Vizier catalogs

# Strasbourg astronomical Data Center (CDS)

- Strasbourg astronomical Data Center (CDS) is dedicated to the collection and worldwide distribution of astronomical data and related information
- The CDS mission is to:
  - Collect useful information concerning astronomical objects that is available in computerized form
  - Upgrade these data by critical evaluations and comparisons
  - Distribute the results to the astronomical community
  - Conduct research, using these data



## CDS



**CDS** Centre de Données astronomiques de Strasbourg  
Strasbourg astronomical Data Center

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

**Other services**

 X-match
  Dictionary
  Sesame
  SimPlay

**Latest news**

- HSC (Hyper Suprime-Cam) DR2 HiPS available
- hips2fits: fast generation of FITS images cutouts from HiPS
- Catalogs added between 22-Feb-2020 and 29-Feb-2020
- Catalogs added between 15-Feb-2020 and 22-Feb-2020
- Catalogs added between 08-Feb-2020 and 15-Feb-2020

[More news](#)

Figure: The home page of CDS.

# Strasbourg astronomical Data Center (CDS)

## ■ The CDS hosts:

- **SIMBAD** astronomical database, the world reference database for the identification of astronomical objects
- **VizieR** catalogue service for the CDS reference collection of astronomical catalogues and tables published in academic journals
- **Aladin** interactive software sky atlas for access, visualization and analysis of astronomical images, surveys, catalogues, databases and related data

# Simbad

- **SIMBAD** (the Set of Identifications, Measurements and Bibliography for Astronomical Data) is an astronomical database of objects beyond the Solar System.
- **SIMBAD** was created by merging the Catalog of Stellar Identifications (CSI) and the Bibliographic Star Index as they existed at the Meudon Computer Centre until 1979, and then expanded by additional source data from other catalogues and the academic literature.

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- As of 2 March 2020, it contains information for 11,021,649 objects under 35,753,171 different names, with 368,154 bibliographical references and 20,713,563 bibliographic citations.

# Simbad queries

- **SIMBAD** is easily accessible
- It allows queries by
  - Object identifiers
  - Coordinates
  - Bibliographical references
  - And various other criteria ...
- Useful is the query of a list of coordinates: you can upload your own ASCII table and query all its rows in **SIMBAD**

# Simbad

**SIMBAD Astronomical Database - CDS (Strasbourg)**

What is SIMBAD ?

Queries	Documentation	Information
<a href="#">basic search</a>	<a href="#">User's guide</a>	<a href="#">Presentation</a>
<a href="#">by identifier</a>		
<a href="#">by coordinates</a>		<a href="#">Image thumbnails</a>
<a href="#">by criteria</a>	<a href="#">Query by urls</a>	<a href="#">BETA - Mobile version</a>
<a href="#">reference query</a>	<a href="#">Nomenclature Dictionary</a>	
<a href="#">scripts</a>	<a href="#">Object types</a>	<a href="#">SimWatch</a>
<a href="#">TAP queries</a>	<a href="#">List of journals</a>	
	<a href="#">Measurement description</a>	<a href="#">Release:</a>
<a href="#">options</a>	<a href="#">Spectral type coding</a>	<a href="#">SIMBAD4 1.7 - May-2018</a>
	<a href="#">User annotations documentation</a>	<a href="#">Release history</a>
<a href="#">Display all user annotations</a>	<a href="#">Acknowledgment</a>	

Content	Basic search
<p>The SIMBAD astronomical database provides basic data, cross-identifications, bibliography and measurements for astronomical objects outside the solar system.</p> <p>SIMBAD can be queried by object name, coordinates and various criteria. Lists of objects and scripts can be submitted.</p> <p>Links to some other on-line services are also provided.</p>	<div> <input type="text"/> </div> <p>identifier, coordinates (radius=10 arcmin), or bibcode</p> <p> <input type="button" value="SIMBAD search"/> <input type="button" value="clear"/> <input type="button" value="help"/> </p>

Figure: The home page of Simbad catalog.

# Simbad - Coordinate query

**SIMBAD: Query by coordinates**

**other query modes :**
Identifier query
Coordinate query
Criteria query
Reference query
Basic query
Script submission
TAP
Output options
Help

**Enter coordinates:**

**Coordinates:** 

*The following writings are allowed:*  
 20 54 05.289 +37 01 17.38  
 10:12:45.3-45:17:50  
 15h17m-11d10s  
 15h17+9d15  
 275d11m15.6954s+17d59m59.876s  
 12.34567h-17.87654d  
 350.123456d-17.33333d <=> 350.123456 -17.33333

define the input : system : FKS epoch : 2000 equinox : 2000

or choose : -- a predefined frame --

define a radius : 2 arc min

submit query
clear
 Preview

**Query a list of coordinates**

**Enter the name of an ASCII file produced by a text editor containing one coordinate per line:**
Browse...
No file selected.

submit file
clear

If you have a high number of coordinates to submit, please use the dedicated and faster service offered by CDS where you can select your file and SIMBAD: [CDS-Xmatch](#)

Figure: Simbad query by coordinates.

# Simbad - Query from a list

**SIMBAD: Query by coordinates**

**other query modes :** Identifier query | Coordinate query | Criteria query | Reference query | Basic query | Script submission | TAP | Output options | Help

**Enter coordinates:**

**Coordinates:**

*The following writings are allowed:*  
 20 54 05.289 +37 01 17.38  
 10:12:45.3-45:17:50  
 15h17m-11d10s  
 15h17+9d15  
 275d11m15.6954s+17d59m59.876s  
 12.34567h-17.87654d  
 350.123456d-17.33333d <=> 350.123456 -17.33333

define the input : system : FKS epoch : 2000 equinox : 2000

or choose : -- a predefined frame --

define a radius : 2 arc min

**Query a list of coordinates**

**Enter the name of an ASCII file produced by a text editor containing one coordinate per line:**  No file selected.

If you have a high number of coordinates to submit, please use the dedicated and faster service offered by CDS where you can select your file and SIMBAD: [CDS-Xmatch](#)

Figure: Simbad query from a list.



# VizieR

- **VizieR** is an astronomical catalog service provided by Centre de données astronomiques de Strasbourg (CDS)
- Since 1996, **VizieR** has become a reference point for astronomers worldwide engaged in research, who come to access catalogued data regularly published in astronomical journals
- As of now it contains more than 19586 catalogues

# VizieR

- The **VizieR** service allows you to search for specific objects or bibliographical references
- You can able browse various survey data releases such as Gaia, Hipparcos, Lamost, SLOAN ...

# VizieR

[VizieR home](#) · [Photometry viewer](#) · [Query VizieR using TAP](#) · [X-match tables](#) · [Query images/spectra](#)

**Search Criteria**

**Preferences**  
max: 50  
HTML Table  
All columns  
Compute  
**Mirrors**  
CDS, France

**Find catalogs among 14941 available**  
   
Expand search

**Wavelength**  
Radio  
Millimeter  
IR  
optical  
UV  
EUV  
X-ray

**Mission**  
AKARI  
ANS  
ASCA  
BeppoSAX  
CGRO  
Chandra  
COBE

**Astronomy**  
Abundances  
Ages  
AGN  
Associations  
Asteroseismology  
Atomic Data  
Binaries: cataclysmic

**Search by Position across 21091 tables**  
Target Name (resolved by [Sesame](#)) or Position:  
      
☒ Radius ☐ Box size

[More about VizieR](#)

**Tools related to VizieR**

- [CDS Portal](#) : Access CDS data including VizieR, Simbad and Aladin using the CDS portal
- [Spectra, images in VizieR](#) : Search Spectra, images in VizieR
- [Photometry viewer](#) : Plot photometry (sed) including all VizieR
- [TAP VizieR](#) : query VizieR using ADQL (a SQL extension dedicated for astronomy)
- [CDS cross-match service](#) : fast cross-identification between any 2 tables, including VizieR catalogues, SIMBAD

→ [Thanks for acknowledging the VizieR Service](#)

→ [Rules of usage of VizieR data](#)

Figure: VizierR query.

## VizieR

**Catalog**

37 catalogs found

Search Criteria

Keywords

hyades

Tables

J/A+A/623/A35

J/A+A/615/L12

J/Ap/448/683

J/A+AS/115/469

J/A+A/354/881

J/Ap/795/161

J/ApJS/159/100

J/AZJ/77/96

J/ApJ/822/47

Preferences

max: 50

HTML Table

All columns

Compute

Mirrors

CDS, France

Reset All

Show table details or Query selected Catalogs

02	A 3D view of the Hyades population (Lodieu+, 2019)	2019A&A...623A...35L	ReadMe+fp	
1k	2MASS J04183483+2131275 spectrum (Lodieu+, 2018)	2018A&A...615L...12L	ReadMe+fp	
05	Hyades RASS observations (Stern+ 1995)	1995ApJ...448...683S	ReadMe+fp	
464	Photoelectric V photometry of 57 and 58 Tau (Fu+ 1996)	1996A&AS...115...469F	ReadMe+fp	
05	Radial velocities of Praesepe & Hyades Am stars (Debernardi+ 2000)	2000A+A...354...881D	ReadMe+fp	
411	Activity and rotation in Praesepe and the Hyades (Douglas+, 2014)	2014ApJ...795...161D	ReadMe+fp	
05	Temperatures and Re photometry in the Hyades (Taylor+, 2005)	2005ApJS...129...100T	ReadMe+fp	
146	Abundances in Hyades red giants (Boyarukhuk+, 2000)	2000AZh...77...96B	ReadMe+fp	
05	K2 rotation periods for 65 Hyades members (Douglas+, 2016)	2016ApJ...822...47D	ReadMe+fp	
140	8k eps Tau intensity and RV time-series data (Arentoft+, 2019)	2019A&A...622A...190A	ReadMe+fp	

**Figure:** VizieR query of the Hyades cluster. The query returns all the available catalogs (and papers), which have data of the cluster. The table identifiers are highlighted.

# VizieR from ADS

- You can also directly access the **VizieR** service from the ADS
- If a paper on ADS has some tables attached, these tables are often stored on VizieR and Simbad

# VizieR from ADS

ads

QUICK FIELD: Author First Author Abstract Year Fulltext All Search Terms

Back to results

A 5D view of the  $\alpha$  Per, Pleiades, and Praesepe clusters

VIEW

- Abstract
- Citations (3)
- References (246)
- Co-Reads
- Similar Papers
- Volume Content
- Graphics
- Metrics
- Export Citation

A 5D view of the  $\alpha$  Per, Pleiades, and Praesepe clusters

Show affiliations

Lodieu, N.; Pérez-Garrido, A.; Smart, R. L.; Silvotti, R.

Aims: Our scientific goal is to provide revised membership lists of the  $\alpha$  Per, Pleiades, and Praesepe clusters exploiting the second data release of Gaia and produce five-dimensional maps ( $\alpha$ ,  $\delta$ ,  $\pi$ ,  $\mu_\alpha \cos \delta$ ,  $\mu_\delta$ ) of these clusters.

Methods: We implemented the kinematic method combined with the statistical treatment of parallaxes and proper motions to identify astrometric member candidates of three of the most nearby and best studied open clusters in the sky.

Results: We cross-correlated the Gaia catalogue with large-scale public surveys to complement the astrometry of Gaia with multi-band photometry from the optical to the mid-infrared. We identified 517, 1248, and 721 bona fide astrometric member candidates inside the tidal radius of  $\alpha$  Per, the Pleiades, and Praesepe, respectively. We cross-matched our final samples with catalogues from previous surveys to address the level of completeness. We update the main physical properties of the clusters, including mean distance and velocity, as well as core, half-mass, and tidal radii. We infer updated ages from the white dwarf

FULL TEXT SOURCES

Publisher arXiv

DATA PRODUCTS

SIMBAD (20) IRSA (2) CDS (1)

GRAPHICS

Figure: A link to VizieR, where the corresponding tables of the paper are stored.

# VizieR from ADS

- Here you can see and browse all the tables from the paper
- You can query query each column of the table
- Or you can download the table in various formats - voTable, fits, ASCII, csv ...

# VizieR from ADS

**VizieR**

[Fast Xmatch with large catalogues or Simbad](#)

**Search Criteria**

[Save in CDSPortal](#)

Keywords

• J/A+A/628/A66/al...

Tables

J/A+A/628/A66  
 \_alpaper  
 \_pleiades  
 \_praesepe

**Preferences**

max: 50

HTML Table

☒ All columns

☒ Compute

☒ Distance p

☒ Position angle 0

☒ Distance (ky)

☒ Galactic

☒ J2000

☒ B1950

☒ Ecl. J2000

☒ Default

☒ Sort by Distance

☒ + order

☒ No sort

Position in:

☒ Scattered

☒ Decadal

☒ Truncated prec.

Mirrors

CDS, France

**Simple Target** [List Of Targets](#)

Target Name (resolved by [Sesame](#)) or Position:  Target dimension:

☒ Radius ☒ Box size

**J/A+A/628/A66**  [Similar Catalogs](#) [2019A&A...628A...66L](#) [ReadMe-ftp](#)

[alpha Persei, Pleiades and Praesepe clusters \(Lodieu+, 2019\)](#)

[Footprint](#)

1. J/A+A/628/A66/alpaper <sup>(1)</sup>alpha Per catalogue of all kinematic candidate members (3162 rows)

2. J/A+A/628/A66/pleiades <sup>(2)</sup>Pleiades catalogue of all kinematic candidate members (2281 rows)

3. J/A+A/628/A66/praesepe <sup>(3)</sup>Praesepe catalogue of all kinematic candidate members (2200 rows)

☒ Search is off

**Simple Constraint** [List Of Constraints](#)

Query by [Constraints](#) applied on Columns (Output Order: ☐ + ☒ -) (*(Not all columns present in the form!)*)

Show	Sort	Join tables	Columns	Clear	Constraint	Explain
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<a href="#">more</a>	<a href="#">(ALL)</a> reco			Record number assigned by the VizieR team. Should Not be used for identification.
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(1-2)</a> RA_ICRS		<a href="#">deg</a> <sup>(1)</sup>	Right ascension (ICRS) at epoch 2015.5 (RA_sxa)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(1-2)</a> DE_ICRS		<a href="#">deg</a> <sup>(1)</sup>	Declination (ICRS) at epoch 2015.5 (dec_sxa)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(ALL)</a> SourceCP			Gaia DR2 source_id (SOURCEID_CP)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(ALL)</a> RVCP		<a href="#">km/s</a> <sup>(0)</sup>	Radial velocity (RV_CP)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(ALL)</a> e_RVCP		<a href="#">km/s</a> <sup>(0)</sup>	Radial velocity error (eRV_CP)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(ALL)</a> PlxCP		<a href="#">mas</a>	Parallax (Plx_CP)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(ALL)</a> e_PlxCP		<a href="#">mas</a>	Parallax error (ePlx_CP)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(ALL)</a> GmagCP		<a href="#">mag</a>	G magnitude (magG_CP)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(ALL)</a> pmRACP		<a href="#">mas/yr</a>	Proper motion along RA, pmRA*DE (pmRA_CP)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<a href="#">(ALL)</a> e_pmRACP		<a href="#">mas/yr</a>	Proper motion along RA error (epmRA_CP)

Figure: Tables of the selected paper on VizieR.



# VizieR from ADS

**VizieR**

[Simple Target](#) | [List Of Targets](#) [Fast Xmatch with large catalogs or Simbad](#)

Target Name (resolved by [Sesame](#)) or Position:  Target dimension:

☐ Radius ☒ Box size

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**J/A+A/628/A66** [alpha Persei, Pleiades and Praesepe clusters \(Lodieu+, 2019\)](#) [Similar Catalogs](#) [2019A&A...628A...66L](#) [ReadMe!@](#)

[J/A+A/628/A66/alphaper](#) [alpha Per catalogue of all kinematic candidate members \(3/62 rows\)](#)

---

**Simple Constraint** | [List Of Constraints](#)

Query by [Constraints](#) applied on Columns (Output Order: ☐ + ☒ -)

Show	Sort	Column	Clear	Constraint	Explain (UCD)
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	recno			Record number assigned by the VizieR team. Should Not be used for identification. ( <a href="#">meta:record</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RA_ICRS	<a href="#">deg</a>	<a href="#">deg</a>	(1) Right ascension (ICRS) at epoch 2015.5 (RA_sixa) ( <a href="#">pos.eq.ra:meta.main</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	DE_ICRS	<a href="#">deg</a>	<a href="#">deg</a>	(1) Declination (ICRS) at epoch 2015.5 (dec_sixa) ( <a href="#">pos.eq.dec:meta.main</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	SourceCP			Gaia DR2 source_id (SOURCEID_CP) ( <a href="#">meta.id:meta.main</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	RVCP	<a href="#">km/s</a>	<a href="#">km/s</a>	(u) Radial velocity (RV_CP) ( <a href="#">phys.veloc:pos.heliocentric</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	e_RVCP	<a href="#">km/s</a>	<a href="#">km/s</a>	(u) Radial velocity error (eRV_CP) ( <a href="#">stat.error</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	PixCP	<a href="#">mas</a>	<a href="#">mas</a>	Parallax (Pix_CP) ( <a href="#">pos.parallax.trig</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	e_PixCP	<a href="#">mas</a>	<a href="#">mas</a>	Parallax error (ePix_CP) ( <a href="#">stat.error</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	GmagCP	<a href="#">mag</a>	<a href="#">mag</a>	G magnitude (magG_CP) ( <a href="#">phot.mag:gm:opt</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	pmRACP	<a href="#">mas/yr</a>	<a href="#">mas/yr</a>	Proper motion along RA, pmRA*DE (pmRA_CP) ( <a href="#">pos.pm:pos.eq.ra</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	e_pmRACP	<a href="#">mas/yr</a>	<a href="#">mas/yr</a>	Proper motion along RA error (epmRA_CP) ( <a href="#">stat.error:pos.pm:pos.eq.ra</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Reset All	<a href="#">mas/yr</a>	<a href="#">mas/yr</a>	(u) indicates a possible blank or NULL column <span style="float: right;">(u) indexed column <input type="button" value="Submit"/></span>
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Clear			
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	pmDEC	<a href="#">mas/yr</a>	<a href="#">mas/yr</a>	Proper motion along DE (pmDEC_CP) ( <a href="#">pos.pm:pos.eq.dec</a> )
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	e_pmDEC	<a href="#">mas/yr</a>	<a href="#">mas/yr</a>	Proper motion along DE error (epmDEC_CP) ( <a href="#">stat.error:pos.pm:pos.eq.dec</a> )

Figure: Download the table in various formats.



Topcat

# Topcat

- **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

# Topcat

- Fast access to large datasets (millions of rows/hundreds of columns)
- View/edit table data in a scrollable browser
- Insert 'synthetic' columns defined by algebraic expression
- Sort rows on the values in a given column
- Define row subsets in various ways
- Plot types are histogram, plane, sky, cube, sphere, time
- Features include variable transparency, error bars, point labelling, colour axes, all-sky plots, configurable density shading, vectors, ellipses, polygons, contours, density maps, KDEs, analytic functions, plain text/LaTeX axis annotation,
- Calculate statistics on each column for some or all rows
- Perform flexible and fast matching of rows in the same or different tables
- Acquire tables from a file, URL, or SQL query
- Communicate with external VO and non-VO data services, including TAP, cone search, VizieR, CDS X-Match, CDS Hips2fits, SIA, SSA or DataLink
- Write modified tables out in original or different format to file or an SQL database

# Topcat

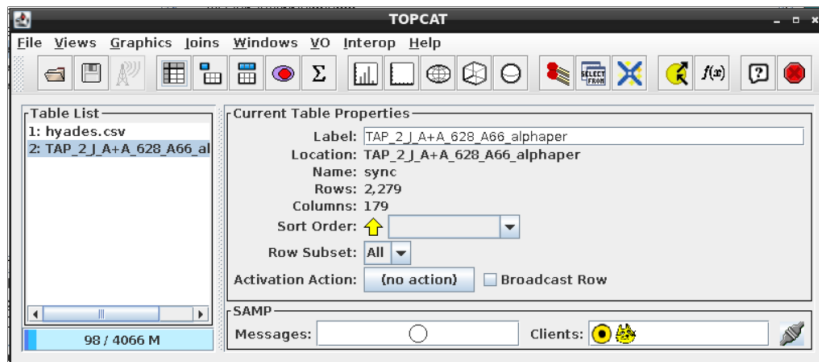


Figure: Topcat - main window.

# Topcat features

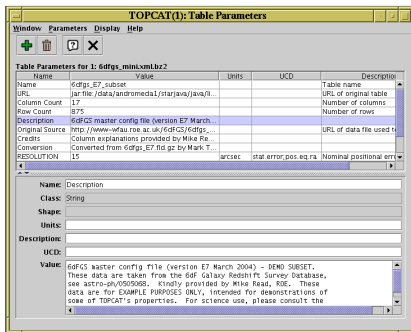


Figure: Topcat - table parameters.

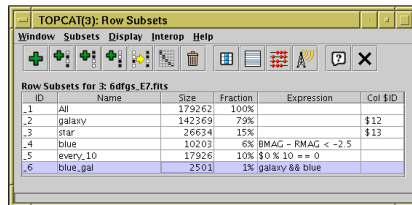
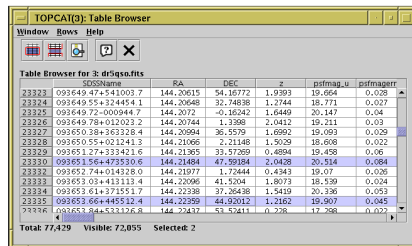


Figure: Topcat - table view and subsets.

# Topcat plots

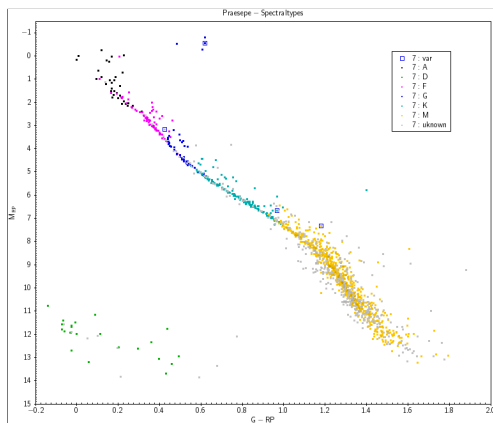
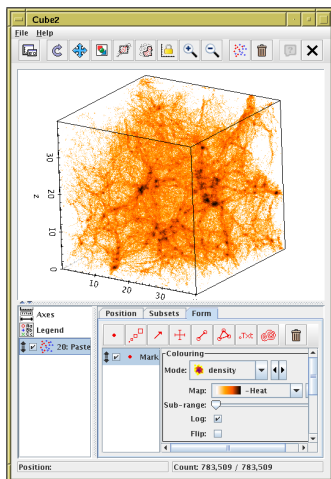


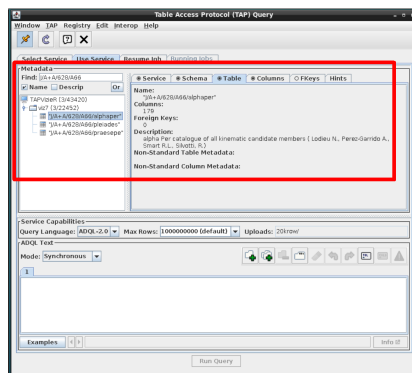
Figure: Various plots produced with Topcat.

# Access catalogs from Topcat - TAP queries

- You can use **Topcat** to directly access and query catalog, which are available online
- The queried are then downloaded to Topcat as a new table
- This feature is called **Table Access Protocol (TAP)** query

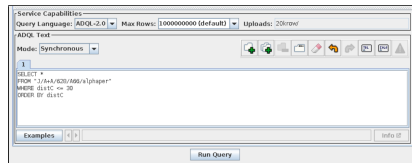
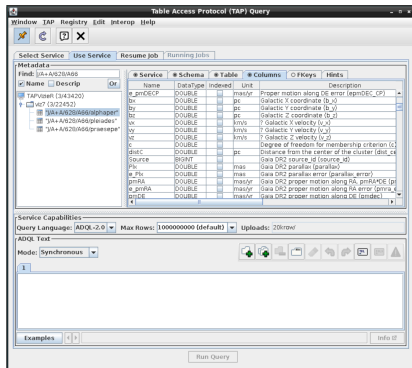


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**Figure:** Available services and a selected entry from VizieR.

# Topcat TAP



**Figure:** Select data from the table by selecting columns or by an SQL (ADQL) query.

# Cross-matching tables with Topcat

- Topcat is able to cross-match tables
- You can crossmatch online tables or your local table with online tables (for example with Simbad)
- Usually, cross-matching is done through coordinates of the objects

# Cross-matching tables with Topcat

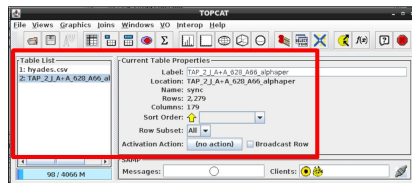
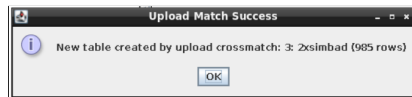
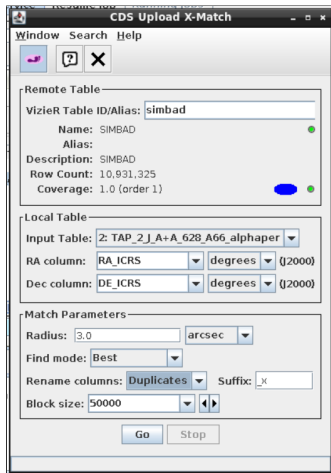


Figure: Cross-matching a local table through coordinates with the Simbad catalog.

## Python libraries

# Accessing databases and manipulating tables with Python

- Topcat is a highly efficient and very fast tool for accessing databases, manipulating tables and to create plots
- However, you might want to do all these tasks from your own algorithm
- Fortunately, Python has a library for everything ...
- Useful libraries to access and manipulate databases are:
  - *astroquery*
  - *pystilts*
  - *pandas*

# *astroquery*

- *astroquery* is a set of tools for querying astronomical web forms and databases
- The list of available databases among many others includes"
  - ALMA Queries ([astroquery.alma](#))
  - Gaia TAP ([astroquery.gaia](#))
  - IRSA Dust Extinction Service Queries ([astroquery.irsadust](#))
  - JPL Spectroscopy Queries ([astroquery.jplspec](#))
  - Minor Planet Center Queries ([astroquery.mpcastroquery.solarsystem.MPC](#))
  - NASA ADS Queries ([astroquery.nasaads](#))
  - SIMBAD Queries ([astroquery.simbad](#))
  - VizieR Queries ([astroquery.vizier](#))
  - And many more ...

# astroquery TAP query

```
>>> from astropy import coordinates
>>> import astropy.units as u
>>> # works only for ICRS coordinates:
>>> c = coordinates.SkyCoord("05h35m17.3s -05d23m28s", frame='icrs')
>>> r = 5 * u.arcminute
>>> result_table = Simbad.query_region(c, radius=r)
>>> result_table.pprint(show_unit=True, max_width=80, max_lines=5)
```

MAIN_ID	RA	DEC	... COO_WAVELENGTH	COO_BIBCODE
	"h:m:s"	"d:m:s"	...	
-----	-----	-----	...	-----
M 42	05 35 17.3	-05 23 28	...	1981MNRAS.194..693L
...	...	...	...	...
V* V2114 Ori	05 35 01.671	-05 26 36.30	...	I 2003yCat.2246....0C

Figure: Example of an *astroquery* coordinate query from the Simbad catalog.



# *pystilts*

- STILTS is a set of command-line tools for processing tabular data. It has been designed for, but is not restricted to, use on astronomical data such as source catalogues.
- *pystilts* is the Python analogue of the STILTS
- Library *pystilts* allows you to execute TAP queries and cross-matching on online databases, similarly to Topcat

# pystilts cross-matching

```

from pystilts import tapskymatch
from pystilts import keepcols, renamecols

filename = 'table1.fits'
outfile = 'table2.fits'
name = 'ppmx1'
tapurl = "http://dc.zah.uni-heidelberg.de/tap"
taptable = "ppmx1.main"
taplong = 'raj2000'
taplat = 'dej2000'
crossmatch = 3
nra1, ndec1 = 'ra', 'dec'
nra2, ndec2 = 'ra_table1', 'dec_table1'
# Run sky match via TAP
tapskymatch(tapurl=tapurl, taptable=taptable,
            taplon=taplong, taplat=taplat,
            infile=filename, inlon=nra1, inlat=ndec1,
            radius=crossmatch, outfile=outfile,
            icmd=keepcols([nra1, ndec1]), fixcols='all', suffixin='',
            suffixremote='_{}'.format(name))
# Rename table1.fits ra and dec columns
renamecols(outfile, [nra1, ndec1], [nra2, ndec2])

```

Figure: Example of a *pystilts* cross-matching.

# *pandas*

- *pandas* is a powerful Python data analysis toolkit
- It has immense features for manipulating tables, creating plots and histograms and analyzing data
- Once you downloaded your data with the *astroquery* or *pystilts*, *pandas* offers an efficient way of data manipulation

## *pandas* - some important features

- *pandas* is in many ways similar to MS Excel as it offers some similar features:
  - Labeling and indexing data
  - Sorting and filtering data columns
  - Cross-matching tables (the equivalent of the Excel vlookup function)
  - Creating pivot tables
  - Grouping the data
  - Performing mathematical operations on the data
  - Visualizing data
  - And many more ...

# A quick look to *pandas*

```
1 import pandas as pd
2 df = pd.DataFrame({'Num': [1, 2, 3, 4], 'Alp': ['a', 'b', 'c', 'd'],
3 'Dat': pd.date_range('2018-08-01', freq='d', periods=4),
4 'Cat': pd.Categorical(['a', 'b', 'c', 'c'])
5 }, index=pd.Index(range(4), name='ids'))
6 df
```

	Num	Alp	Dat	Cat
ids				
0	1	a	2018-08-01	a
1	2	b	2018-08-02	b
2	3	c	2018-08-03	c
3	4	d	2018-08-04	c

```
df.dtypes
```

Num	int64
Alp	object
Dat	datetime64[ns]
Cat	category
dtype:	object

```
8 df.to_json('test.json', orient='table')
9 new_df = pd.read_json('test.json', orient='table')
10 new_df
```

Farewell

# Summary

- The aim of this presentation was to introduce online accessible astronomy catalog
- The application Topcat is an effective and fast tool to access these catalogs and to process the data
- On the other hand, the processing can be done through Python

Thank you for your attention