

AST1501 - Introduction to Research

Jo Bovy

How to access astronomical data

Overview

- Types of astronomical data
- Data from individual papers
- Small data sets
- Large data sets
- Cross-matching

Types of astronomical data



Types of astronomical data

- Focus in this class: public data sets useful for your work
- Table in a paper
- Small data sets: online-only table in a paper, small survey
 - CDS
- Large data sets: large surveys
 - Dedicated tools
 - Astroquery

Table in a paper

| Name | Period (d) | Mass (kg) | Average orbit radius (km) | Astronomical unit (1 AU) | Radius weights (r_i) | Angular velocity (ω) |
|---------|---------------|--------------------------|------------------------------|-----------------------------|-----------------------------|----------------------------------|
| Mercury | 87.969 | 0.3301×10^{24} | 56 672 443.84 | 0.38709893 | 4.69091E-05 | 26.08840762 |
| Venus | 224.701 | 4.8676×10^{24} | 108 207 517.8 | 0.72333199 | 0.001320004 | 10.21344422 |
| Earth | 365.256 | 5.9726×10^{24} | 149 579 112 | 1.00000011 | 0.002238882 | 6.2831853 |
| Mars | 686.98 | 0.64174×10^{24} | 226 923 421.8 | 1.52366231 | 0.000363432 | 3.340666584 |
| Jupiter | 4332.587 | 1898.3×10^{24} | 777 657 818.7 | 5.20336301 | 3.699505551 | 0.529699953 |
| Saturn | 10 759.22 | 568.36×10^{24} | 1 431 426 696 | 9.53707032 | 2.038821640 | 0.213302742 |
| Uranus | 30 685.4 | 86.816×10^{24} | 2 869 262 907 | 19.1912393 | 0.624274378 | 0.074790328 |
| Neptune | 60 189.0 | 102.42×10^{24} | 4 494 894 315 | 30.48168677 | 1.153633570 | 0.038129411 |
| Pluto | 90 465.0 | 0.0131×10^{24} | 5 720 641 564 | 39.48168677 | 1.88377E-04 | 0.025368608 |

Note: These are basic data from NASA.

You find a useful (small) table in a paper, now what?

- IOP journals
(ApJ, ApJS, AJ, ApJL, PASP)

- All tables available in
ASCII format!

| Name | Period (d) | Mass (kg) | Average orbit radius (km) | Astronomical unit (1 AU) | Radius weights (r_i) | Angular velocity (ω) |
|---------|---------------|--------------------------|------------------------------|-----------------------------|-----------------------------|----------------------------------|
| Mercury | 87.969 | 0.3301×10^{24} | 56 672 443.84 | 0.38709893 | 4.69091E-05 | 26.08840762 |
| Venus | 224.701 | 4.8676×10^{24} | 108 207 517.8 | 0.72333199 | 0.001320004 | 10.21344422 |
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| Saturn | 10 759.22 | 568.36×10^{24} | 1 431 426 696 | 9.53707032 | 2.038821640 | 0.213302742 |
| Uranus | 30 685.4 | 86.816×10^{24} | 2 869 262 907 | 19.1912393 | 0.624274378 | 0.074790328 |
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THE ASTROPHYSICAL JOURNAL

OPEN ACCESS

Identification of Superclusters and Their Properties in the Sloan Digital Sky Survey Using the WHL Cluster Catalog

Shishir Sankhyayan¹ , Joydeep Bagchi² , Elmo Tempel^{1,3} , Surhud More^{4,5} , Maret Einasto¹ , Pratik Dabhadse^{6,7} , Somak Raychaudhury^{4,8} , Ramana Athreya⁹ , and Pekka Heinämäki¹⁰ 

Published 2023 November 13 • © 2023. The Author(s). Published by the American Astronomical Society.

[The Astrophysical Journal, Volume 958, Number 1](#)

Citation Shishir Sankhyayan et al 2023 *ApJ* 958 62

DOI 10.3847/1538-4357/acfaeb

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Figures ▾

Tables ▾

References ▾

Article data ▾

+ Article and author information

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CITATION: SARKAR, SARITADEVAN ET AL. 2020 MNRAS 000 000

DOI 10.3847/1538-4357/acfaeb



Figures ▾ Tables ▾ References ▾ Article data ▾

Skip to each table in the article

| Their Masses | | | |
|--------------|---------------------------------|------------------|--------------------|
| e | Mass ($10^{14} M_{\odot}$) | N_{mem} | N_{Abels} |
| c) | (%) | (%) | (10) |
| 10 | 257.106 | 54 | 2 |
| 59 | 255.164 | 57 | 7 |
| 40 | 210.629 | 41 | 10 |
| 50 | 196.421 | 38 | 1 |
| 10 | 191.222 | 44 | 0 |

Column (2): R.A. Column (3): decl. Column (4): R.A. of
center (6): redshift. Column (7): linear comoving size.
cm.

Table 3
Summary of the Properties of the Observed and Mock Superclusters

| | WHL (0.05 $\leq z \leq 0.42$) | WHL (0.05 $\leq z \leq 0.366$) | Mock (0.05 $\leq z \leq 0.366$) |
|-------------------------------------|-----------------------------------|------------------------------------|-------------------------------------|
| Linking Length l_o (Mpc) | 20.65 | 19.22 | 19.88 |
| Number of Superclusters | 662 | 456 | 451 |
| Median Mass ($10^{14} M_{\odot}$) | 57.80 | 55.97 | 46.43 |
| Median Size (Mpc) | 64.87 | 60.49 | 60.83 |
| Median Density Contrast | 11.64 | 15.40 | 10.88 |
| Median No. of Members | 13 | 13 | 12 |

Table 3

superclusters covering a wide range of redshifts and sky areas is essential. Here, we present a large

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Table 3. Summary of the Properties of the Observed and Mock Superclusters

| | WHL (0.05 $\leq z \leq$ 0.42) | WHL (0.05 $\leq z \leq$ 0.366) | Mock (0.05 $\leq z \leq$ 0.366) |
|-----------------------------------|----------------------------------|-----------------------------------|------------------------------------|
| Linking Length l_0 (Mpc) | 20.65 | 19.22 | 19.88 |
| Number of Superclusters | 662 | 456 | 451 |
| Median Mass ($10^{14} M_\odot$) | 57.80 | 55.97 | 46.43 |
| Median Size (Mpc) | 64.87 | 60.49 | 60.83 |
| Median Density Contrast | 11.64 | 15.40 | 10.88 |
| Median No. of Members | 13 | 13 | 12 |

Download table as:

ASCII

Typeset image

You find a useful (small) table in a paper, now what?

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(ApJ, ApJS, AJ, ApJL, PASP)
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Table 3
Summary of the Properties of the Observed and Mock Superclusters

| | WHL (0.05 < or=z < or=0.42) | WHL (0.05 < or=z < or=0.366) | Mock (0.05 < or=z < or=0.366) |
|---------------------------|--------------------------------|---------------------------------|----------------------------------|
| Linking Length l_o (Mpc) | | 20.65 | 19.22 19.88 |
| Number of Superclusters | 662 | 456 | 451 |
| Median Mass (10^14 M_sun) | | 57.80 | 55.97 46.43 |
| Median Size (Mpc) | 64.87 | 60.49 | 60.83 |
| Median Density Contrast | 11.64 | 15.40 | 10.88 |
| Median No. of Members | 13 | 13 | 12 |

You find a useful (small) table in a paper, now what?

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(ApJ, ApJS, AJ, ApJL, PASP)
 - All tables available in ASCII format!
- Other journals: no machine-readable version generally available

The screenshot shows a journal article page from *Monthly Notices of the Royal Astronomical Society*. The article is titled "Release 17 (DR17; SDSS Collaboration in preparation). The majority of these (9188, or 92 per cent) have Galaxy Zoo: 3D analysis. Detailed Galaxy Zoo (GZ2) classifications". The table, labeled Table 1, details the number of MaNGA targets shown to GZ:3D volunteers for each workflow task. The table is as follows:

| Task | DR14 (Phase 1) | All MaNGA targets (Phase 2) | DR17* (Subset of Phase 2) | GZ2 Pre-selection |
|------------------|-------------------|--------------------------------|------------------------------|--------------------------------------|
| Galaxy centre | 2778 | 29831 | 9188 | All |
| Foreground stars | 2778 | 29831 | 9188 | All |
| Bars | 175 | 5456 | 1355 | $N_{\text{bar}} > 0.2N_{\text{tot}}$ |
| Spirals | 294 | 7418 | 1973 | $N_{1-4} > 0.2N_{\text{tot}}$ |

*The total DR17 sample size will be 10010 unique galaxies with high quality data cubes (SDSS Collaboration et al., in preparation); the number in this table is the number also in GZ:3D.

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You find a useful (small) table in a paper, now what?

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(ApJ, ApJS, AJ, ApJL, PASP)
 - All tables available in ASCII format!
- Other journals: no machine-readable version generally available
 - Can go to arXiv

The screenshot shows a Cornell University arXiv page for a paper titled "Galaxy Zoo: 3D -- Crowd-sourced Bar, Spiral and Foreground Star Masks for MaNGA Target Galaxies". The page includes a navigation bar with links for search, help, and advanced search. On the right, there's a sidebar for "Access Paper" with options for PDF, PostScript, and Other Formats. A red circle highlights the "PostScript" link. The main content area displays the paper's abstract, authors, and a detailed description of the Galaxy Zoo: 3D project.

We gratefully acknowledge support from the Simons Foundation, member institutions, and all contributors. [Donate](#)

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Galaxy Zoo: 3D -- Crowd-sourced Bar, Spiral and Foreground Star Masks for MaNGA Target Galaxies

Karen L. Masters, Coleman Krawczyk, Shoaib Shamsi, Alexander Todd, Daniel Finnegan, Matthew Bershady, Kevin Bundy, Brian Cherinka, Amelia Fraser-McKelvie, Dhanesh Krishnarao, Sandor Kruk, Richard R. Lane, David Law, Chris Lintott, Michael Merrifield, Brooke Simmons, Anne-Marie Weijmans, Renbin Yan

The challenge of consistent identification of internal structure in galaxies – in particular disc galaxy components like spiral arms, bars, and bulges – has hindered our ability to study the physical impact of such structure across large samples. In this paper we present Galaxy Zoo: 3D (GZ: 3D) a crowdsourcing project built on the Zooniverse platform which we used to create spatial pixel (spaxel) maps that identify galaxy centres, foreground stars, galactic bars and spiral arms for 29831 galaxies which were potential targets of the MaNGA survey (Mapping Nearby Galaxies at Apache Point Observatory, part of the fourth phase of the Sloan Digital Sky Surveys or SDSS-IV), including nearly all of the 10,010 galaxies ultimately observed. Our crowd-sourced visual identification of asymmetric, internal structures provides valuable insight on the evolutionary role of non-axisymmetric processes that is otherwise lost when MaNGA data cubes are azimuthally averaged. We present the publicly available GZ:3D catalog alongside validation tests and example use cases. These data may in the future provide a useful training set for automated identification of spiral arm features. As an illustration, we use the spiral masks in a sample of 825 galaxies to measure the enhancement of star formation spatially linked to spiral arms, which we measure to be a factor of three over the background disc, and how this enhancement increases with radius.

Comments: 13 pages, 9 figures. MNRAS accepted

Subjects: Astrophysics of Galaxies (astro-ph.GA)

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```
\begin{table*}
\caption{\label{tab:samples}Galaxy samples and selection in GZ:3D. We release ma
sks from the final phases only, as we only recommend their use for science. The
number are MaNGA targets shown to GZ:3D volunteers for each workflow task, not t
he number which have successful masks or clusters. The total DR17 sample size w
ill be 10,010 unique galaxies with high quality data cubes (SDSS Collaboration e
t al. in prep.); the number in this table is the number also in GZ:3D.}
\begin{tabular}{lcccc}
Task & DR14 & All MaNGA targets & DR17$^*\$ & GZ2 Pre-selection \\
& (Phase 1) & (Phase 2) & (Subset of Phase 2) & \\
\hline
Galaxy Centre & 2778 & 29831 & 9188 & All \\
Foreground Stars & 2778 & 29831 & 9188 & All \\
Bars & 175 & 5456 & 1355 & $N_{\rm bar} > 0.2N_{\rm tot} \$ \\
Spirals & 294 & 7418 & 1973 & $N_{\rm 1-4} > 0.2N_{\rm tot} \$ \\
\end{tabular}
\end{table*}
```

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- IOP journals
(ApJ, ApJS, AJ, ApJL, PASP)
 - All tables available in ASCII format!
- Other journals: no machine-readable version generally available
 - Can go to arXiv
 - Download source (rename .zip)
 - Copy and read with astropy

```
In [1]: from astropy.io import ascii
In [2]: table= r"""
...: \begin{table}
...: \caption{\label{tab:samples}Galaxy samples and selection in GZ:3D. We re
...: lease masks from the final phases only, as we only recommend their use f
...: or science. The numbers are MaNGA targets shown to GZ:3D volunteers for e
...: ach workflow task, not the numbers which have successful masks or cluste
...: rs. The total DR17 sample size will be 10,010 unique galaxies with high
...: quality data cubes (SDSS Collaboration et al. in prep.); the number in t
...: his table is the number also in GZ:3D.}
...: \begin{tabular}{lcccc}
...: Task & DR14 & All MaNGA targets & DR17$^* & GZ2 Pre-selection \\
...: & (Phase 1) & (Phase 2) & (Subset of Phase 2) & \\
...: \hline
...: Galaxy Centre & 2778 & 29831 & 9188 & All \\
...: Foreground Stars & 2778 & 29831 & 9188 & All \\
...: Bars & 175 & 5456 & 1355 & $N_{\rm bar} > 0.2N_{\rm tot} \\
...: Spirals & 294 & 7418 & 1973 & $N_{\rm 1-4} > 0.2N_{\rm tot} \\
...: \end{tabular}
...: \end{table*}
...: """
In [3]: tab= ascii.read(table)
In [4]: tab
Out[4]:
<Table length=5>
  Task          DR14      ...      GZ2 Pre-selection
  str16         str9      ...      str30
  -----
  -- (Phase 1) ...
  Galaxy Centre 2778 ...          All
  Foreground Stars 2778 ...          All
  Bars           175 ... $N_{\rm bar} > 0.2N_{\rm tot}
  Spirals        294 ... $N_{\rm 1-4} > 0.2N_{\rm tot}
```



Small data sets



Small, machine-readable data sets

- Extended table in a paper
“Only a portion of this table is shown here to demonstrate its form and content. A machine-readable version of the full table is available.”

Table 1. Properties of 85,686 Groups and Clusters Extracted from the WHL Cluster Catalog within the Redshift Range $0.05 \leq z \leq 0.42$

| ID | RA | Decl. | z | R_{200c} | M_{200c} | SCI |
|------------------|---------|----------|--------|------------|------------|-----|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| J000000.6+321233 | 0.00236 | 32.20925 | 0.1274 | 1.72 | 5.9478 | 0 |
| J000002.3+051718 | 0.00957 | 5.28827 | 0.1694 | 0.94 | 1.9627 | 0 |
| J000003.5+314708 | 0.01475 | 31.78564 | 0.0916 | 0.94 | 1.6766 | 0 |
| J000004.7+022826 | 0.01945 | 2.47386 | 0.4179 | 0.95 | 0.4769 | 0 |
| J000006.0+152548 | 0.02482 | 15.42990 | 0.1731 | 1.13 | 1.5391 | 0 |

Note. Columns (1)–(4) are taken from the WHL catalog and columns (5)–(7) have been computed in the current paper (see Sections 3 and 4). Column (1): cluster identifier. Column (2): R.A. of the brightest cluster galaxy (BCG). Column (3): decl. of the BCG. Column (4): redshift of the BCG. Column (5): R_{200c} of the cluster. Column (6): M_{200c} of the cluster. Column (7): supercluster number to which the cluster belongs. SCI = 0 means the cluster is not a part of any supercluster.

Only a portion of this table is shown here to demonstrate its form and content. A [machine-readable](#) version of the full table is available.

Download table as: [Data](#) [Figureset image](#)

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Title: Identification of Superclusters and their Properties in the Sloan Digital Sky Survey Using WHL Cluster Catalog

Authors: Sankhyayan S., Bagchi J., Tempel E., More S., Einasto M., Dabade P., Raychaudhury S., Athreya R., Heinamaki P.

Table: Properties of the WHL clusters used in this work

=====

Byte-by-byte Description of file: apjacfaebt1_mrt.txt

| Bytes | Format | Units | Label | Explanations |
|--------|--------|-----------|-------|---|
| 1- 16 | A16 | --- | ID | Cluster identifier as given in WH15 |
| 18- 26 | F9.5 | deg | RAdeg | Right Ascension in decimal degrees of the BCG (J2000) |
| 28- 36 | F9.5 | deg | DEdeg | Declination in decimal degrees of the BCG (J2000) |
| 38- 43 | F6.4 | --- | z | Redshift of the BCG |
| 45- 48 | F4.2 | Mpc | R200c | Radius of sphere where matter density is 200 times the critical density |
| 50- 56 | F7.4 | 10+14Msun | M200c | Mass within a sphere of radius R200c |
| 58- 60 | I3 | --- | SCL | Supercluster number |

| | | | | | | |
|-------------------|---------|----------|--------|------|--------|-----|
| J000000.6+321233 | 0.00236 | 32.20925 | 0.1274 | 1.72 | 5.9478 | 0 |
| J000002.3+051718 | 0.00957 | 5.28827 | 0.1694 | 0.94 | 1.9627 | 0 |
| J000003.5+314708 | 0.01475 | 31.78564 | 0.0916 | 0.94 | 1.6766 | 0 |
| J000004.7+022826 | 0.01945 | 2.47386 | 0.4179 | 0.95 | 0.4769 | 0 |
| J000006.0+152548 | 0.02482 | 15.42990 | 0.1731 | 1.13 | 1.5391 | 0 |
| J000006.3+221220 | 0.02643 | 22.20558 | 0.3985 | 0.84 | 0.9030 | 0 |
| J000006.6+100648 | 0.02755 | 10.11333 | 0.3747 | 0.93 | 1.8814 | 0 |
| J000006.6+315235 | 0.02762 | 31.87626 | 0.2092 | 1.18 | 1.9203 | 0 |
| J000006.6+292129 | 0.02765 | 29.35813 | 0.2489 | 0.92 | 1.0586 | 0 |
| J000007.1-092910 | 0.02957 | -9.48607 | 0.3332 | 0.80 | 1.3679 | 0 |
| J000007.6+155003 | 0.03177 | 15.83424 | 0.1527 | 1.17 | 3.3484 | 0 |
| J000007.7+185245 | 0.03208 | 18.87909 | 0.4085 | 1.03 | 2.3615 | 0 |
| J000008.0+343316 | 0.03350 | 34.55436 | 0.2346 | 1.05 | 0.8036 | 0 |
| J000008.6+085715 | 0.03580 | 8.95418 | 0.2799 | 0.88 | 1.2017 | 0 |
| J000009.4+211655 | 0.03905 | 21.28191 | 0.2997 | 1.31 | 3.0975 | 0 |
| J000000.0+230241 | 0.04154 | 23.04467 | 0.3778 | 1.06 | 1.4712 | 230 |
| J000010.7+134747 | 0.04439 | 13.79632 | 0.1992 | 0.80 | 0.4341 | 0 |
| J000011.4-092850 | 0.04770 | -9.48058 | 0.4100 | 0.89 | 1.3098 | 0 |
| J000012.6+103806 | 0.05238 | 10.63509 | 0.1694 | 1.43 | 3.7158 | 233 |
| J000012.7+341335 | 0.05276 | 34.22628 | 0.2542 | 0.96 | 0.6371 | 0 |
| J000012.8+070555 | 0.05317 | 7.09848 | 0.1290 | 0.89 | 0.8818 | 0 |
| J000014.2+355136 | 0.05906 | 35.86013 | 0.2606 | 0.93 | 1.3806 | 0 |
| J000015.0+081513 | 0.06265 | 8.25366 | 0.3113 | 0.98 | 1.0363 | 0 |
| J000015.8+223812 | 0.06595 | 22.63655 | 0.3701 | 1.03 | 1.5920 | 230 |
| J000016.9+235043 | 0.07057 | 23.84517 | 0.3106 | 0.93 | 0.8565 | 0 |
| J000017.4-061436 | 0.07246 | -6.24328 | 0.2921 | 0.87 | 0.9014 | 0 |
| J000017.4-0715540 | 0.07259 | 21.02841 | 0.3076 | 0.93 | 2.5395 | 0 |

Small, machine-readable data sets

- Extended table in a paper
“Only a portion of this table is shown here to demonstrate its form and content. A machine-readable version of the full table is available.”
- Vizier Online Data Catalogs

VizieR Online Data Catalog: CVs from SDSS V (Inight+, 2023)

Show affiliations Show all authors

Inight, K. ; Gansicke, B. T. ; Schwone, A. ; Anderson, S. F. ; Badenes, C. ; Breedt, E. ; Chandra, V. ; Davies, B. D. R. ; Gentile Fusillo, N. P. ; Green, M. J. ; Hermes, J. J. ; Huamani, I. A. ; Hwang, H. ; Knauff, K. ; Kurpas, J. ; Long, K. S. ; Malanushenko, V. ; Morrison, S. ; Quiroz, C. I. J. ; Ramos, G. N. A. ; ...

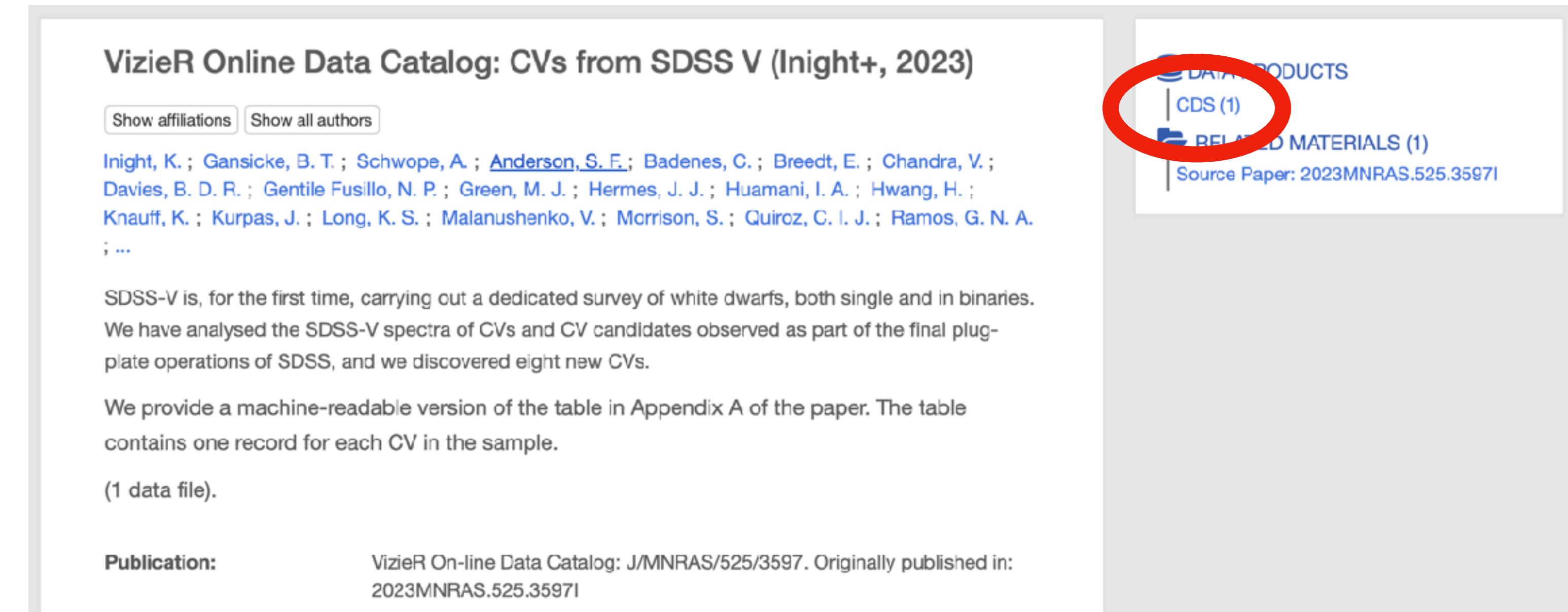
SDSS-V is, for the first time, carrying out a dedicated survey of white dwarfs, both single and in binaries. We have analysed the SDSS-V spectra of CVs and CV candidates observed as part of the final plug-plate operations of SDSS, and we discovered eight new CVs.

We provide a machine-readable version of the table in Appendix A of the paper. The table contains one record for each CV in the sample.

(1 data file).

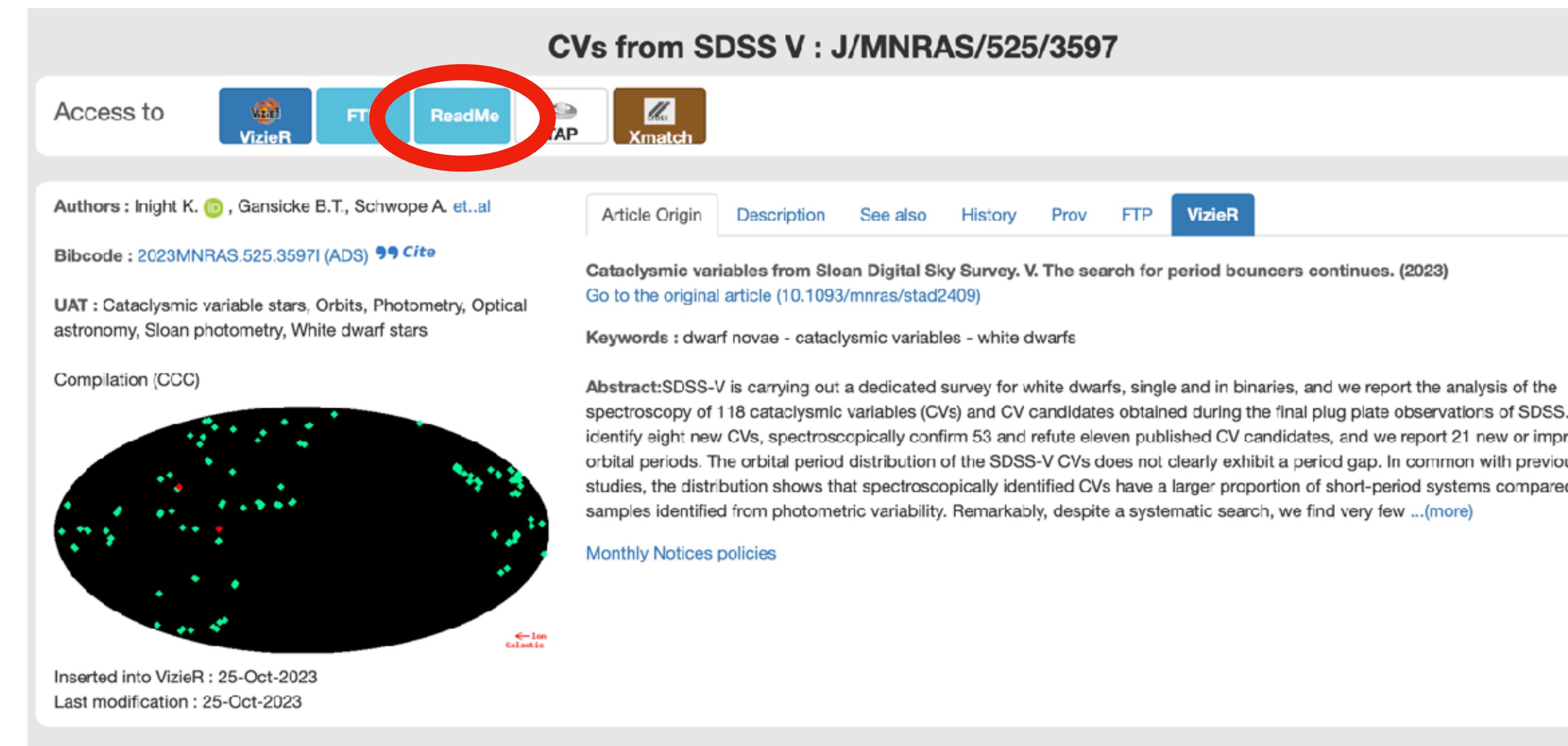
Publication: VizieR On-line Data Catalog: J/MNRAS/525/3597. Originally published in: 2023MNRAS.525.3597I

DATA PRODUCTS
CDS (1)
RELATED MATERIALS (1)
Source Paper: 2023MNRAS.525.3597I



Small, machine-readable data sets

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- Vizier Online Data Catalogs



Small, machine-readable data sets

- Extended table in a paper
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- Vizier Online Data Catalogs

| J/MNRAS/525/3597 | CVs from SDSS V | (Inight+, 2023) | | |
|--|-----------------|-----------------|----------|--|
| Cataclysmic variables from Sloan Digital Sky Survey. V. The search for period bouncers continues. | | | | |
| Inight K., Gansicke B.T., Schwöpe A., Anderson S.F., Badenes C., Breedt E., Chandra V., Davies B.D.R., Gentile Fusillo N.P., Green M.J., Hermes J.J., Huamani I.A., Hwang H., Knauff K., Kurpas J., Long K.S., Malanushenko V., Morrison S., Quiroz C.I.J., Ramos G.N.A., Roman-Lopes A., Schreiber M.R., Standke A., Stutz L., Thorstensen J.R., Toloza O., Tovmassian G., Zakamska N.L. <Mon. Not. R. Astron. Soc., 525, 3597–3625 (2023)> =2023MNRAS.525.3597I (SIMBAD/NED BibCode) | | | | |
| ADC_Keywords: Binaries, cataclysmic ; Photometry, SDSS ; Binaries, orbits ; Stars, white dwarf | | | | |
| Keywords: dwarf novae – cataclysmic variables – white dwarfs | | | | |
| Abstract: SDSS-V is carrying out a dedicated survey for white dwarfs, single and in binaries, and we report the analysis of the spectroscopy of 118 cataclysmic variables (CVs) and CV candidates obtained during the final plug plate observations of SDSS. We identify eight new CVs, spectroscopically confirm 53 and refute eleven published CV candidates, and we report 21 new or improved orbital periods. The | | | | |
| Byte-by-byte Description of file: table1.dat | | | | |
| Bytes | Format | Units | Label | Explanations |
| 1– 19 | A19 | --- | SDSS | Unique reference for the SDSS object (JHHMMSS.ss+DDMMSS.s) |
| 21– 49 | A29 | --- | Name | Other name (where available) |
| 51– 69 | I19 | --- | GaiaEDR3 | The unique source_id of the Gaia EDR3 counterpart source_id |
| 71– 81 | F11.8 | h | Per | ? Orbital period in hours |
| 83– 92 | F10.8 | h | e_Per | ? Error on orbital period |
| 94 | A1 | --- | n_Per | [*:] Note on Per (1) |
| 96–100 | F5.2 | mag | Gmag | G-band magnitude from the Gaia EDR3 survey |
| 102–105 | I4 | pc | Distance | ? Distance from Bailer-Jones et al. (2021AJ....161..147B , Cat. I/352) |
| 107–117 | A11 | --- | VType | Classification using the taxonomy defined in the paper (2) |
| 119–132 | A14 | --- | Cartons | Cartons (3) |
| 136–162 | A27 | --- | Ref-disc | BibCode of the earliest identification of this CV |
| 164–182 | A19 | --- | Ref-sp | BibCode of the first published spectrum |
| 184–204 | A21 | --- | Ref-P | BibCode of the source of the orbital period |
| 206–223 | F18.14 | deg | RAdeg | Right ascension (J2000) |
| 225–243 | F19.15 | deg | DEdeg | Declination (J2000) |

Small, machine-readable data sets

- Extended table in a paper
“Only a portion of this table is shown here to demonstrate its form and content. A machine-readable version of the full table is available.”
- Vizier Online Data Catalogs

CVs from SDSS V : J/MNRAS/525/3597

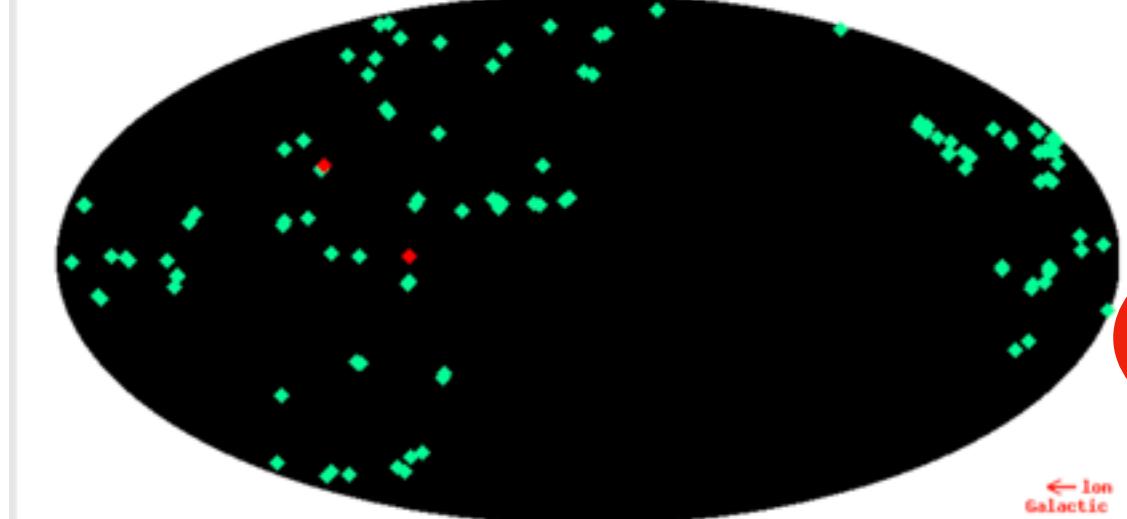
Access to [VizieR](#) [FTP](#) [ReadMe](#) [TAP](#) [Xmatch](#)

Authors : Inglot K. , Gansicke B.T., Schworer A. et.al

Bibcode : [2023MNRAS.525.3597I](#) (ADS)  [Cite](#)

UAT : Cataclysmic variable stars, Orbits, Photometry, Optical astronomy, Sloan photometry, White dwarf stars

Compilation (CCC)



Article Origin Description See also History Prov [FTP](#) [VizieR](#)

Archives are available through FTP in standardized format described in the ReadMe. VizieR tables are built from archives with additional transformations.

J/MNRAS/525/3597 CVs from SDSS V (Inglot+, 2023)
The following files can be converted to FITS (extension .fit or fit.gz)
`tablea1.dat`

Query from: <http://vizier.cds.unistra.fr/viz-bin/VizieR?-source=J/MNRAS/525/3597>

Go to [ftp](#) - web page - Download all tables in [tar.gz](#)

| | | | |
|-----------------------------|---------------------|---------------------------------------|------|
| readme.viz | "25-Oct-2023 08:56" | -r--r--r-- | 5.7K |
| tablea1.dat | "25-Oct-2023 08:59" | -r--r--r-- | 5.7K |
| | "24-Oct-2023 11:19" | -r--r--r-- | 29K |
| | | -txt - txt.gz - fits - fits.gz - html | |

Small, machine-readable data sets

- Extended table in a paper
“Only a portion of this table is shown here to demonstrate its form and content. A machine-readable version of the full table is available.”
- Vizier Online Data Catalogs

| | | | | | | | | | |
|----------------------|--------------------------|---------------------|---------------------|----------|----------|---------|------|----------------------|-----------------------|
| J000600.15+012129.8 | | | 2738755406045571968 | 1.52 | 0.10 | 19.57 | 352 | WZ Sge:PS : gg,u2,wd | *This work |
| work | 1.50064345676278 | 1.35827514714031 | | | | | | | |
| J003827.05+250925.0 | 1RXS J003828.7+250920 | | 2806802123399581056 | 2.26826 | 0.00002 | 18.63 | 503 | SU UMa | cv,gg,u1,u2 |
| et al in prep | 9.61272342040272 | 25.1569563739546 | | | | | | | *VSNET 12318 |
| J003941.08+005427.5 | SDSS J003941.06+005427.5 | | 2543387617312121216 | 1.523 | 0.002 | 20.76 | 1078 | WZ Sge: | cv,u1,u2,u4 |
| 2010A&A...524A..86S | 9.92118587245779 | 0.907630946264153 | | | | | | | 2005AJ....129.2386S |
| J004335.16-003729.7 | SDSS J004335.14-003729.8 | | 2530961280492678528 | 1.3721 | 0.0014 | 19.85 | 447 | WZ Sge: | cv,gg,u2,wd |
| 2008MNRAS.391..591S | 10.8965127441555 | -0.624919920328629 | | | | | | | 2004AJ....128.1882S |
| J014227.07+001729.8 | | | 2510205490257050496 | 1.88 | 0.04 | 19.89 | 697 | Polar: | cv,u1,u2 |
| work | 25.6128096966956 | 0.291604463777139 | | | | | | | 2017ApJS..228...19C |
| J015543.47+002807.4 | FL Cet | | 2507796391561705728 | 1.452389 | 0.000001 | 18.65 | 317 | Polar+E | cv,gg,u1,u2 |
| 2005ApJ...620..422S | 28.9311192294966 | 0.468710388240133 | | | | | | | 2002AJ....123..430S |
| J020712.72-014116.3 | SDSS J020712.71-014116.2 | | 2494386992562185088 | 1.55 | 0.15 | 20.27 | | Polar: | cv |
| work | 31.8030160472918 | -1.68784823887102 | | | | | | | 2023MNRAS.524.4867I |
| J020809.57+565239.7 | | | 505110900157013376 | | | 18.77 | 2961 | CV | u4 |
| 32.0398758932033 | 56.8777045605961 | | | | | | | | 2021A&A...648A..44M |
| J021008.33+571121.0 | UV Per | | 457106501671769472 | 1.557 | 0.003 | 17.75 | 250 | SU UMa | cv |
| 1997PASP..109.1359T | 32.5347258071429 | 57.1891648736762 | | | | | | | 1985AJ....90.1837S |
| J021315.48+533822.9 | MASTER OT | J021315.37+533822.7 | 455380951309048320 | 2.549 | 0.007 | * 20.05 | 3224 | SU UMa | cv |
| 2017PASJ...69...75K | 33.3145094962966 | 53.6396813044143 | | | | | | | 2013ATel.5536....1Y |
| J022102.79+732245.0 | ASASSN-14jq | | 546910213373341184 | 1.32427 | 0.00031 | * 19.94 | 425 | WZ Sge | cv,gg,wd |
| 2015PASJ...67...105K | 35.2616338626198 | 73.3791783513299 | | | | | | | *ASAS-SN CV candidate |
| J022623.34+711831.5 | AM Cas | | 545338083544363392 | 3.9576 | 0.0003 | 14.37 | 420 | U Gem | cv,gg,u1,u2 |
| 1996PASP..108..894T | 36.5972449914027 | 71.3087570542901 | | | | | | | 1988AN....309...91R |
| J023322.61+005059.4 | HP Cet | | 2500552912036565120 | 1.601 | 0.002 | 20.12 | 683 | WZ Sge:PS : cv | 2002AJ....123..430S |
| 2006MNRAS.373..687S | 38.3442161025676 | 0.849827971521724 | | | | | | | |
| J024131.07+593630.5 | ASASSN-16jv | | 464373929923792384 | | | 19.84 | 607 | U Gem | cv |
| 40.3794706143822 | 59.6084629440548 | | | | | | | | *ASAS-SN CV candidate |



Read with astropy

ApJ table

```
[In [1]: from astropy.io import ascii  
  
[In [2]: tab= ascii.read("apjacfaebt1_mrt.txt", format='cds')
```

```
[In [3]: tab  
Out[3]:  
<Table length=85686>

| ID               | RAdeg   | DEdeg    | z       | R200c   | M200c      | SCL   |
|------------------|---------|----------|---------|---------|------------|-------|
| str16            | float64 | float64  | float64 | float64 | 1e+14 Msun | int64 |
| J000000.6+321233 | 0.00236 | 32.20925 | 0.1274  | 1.72    | 5.9478     | 0     |
| J000002.3+051718 | 0.00957 | 5.28827  | 0.1694  | 0.94    | 1.9627     | 0     |
| J000003.5+314708 | 0.01475 | 31.78564 | 0.0916  | 0.94    | 1.6766     | 0     |
| J000004.7+022826 | 0.01945 | 2.47386  | 0.4179  | 0.95    | 0.4769     | 0     |
| J000006.0+152548 | 0.02482 | 15.4299  | 0.1731  | 1.13    | 1.5391     | 0     |
| J000006.3+221220 | 0.02643 | 22.20558 | 0.3985  | 0.84    | 0.903      | 0     |
| J000006.6+100648 | 0.02755 | 10.11333 | 0.3747  | 0.93    | 1.8814     | 0     |
| J000006.6+315235 | 0.02762 | 31.87626 | 0.2092  | 1.18    | 1.9203     | 0     |
| J000006.6+292129 | 0.02765 | 29.35813 | 0.2489  | 0.92    | 1.0586     | 0     |
| J000007.1-092910 | 0.02957 | -9.48607 | 0.3332  | 0.8     | 1.3679     | 0     |
| J000007.6+155003 | 0.03177 | 15.83424 | 0.1527  | 1.17    | 3.3484     | 0     |
| J000007.7+185245 | 0.03208 | 18.87909 | 0.4085  | 1.03    | 2.3615     | 0     |
| J000008.0+343316 | 0.0335  | 34.55436 | 0.2346  | 1.05    | 0.8036     | 0     |
| J000008.6+085715 | 0.0358  | 8.95418  | 0.2799  | 0.88    | 1.2017     | 0     |


```



Read with astropy

ApJ table

```
[In [1]: from astropy.io import ascii ]  
  
[In [2]: tab= ascii.read("apjacfaebt1_mrt.txt",format='cds') ]  
WARNING: UnitsWarning: 'the' did not parse as cds unit: At col 0, Unit 'the' not  
supported by the CDS SAC standard. Did you mean TH, Te, Th or he? If this is me  
ant to be a custom unit, define it with 'u.def_unit'. To have it recognized insi  
de a file reader or other code, enable it with 'u.add_enabled_units'. For detail  
s, see https://docs.astropy.org/en/latest/units/combining_and_defining.html [ast  
ropy.units.core]  
-----  
KeyError Traceback (most recent call last)  
File ~/miniforge3/envs/py310/lib/python3.10/site-packages/astropy/io/ascii/core.  
py:721, in BaseHeader.get_col_type(self, col)  
    720     type_map_key = self.get_type_map_key(col)  
--> 721     return self.col_type_map[type_map_key.lower()]  
    722 except KeyError:  
  
KeyError: 't'  
  
During handling of the above exception, another exception occurred:  
  
ValueError Traceback (most recent call last)  
Input In [2], in <cell line: 1>()  
----> 1 tab= ascii.read("apjacfaebt1_mrt.txt",format='cds')  
  
File ~/miniforge3/envs/py310/lib/python3.10/site-packages/astropy/io/ascii/ui.py  
:426, in read(table, guess, **kwargs)  
    424     else:  
    425         reader = get_reader(**new_kwargs)  
--> 426         dat = reader.read(table)  
    427         _read_trace.append(  
    428             {  
    429                 "kwargs": copy.deepcopy(new_kwargs),  
    (...)  
    File ~/miniforge3/envs/py310/lib/python3.10/site-packages/astropy/io/ascii/core.  
py:723, in BaseHeader.get_col_type(self, col)  
    721     return self.col_type_map[type_map_key.lower()]  
ji 722 except KeyError:  
--> 723     raise ValueError(  
    724         f'Unknown data type "{col.raw_type}" for column "{col.name}"'  
    725     )  
  
ValueError: Unknown data type ""times"" for column "critical"  
[In [3]: ]
```



Read with astropy

ApJ table

astropy / astropy

Type ⌂ to search | > | + | ⌂ | ⌂

Code Issues 1.2k Pull requests 49 Actions Projects 2 Wiki Security Insights

Incorrect reading of multi-line Explanations in MRT/CDS ReadMes #15608

Open jobovy opened this issue 3 minutes ago · 0 comments

jobovy commented 3 minutes ago Member ...

Description

I'm trying to read [this table](#) (Table 1 from [this paper](#)) using `astropy.io.ascii` and this fails with

```
ValueError: Unknown data type "'times'" for column "critical"
```

This error points to a multi-line Explanation in the ReadMe being read wrong. This seems to happen because the first non-whitespace character in the second line is a number (the line is " 200 times the critical density"), because just adding a letter in front of the 200 lets the table be read. It seems like what's happening is that the parser thinks the line is a new column because it starts with a number.

Expected behavior

Read the table without error

How to Reproduce

Download the table:

```
curl -0 "https://content.cld.iop.org/journals/0004-637X/958/1/62/revision1/apjacfaebt1_mrt.txt?Expires=1" 5.
```

Assigees
No one assigned

Labels
Bug

Projects
None yet

Milestone
No milestone

Development
No branches or pull requests

Notifications Customize
Unsubscribe

You're receiving notifications because you authored the thread.



Read with astropy

ApJ table

astropy / astropy

Type to search

Code Issues 1.2k Pull requests 77 Actions Projects 3 Wiki Security 1 Insights

[io.ascii.cds] Fix reading of multi-line CDS descriptions where the continued line starts with a number #15617

Merged hamogu merged 9 commits into [astropy:main](#) from [jobovy:fix-cds-multi-line-explanation](#) on Dec 12, 2023

Conversation 25 Commits 9 Checks 22 Files changed 4 +36 -8

jobovy commented on Nov 15, 2023

Description

Fixes [#15608](#)

Fixing this turned out to be a bit tricky, because a multi-line continuation of a column description starting with a number can just get read in like a normal line and have all of the required entries (end, format, units, name, and descr). In particular, the line I was having an issue with is

```
" 200 times the critical density"
```

and gets matched using the regular expression to

```
>>> match.groupdict()
{'start': None,
 'end': '200',
 'format': 'times',
 'units': 'the',
 'name': 'critical',
```

Reviewers: dhomeier (✓), taldcroft (1), hamogu (1)

Assignees: No one assigned

Labels: Bug, io.ascii, backport-v6.0.x

Projects: None yet

Milestone:



Read with astropy

ApJ table

astropy / astropy

Type to search | + | ⌂ | ⌂

Code Issues 1.2k Pull requests 77 Actions Projects 3 Wiki Security 1 Insights

Incorrect reading of multi-line Explanations in MRT/CDS ReadMes #15608

Closed jobovy opened this issue on Nov 13, 2023 · 0 comments · Fixed by #15617

jobovy commented on Nov 13, 2023 Member ...

Description

I'm trying to read [this table](#) (Table 1 from [this paper](#)) using `astropy.io.ascii` and this fails with

```
ValueError: Unknown data type ""times"" for column "critical"
```

This error points to a multi-line Explanation in the ReadMe being read wrong. This seems to happen because the first non-whitespace character in the second line is a number (the line is " 200 times the critical density"), because just adding a letter in front of the 200 lets the table be read. It seems like what's happening is that the parser thinks the line is a new column because it starts with a number.

Expected behavior

Read the table without error

How to Reproduce

Download the table:

```
curl -0 "https://content.cld.iop.org/journals/0004-637X/958/1/62/revision1/apjacfaebt1_mrt.txt?Expires=115...
```

Assignees
No one assigned

Labels
Bug `io.ascii`

Projects
None yet

Milestone
No milestone

Development
Successfully merging a pull request may close this issue.

↳ [io.ascii.cds] Fix reading of multi-line CDS d...

Notifications Customize

Unsubscribe



Read with astropy

CDS table

- Download the ReadMe and the data file

```
[In 1]: from astropy.io import ascii  
[In 2]: tab= ascii.read("tablea1.dat", format='cds', readme='ReadMe')  
  
[In 3]: tab  
Out[3]:  
<Table length=118>  
SDSS  
str19  
str29  
Name  
...  
DEdeg  
deg  
float64  
---  
J000600.15+012129.8  
J003827.05+250925.0  
J003941.08+005427.5  
J004335.16-003729.7  
J014227.07+001729.8  
J015543.47+002807.4  
J020712.72-014116.3  
J020809.57+565239.7  
J021008.33+571121.0  
J021315.48+533822.9  
J022102.79+732245.0  
J022623.34+711831.5  
J023322.61+005059.4  
J024131.07+593630.5  
J040834.99+511448.2  
J041844.44+510731.2  
J042609.34+354144.5  
...  
J183052.72+265514.9  
J183211.36+615505.9  
J192914.75+202759.5  
J192927.83+202035.0  
1RXS J003828.7+250920  
SDSS J003941.06+005427.5  
SDSS J004335.14-003729.8  
FL Cet ...  
SDSSJ020712.71-014116.2  
ASASSN-14jq ...  
UV Per ...  
MASTER OT J021315.37+533822.7  
ASASSN-14jv ...  
AM Cas ...  
HP Cet ...  
ASASSN-16jv ...  
FO Per ...  
NS Per ...  
MASTER OT J042609.34+354144.8  
MGAB-V733 ...  
ASASSN-13ah ...  
NQ Vul ...  
1RXS J192926.6+202038 ...
```

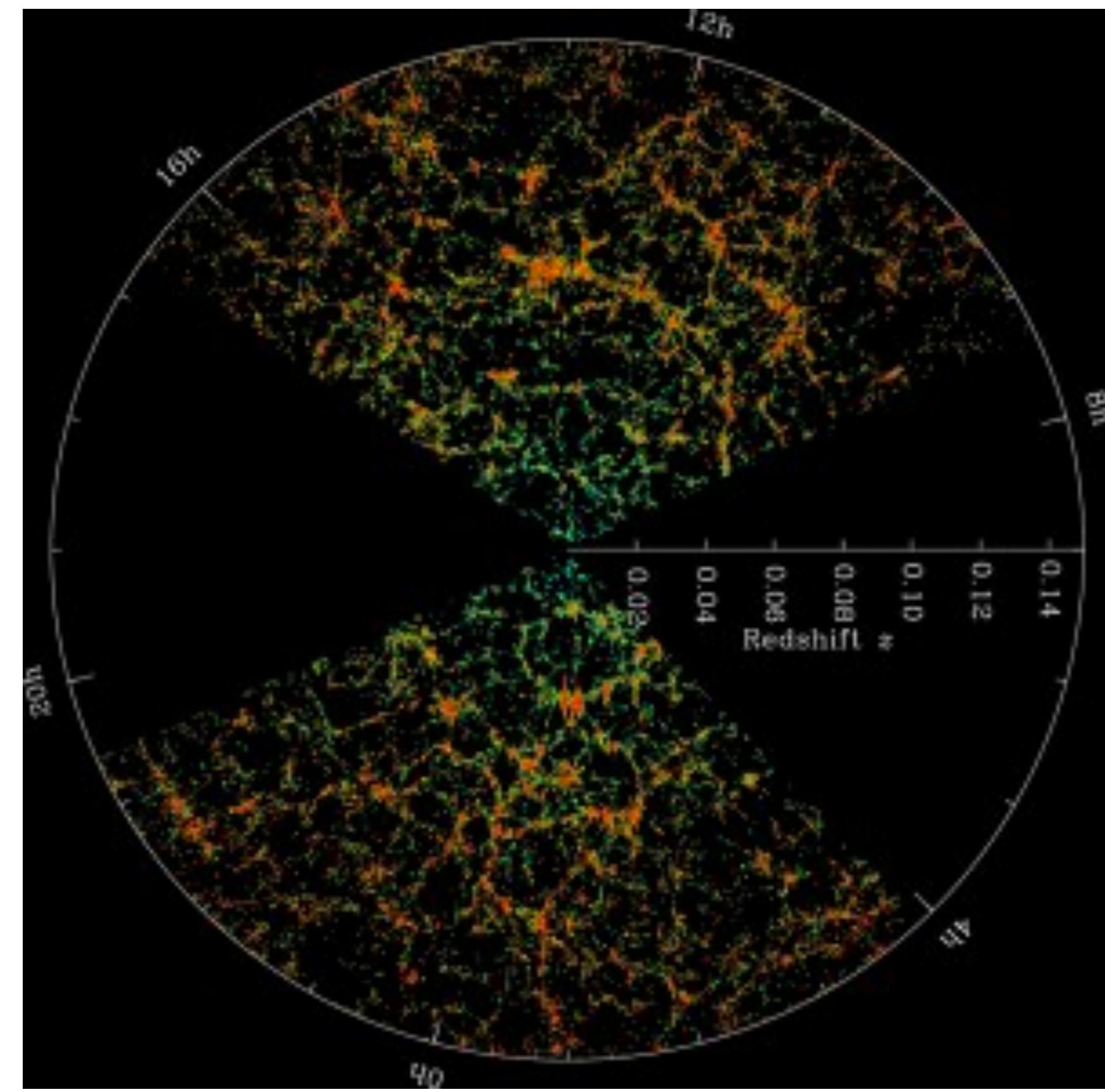
- (In javascript, use <https://github.com/jobovy/vizier.js>)

CDS best practices

- For reproducibility, always use the full files if you can
- Don't use the query interface aside from experimentation:

The screenshot shows the CDS VizieR catalog search interface. At the top, there's a navigation bar with links to Portal, Simbad, VizieR, Aladin, X-Match, Other, and Help. The main title is "Catalog". On the left, there's a sidebar titled "Search Criteria" with sections for "Keywords" (J/MNRAS/525/3597), "Tables" (J/MNRAS/525/3597, ..tablea1), and "Preferences" (max: 50). The main area has tabs for "Simple Target" (selected) and "List Of Targets". It includes fields for "Target Name (resolved by Sesame) or Position:" (with "Clear" and "J2000" dropdowns) and "Target dimension:" (with "2 arcmin" dropdown). A note says "NB: The epoch used for the query is the original epoch of the table(s)" with options for "Radius" (radio button) and "Box size" (radio button). Below this, it shows "CVs from SDSS V (Inight+, 2023)" and "CVs from the plate survey (118 rows)". There are links for "Similar Catalogs", "2023MNRAS.525.3597I", "ReadMe+ftp", and a thumbnail image. At the bottom, there's a "Simple Constraint" section with a table showing columns like "recno", "SDSS", "Name", "GaiaEDR3", "Per", "e_Per", "n_Per", "Gmag", "Distance", and "VType" with their respective constraints and explanations. Buttons for "Submit" and "Reset All" are at the bottom right.

Large data sets



Large survey data

- Astrophysics has many large surveys and more so over time
 - E.g., SDSS (+APOGEE/MaNGA), 2MASS, Gaia, DES, DESI, LAMOST, PanSTARRS, WISE, FIRST, GALEX, Fermi
Future: Rubin, Euclid, SKA, etc.
- Most efficient way to interact with collection of many objects is a *database*
- Databases can be search using SQL (Structured Query Language) or an astro-extension of it ADQL (Astronomical Data Query Language)
- Surveys often contain their own data + helpful data from other surveys in one database

Example: SDSS

The screenshot shows the SciServer SkyServer homepage. At the top, there is a navigation bar with links for Home, Visual Tools, Search Tools, CrossMatch Tools, More Tools, Support, CasJobs, and Sign In. Below the navigation bar is a large logo featuring a stylized cluster of stars within an oval frame, followed by the text "SkyServer". Underneath the logo, the tagline "EXPLORE THE UNIVERSE WITH THE SLOAN DIGITAL SKY SURVEY" is displayed. A dropdown menu labeled "Data Release 18" is open. Below the main title, there is a section titled "Choose a tool..." containing six buttons: "Navigate" (with a map icon), "Explore" (with a map icon), "Finding Chart" (with a magnifying glass icon), "Quick Look" (with a document icon), "Radial Search" (with a magnifying glass icon), and "SQL Search" (with a magnifying glass icon). At the bottom of the page, there are three footer sections: "About the Sloan Digital Sky Survey" (purple background), "How do I get data?" (green background), and "Visual Tools" (blue background). Each footer section has a "+" sign at the end.

Example: Gaia

The screenshot shows the homepage of the Gaia Archive. At the top, there is a navigation bar with links for 'HOME', 'SEARCH', 'SINGLE OBJECT', 'VISUALISATION', and 'HELP'. Below this is a main content area with a red header featuring the 'gaia archive' logo and the 'esa' logo. The header also includes a 'SIGN IN' button and a 'Relaunch to update' button. The main content area has a dark background with a red gradient and a circular logo in the center. The logo features the 'esa' and 'gaia' logos. Below the logo, the text reads: 'Welcome to the Gaia ESA Archive'. A paragraph describes the Gaia mission: 'Gaia is a European space mission providing astrometry, photometry, and spectroscopy of nearly 2000 million stars in the Milky Way as well as significant samples of extragalactic and solar system objects. The Gaia ESA Archive contains deduced positions, parallaxes, proper motions, radial velocities, and brightness measurements. Complementary information on multiplicity, photometric variability, and astrophysical parameters is provided for a large fraction of sources.' In the bottom left, there is a section titled 'Top Features' with eight items:

- Gaia Mission**: News, Gaia alerts, information, and resources on the Gaia mission for the scientific community.
- Gaia DR3**: Direct access to Gaia DR3 papers, known issues, tools, auxiliary data, etc.
- Gaia FPR**: Direct access to all information of the Focused Product Release.
- Download**: Direct bulk download of Gaia data in ECSV format.
- Software Tools**: Software tools for resampling of spectra, calibration of data, etc.
- Auxiliary Data**: Small data sets related to calibration, photometric pass bands, exoplanets, asteroids, etc.
- Citation**: How to cite and acknowledge the use of Gaia data and where to find DOIs.
- Partners**: Partner data centres also serving Gaia data.

Example: Gaia

The screenshot shows the Gaia archive search interface on a web browser. The URL in the address bar is `gea.esac.esa.int/archive/`. The page has a red header with the "gaia archive" logo and the "esa" logo. The navigation menu includes links for "HOME", "SEARCH", "SINGLE OBJECT", "VISUALISATION", and "HELP". Below the menu, there are tabs for "Basic", "Advanced (ADQL)", and "Query Results", with "Advanced (ADQL)" currently selected.

In the main search area, there is a dropdown menu set to "gaia". A "Job name:" input field is present. To the right, there is a "Query examples" section and a "Reset Form" button. The "Submit Query" button is highlighted with a blue background and white text. A tooltip "Ctrl+Space for query autocompletion" is visible near the input field.

A dropdown menu is open over the query input field, listing various database schema and tables. The visible items include:

- agn_cross_id
- alerts_mixedin_sourceids
- allwise_best_neighbour
- allwise_neighbourhood
- apassdr9_best_neighbour
- apassdr9_join
- apassdr9_neighbourhood
- astrophysical_parameters
- astrophysical_parameters_supp
- binary_masses

Below the query input field, a message says "No results found". A table header is shown with columns: Status, Job, Creation date, Num. rows, and Size.

At the bottom of the page, there are navigation icons for back, forward, and search, along with a message "1-1 of 0". There are also buttons for "Download format: VOTable", "Apply jobs filter", "Filter this session", "Select all jobs" (with a checked checkbox), and "Delete selected jobs".

Very basic SQL

- Start query with SELECT then say what you want and what you want if FROM

```
SELECT ra, dec FROM PhotoPrimary  
SELECT top 10 ra, dec, psfmag_i-extinction_i AS mag_i FROM  
SpecPhoto
```

- Add constraints (WHERE) and JOIN on other table

```
SELECT p.ra, p.dec, s.psfmag_i-s.extinction_i AS mag_i  
FROM PhotoPrimary AS p  
JOIN SpecPhoto AS s ON p.objID = s.objID  
WHERE (s.class='QSO')
```

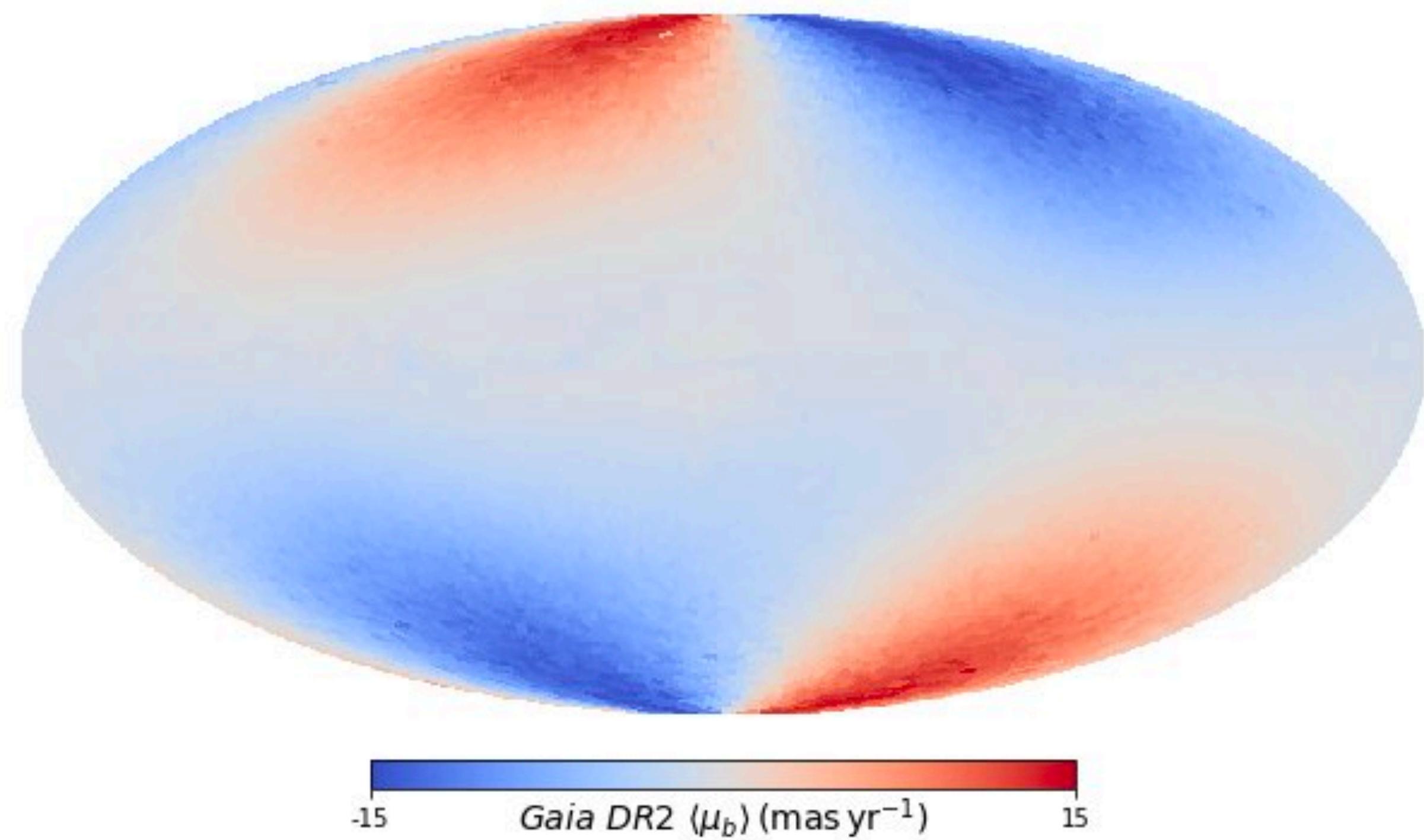
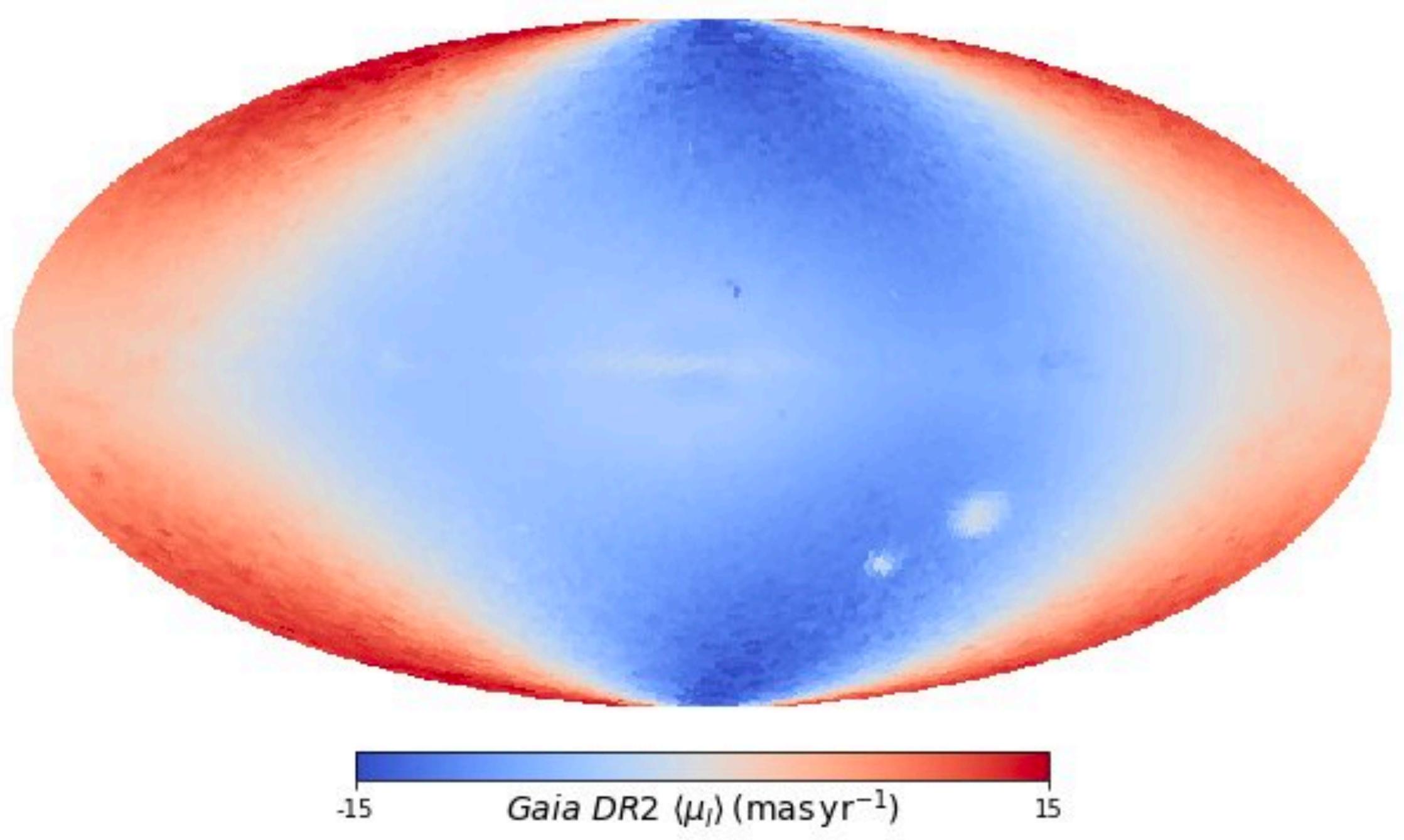
More advanced SQL

- Very powerful, e.g., can do calculations and histograms (Gaia example)

```
SELECT hpx5, AVG( (c1*pmra+c2*pmdec)/cos(b_rad) ) AS mpml1,
AVG( (-c2*pmra+c1*pmdec)/cos(b_rad) ) AS mpmbb
FROM (
    SELECT source_id/562949953421312 as hpx5,
    pmra, pmdec, radians(b) as b_rad, parallax,
    0.4559838136873017*cos(radians(dec))
    -0.889988068265628*sin(radians(dec))
    *cos(radians(ra-192.85947789477598)) as c1,
    0.889988068265628*sin(radians(ra-192.85947789477598)) as c2
    FROM gaiadr2.gaia_source
    WHERE phot_g_mean_mag < 17.
) tab
GROUP BY hpx5
```

- ADQL adds functions to do things like calculate offsets on the sky

More advanced SQL





astroquery

- Convenient Python interface to many astronomical data sets

```
python -m pip install -U --pre astroquery
```

- E.g., SDSS

```
from astroquery.sdss import SDSS
query = f"""select top 1 r-extinction_r as r0
FROM PhotoObjAll
WHERE objid=1237668367999172911"""
res= SDSS.query_sql(query,data_release=17)
print(f"The observed r-band magnitude is {res['r0']}
[0]:.2f}")
```



astroquery

- Convenient Python interface to many astronomical data sets

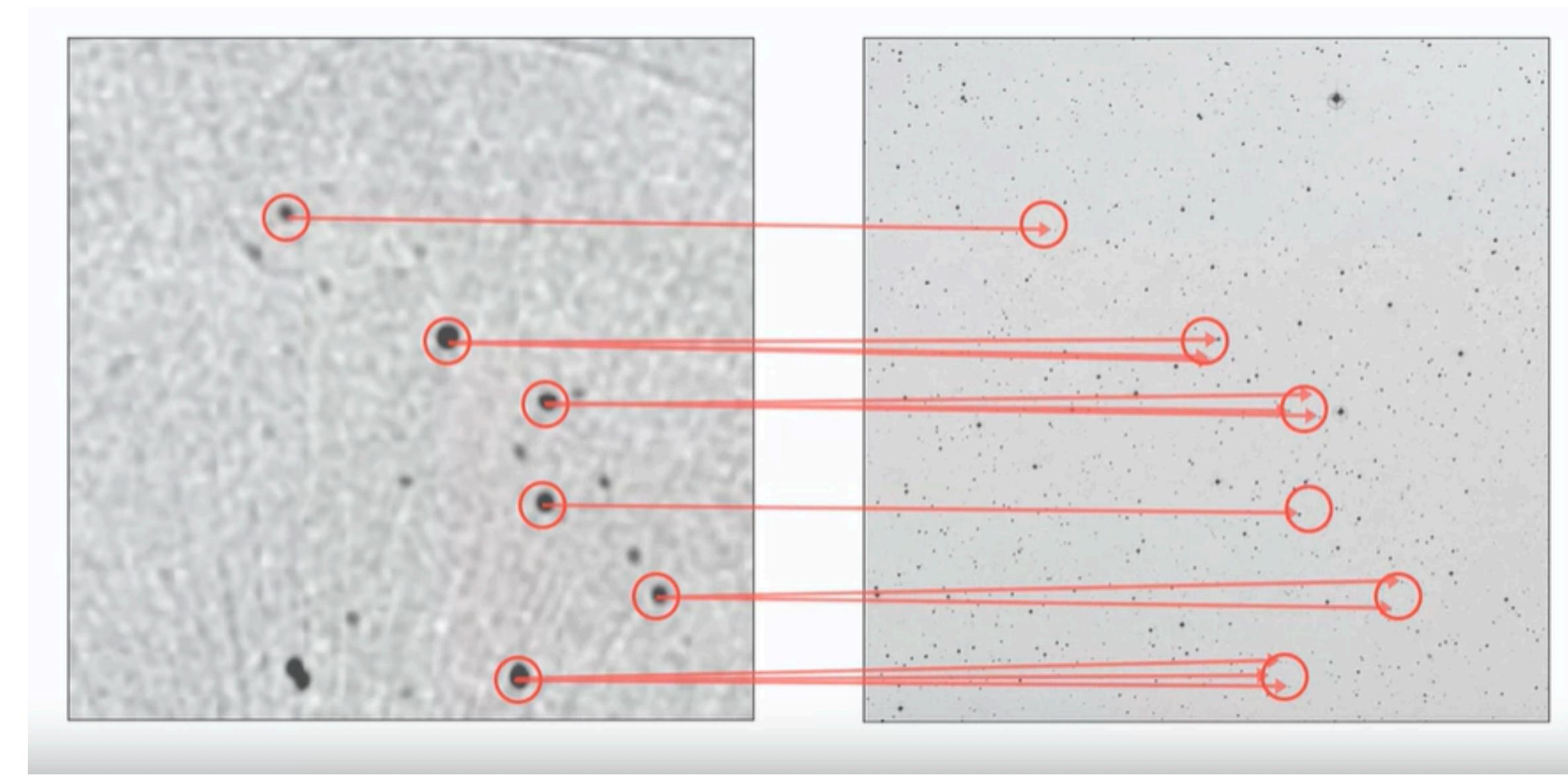
```
python -m pip install -U --pre astroquery
```

- E.g., Gaia

```
>>> from astroquery.gaia import Gaia
>>> job = Gaia.launch_job_async("select top 100 designation,ra,dec "
...                               "from gaiadr3.gaia_source order by source_id")
INFO: Query finished. [astroquery.utils.tap.core]
>>> r = job.get_results()
>>> print(r)
      DESIGNATION          ra          dec
              deg          deg
-----
  Gaia DR3 4295806720  44.99615537864534  0.005615226341865997
  Gaia DR3 34361129088  45.00432028915398  0.021047763781174733
  Gaia DR3 38655544960  45.004978371745516  0.019879675701858644
  Gaia DR3 309238066432  44.99503714416301  0.03815169755425531
...
Length = 100 rows
```

- astroquery caches and is great for reproducibility

Cross-matching



Cross-matching

- Every time you point a telescope at the sky, you have to figure out where it's pointing and what's in it
- Cross-matching is non-trivial because of resolution/crowding, proper motion, SEDs, ...
- Typically, cross-matching is done by 2D position, requiring a close match in RA and Dec, but can also use magnitude/color or other properties → expensive for large surveys

Finding all data on a single object

- Easiest using Simbad, either web:

M87

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

Query : M87 submit id

Basic data :

M 87 -- Active Galaxy Nucleus

Other object types: LIN (), BiC (), Rad (2020A&A,BWE,...), G (2014ApJS,APG,...), X (1A,2A,...), gam (1FGL,2FGL,...), AGN (2011ApJ,[VV2000c],...), GiC (ACSVCS,GIN,...), UV (2EUVE,EUVE,...), rG (2012MNRAS), IR (IRAS,[DML87]), QSO (QSO), GiG ([CHM2007]), AG? (2020MNRAS), * (Gaia), Opt (SDSS)

ICRS coord. (ep=J2000) : 12 30 49.42338414 +12 23 28.0436859 (Radio) [0.0304732 0.0308 0] A 2020A&A...644A.159C

FK4 coord. (ep=B1950 eq=1950) : 12 28 17.60290329 +12 40 01.3345803 [0.0304732 0.0308 0]

Gal coord. (ep=J2000) : 283.77775499474 +74.49115452365 [0.0304732 0.0308 0]

Proper motions mas/yr: -8.029 10.734 [1.178 0.932 90] A 2018yCat.1345....0G

Radial velocity / Redshift / cz: V(km/s) 1256 [36] / z(spectroscopic) 0.00420 [0.00012] / cz 1259.1 [36.0] (Opt) E 2009ApJS..182..543A

Morphological type: E-E/S0 C 2014A&A...569A.124V

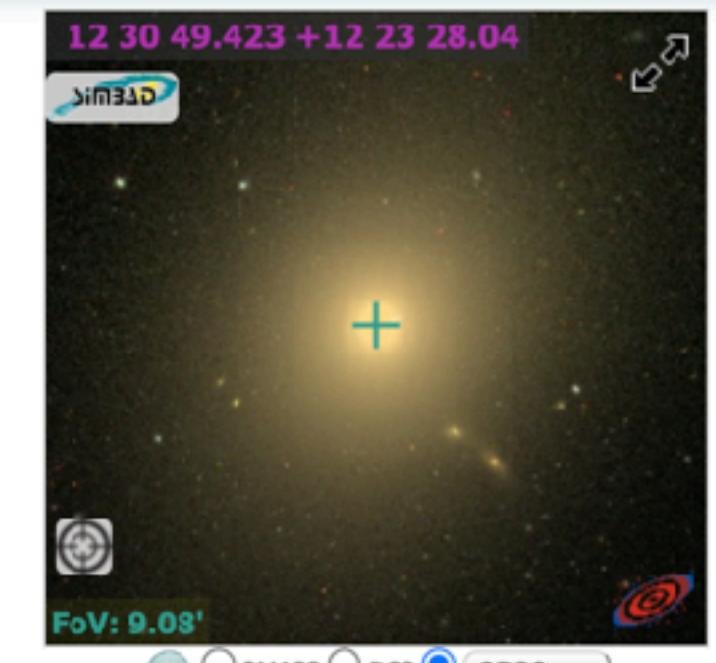
Angular size (arcmin): 9.12 7.94 ~ (Opt) D 2003A&A...412...45P

Fluxes (13) :

| | | | | |
|---|---------|----------|---------|-----------------------|
| U | 10.16 | [0.04] | D | 2007ApJS..173..185G |
| B | 9.59 | [0.04] | D | 2007ApJS..173..185G |
| V | 8.63 | [0.04] | D | 2007ApJS..173..185G |
| G | 15.7940 | [0.0117] | C | 2018yCat.1345....0G |
| I | 7.49 | [~] | D | 2012A&A...538A..69L |
| J | 6.719 | [0.017] | C | 2006AJ....131.1163S |
| H | 6.074 | [0.018] | C | 2006AJ....131.1163S |
| K | 5.812 | [0.019] | C | 2006AJ....131.1163S |
| u | (AB) | 13.480 | [0.003] | C 2009ApJS..182..543A |
| g | (AB) | 11.563 | [0.002] | C 2009ApJS..182..543A |
| r | (AB) | 10.703 | [0.002] | C 2009ApJS..182..543A |
| i | (AB) | 10.272 | [0.002] | C 2009ApJS..182..543A |
| z | (AB) | 9.917 | [0.002] | C 2009ApJS..182..543A |

SIMBAD Query around within 2 arcmin

12 30 49.423 +12 23 28.04



FoV: 9.08'

2MASS DSS SDSS

All CDS (CDSPortal)

Send to Aladin

Photometry within 5 arcsec

Finding all data on a single object

- Easiest using Simbad, either web or through astroquery

```
[In [4]: from astroquery.vizier import Vizier

[In [5]: result = Vizier.query_object("M87")

In [6]: print(result)
TableList with 760 tables:
'0:METAobj' with 5 column(s) and 7 row(s)
'1:ReadMeObj' with 5 column(s) and 7 row(s)
'2:I/122/bd' with 9 column(s) and 1 row(s)
'3:I/151/table3' with 5 column(s) and 1 row(s)
'4:I/252/out' with 8 column(s) and 2 row(s)
'5:I/267/out' with 16 column(s) and 50 row(s)
'6:I/272/m2000' with 6 column(s) and 2 row(s)
'7:I/284/out' with 14 column(s) and 13 row(s)
'8:I/297/out' with 19 column(s) and 18 row(s)
'9:I/300/pm2000' with 12 column(s) and 3 row(s)
'10:I/302/xcfields' with 9 column(s) and 2 row(s)
'11:I/304/out' with 9 column(s) and 6 row(s)
'12:I/313/lqrf' with 10 column(s) and 1 row(s)
```

Finding all data on a single object

- Easiest using Simbad, either web or through astroquery
- Other similar service is NED, focused on external galaxies (linked to by Simbad)
- Can also do regional searches with rectangles or circles using astroquery for given catalogs (e.g., Gaia)
 - This is often also possible on the survey's website

Cross-matching a catalog to another catalog

- Suppose you have a relatively large set of objects that you want to match to another large set of objects (could be a large survey)
 - Can do this locally with astropy:

```
>>> c = SkyCoord(ra=ra1*u.degree, dec=dec1*u.degree)
>>> catalog = SkyCoord(ra=ra2*u.degree, dec=dec2*u.degree)
>>> idx, d2d, d3d = c.match_to_catalog_sky(catalog)
```
 - Sometimes possible on a survey's website
 - CDS x-matching service: <http://cdsxmatch.u-strasbg.fr/>
 - Cross-match two VizieR catalogs to each other
 - Cross-match user catalog to VizieR catalog
 - Can be done programmatically (e.g., using cURL) or through `astroquery.xmatch`