IAU School

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1 Introduction

The CDS hosts three major services, accessible through the CDS portal:

- SIMBAD : The astronomical database SIMBAD contains about 18 million objects. For each object, it provides basic measurements (type, coordinates, proper motion, radial velocity, spectral type, distance, magnitude...), cross-correlations, and a bibliography.
- VizieR: The VizieR catalogue service provides access to more than 25,000 catalogues, being the most complete library of published astronomical data tables available online.
- Aladin: The interactive sky atlas Aladin allows to visualize astronomical images and to superimpose entries from different catalogues and databases. It allows to visualize data from SIMBAD, VizieR, and from archives and databases distributed around the world. Furthermore, you can open your own tables or images. There are two versions of Aladin: Aladin desktop and Aladin Lite, which runs in the browser.
- Xmatch: The CDS cross-match service is a tool allowing astronomers to efficiently cross-identify sources between very large catalogues (up to 1 billion rows) or between a user-uploaded list of positions and a large catalogue.

In addition, the MOC server allows to retrieve the Mutli-Order Coverage (MOC) of astronomical surveys and Hierarchical Progressive Surveys (HiPS) themselves.

2 Goal of the tutorial

This tutorial shows how to use the CDS tools to gather information on specific astronomical objects. We will:

- Search for information on NGC4039 in the CDS portal
- Search for data concerning NGC4039 in Aladin
- Compare the coverage of sky surveys and select interacting galaxies that have SDSS and GALEX data

3 Search for information on NGC4039 in the CDS Portal

Open the CDS Portal and make a query for 'NGC4039'. The result provides an overview of the information and data available for this object in the 3 CDS services: SIMBAD, Aladin and VizieR:

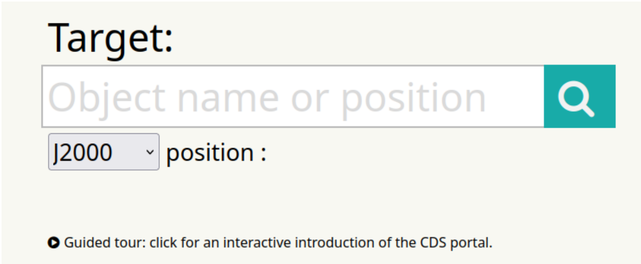

Figure 1: A view of the prompt on the CDS portal

3.1 SIMBAD - Identifiers, Basic Measurements and links to the Bibliography

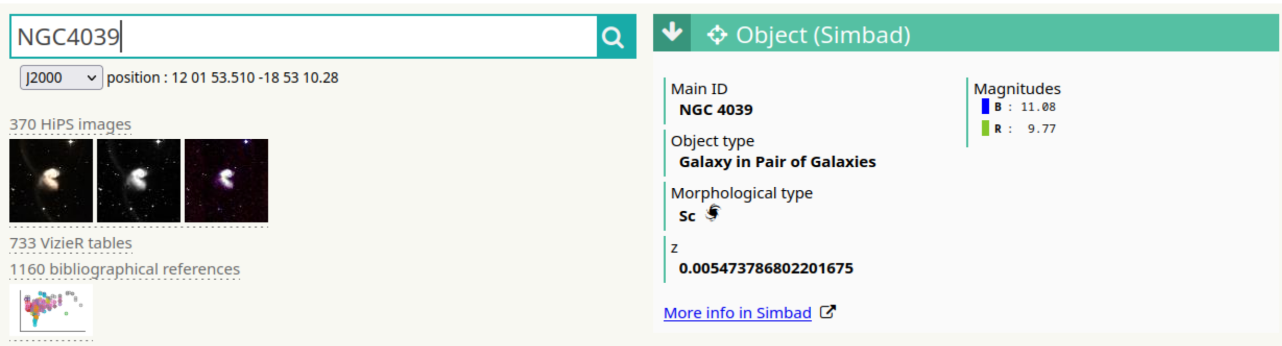

Figure 2: The top part of a CDS portal query.

⇒ You can click on **More info in Simbad** (see bottom right of figure 2) to see the full SIMBAD information on this object in a new tab. The new page should look like figure 3.

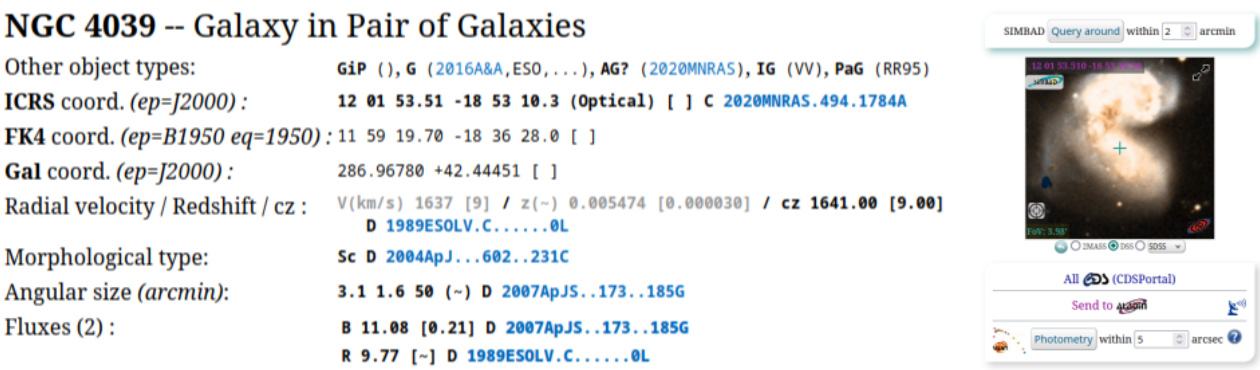

Figure 3: A result page on SIMBAD contains the basic information section (left part of this figure) and a quick Aladin preview (right part of this figure).

⇒ In the main SIMBAD page, you can find under **Documentation**, several user guides, one particularly of interest is the **Object types**, see figure 4. These give information about the physical nature of the object. These types are drawn from the literature and are stored in SIMBAD using a hierarchical classification scheme. The main Object Type of NGC4039 is **Galaxy in Pairs of Galaxies (GiP)**.

⇒ To know more about an object type, you can type in the object's type full name (Galaxy in pair) or its short form, in our case **GiP**. You can then see the in-depth information about the object type.

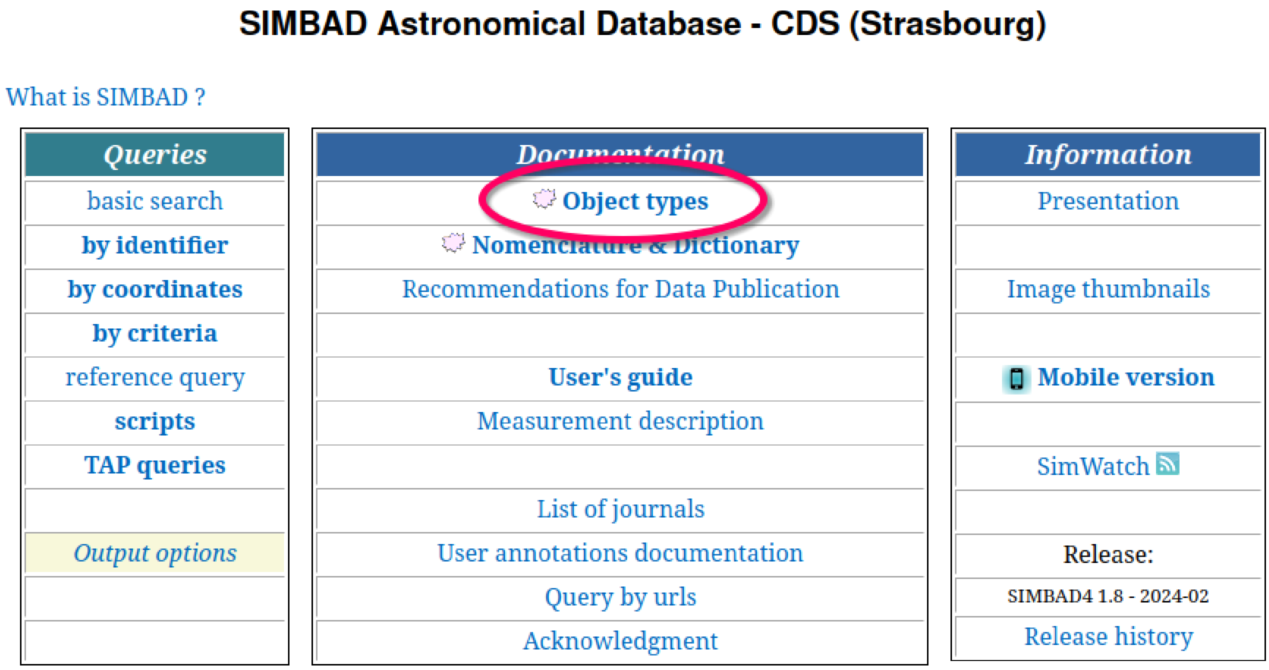

Figure 4: The documentation section in SIMBAD main page (https://simbad.cds.unistra.fr/simbad/)

⇒ Now you can go back to the main webpage pf SIMBAD, again type in **NGC4039**. Click on **More info in Simbad** to see the full SIMBAD information on this object in a new tab.

⇒ Use the **parents** button, see figure 5, to identify the name of the galaxy pair. Sorting by the number of references can help bring out the most important ones.

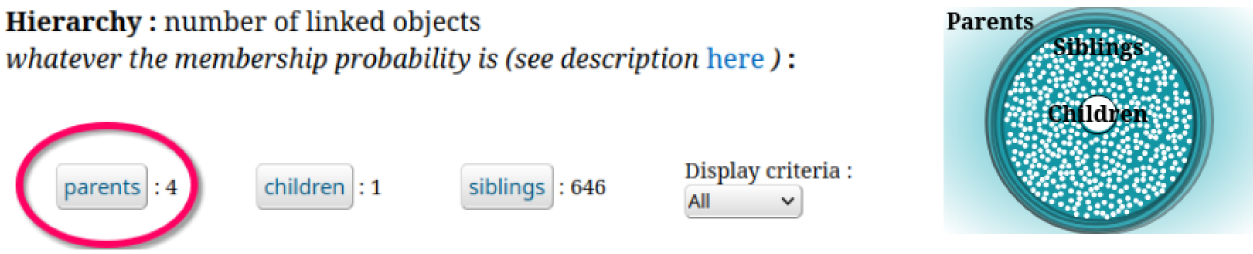

Figure 5: Scroll down on SIMBAD results page to see the hierarchy section.

⇒ Follow the link to the SIMBAD entry of the Antennae galaxy pair , see figure 6. There, click on the **children** button to identify the name of the two galaxies making up the galaxy pair. Again, the number of references might help to find them.

4 parents from 5 bibliographic links

Show 100 entries Search:

N	Identifier	dist(asec)	prob. member	link ref	link comment	Otype	ICRS (J2000) RA	ICRS (J2000) DEC	Mag U	Mag B	Mag V	Mag R	Mag I	Sp type	#ref 1850 - 2024
1	NAME Antennae	32.72	~	~	~	IG	12 01 53.170	-18 52 37.92						~	1695
3	[T2015] nest 100219	2179.66	100	2015AJ....149..171T	B	GrG	11 59 22.3	-18 59 35						~	3
4	[T2015] nest 100219	2179.66	100	2016AJ....152...50T	B	GrG	11 59 22.3	-18 59 35						~	3
2	[TSK2008] 409	2793.76	100	2013AJ....146...86T	B	GrG	11 59 25.9	-19 24 03						~	2
5	[TKT2016] 740	1229.87	100	2016A&A...588A..14T	B	PaG	12 00 41.00	-19 04 24.6						~	1

Figure 6: In the hierarchy results, you can sort results (see ellipse in the right) and then go read more on a specific parent (see ellipse on the left).

⇒ Visit the SIMBAD entry of the interaction partner of NGC 4039 and use the **References** section to find the earliest listed reference in the literature to this object. N.B. You can click on the **Follow** button to subscribe to stay updated with the latest bibliographic additions, see figure 7.

⇒ Return to the CDS portal and scroll down to the Aladin section, see figure 8.

Figure 7: The SIMBAD bibliography section. Note the follow button to suscribe to the object.

3.2 Aladin - Images

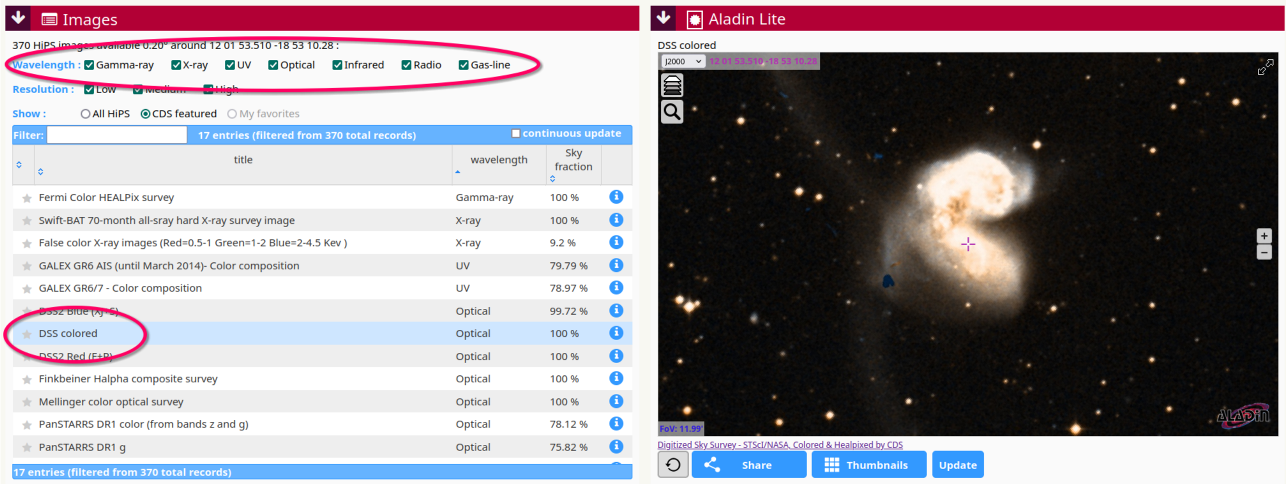

Figure 8: Scroll down in the CDS portal result page to see the Aladin section. The top ellipse highlights the wavelength selection. Click in the list below to load the desired survey. Here DSS colored is selected.

⇒ A DSS (Digitized Sky Survey) image of NGC4039 is shown, see the right part of figure 8.

⇒ Note that you can zoom in and out by scrolling your mouse when the mouse pointer is positioned on top of the Aladin view.

⇒ Other images can be displayed by selecting them in the left column, see left part of figure 8. Select the PanSTARRS DR1 and 2MASS colour images one after another to see a higher resolution image and an image at the infrared wavelength of the galaxy pair.

⇒ Filtering on wavelength and resolution is possible by ticking/unticking the boxes above, see the ellipse on top of figure 8.

3.3 VizieR - Catalogues

⇒ The list of catalogues is sorted by **Popularity**, see ellipse in figure 9 but can also be sorted by the number of rows (**#rows**), **sky fraction**, or **year**. These options appear in the scroll down menu.

⇒ Restrictions and filtering can be applied by clicking on the left or right columns according to your requirements. How many catalogues provide data in the optical for galaxies and come with images as associated data?

⇒ Now go back to displaying all catalogues available within 0.2 deg of NGC4039 by clicking the **Show All** button, see figure 10.

⇒ After selecting one catalogue, it is possible to look at it (either quickly by clicking **Quickview**, see figure 11,

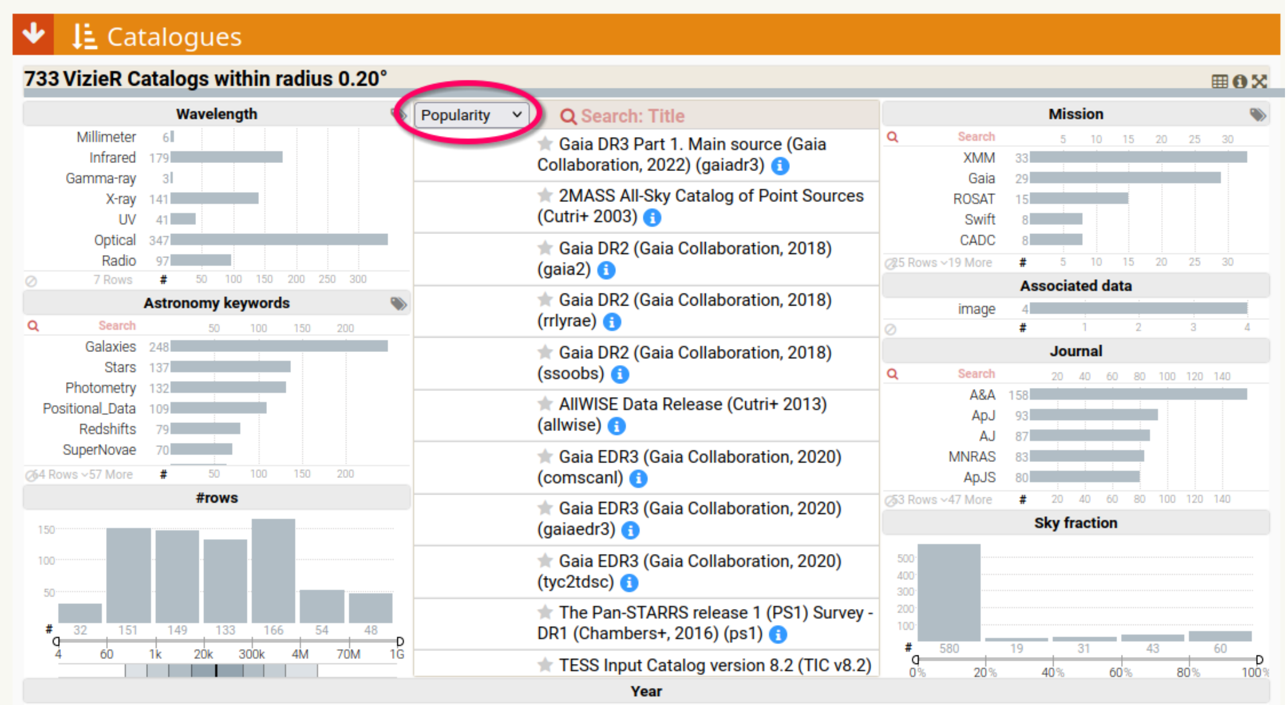

Figure 9: The Vizier section in the CDS portal.

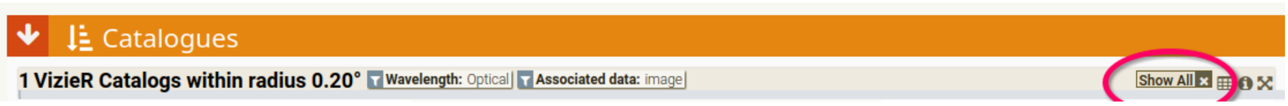

Figure 10: The location of the show all button to remove filters.

or in **VizieR**), to **Plot** column values, and to send it to Aladin (or other SAMP-aware tools like TOPCAT) use the **SAMP** button.

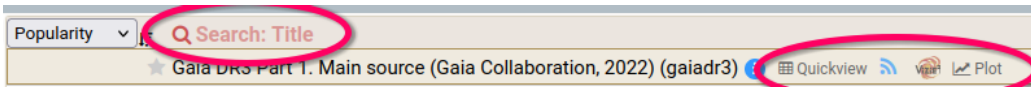

Figure 11: The quick-view button appears when hovering on a record.

⇒ You can search particular catalogues in the Vizier archive using the search bar, see figure 12. For eg., The Antennae astrophysical object is listed in the Arp Atlas of Peculiar Galaxies. We can search for this catalogue by typing 'Arp' into the **Search** box.

⇒ There are two tables for **Webb 1996**, see figure 12. Using the info button you'll see that the **arplist** table contains a list of all galaxies with some additional information. Select the **arplist** table by clicking on it and then on the **VizieR** logo. This would direct you to the VizieR detailed query page.

⇒ Make a first query on this table by clicking on **submit** on the right side of the screen. Examine the output as html. Go back to the previous page.

⇒ Modify the query preferences to add extra coordinate columns in J2000 decimal degrees and to obtain the whole catalogue. To achieve that, remove the restriction on searching only around 'NGC4039' by clicking on the **Clear** button below **Target Name (resolved by Sesame)** or **Position** at the top of the page.

⇒ Change the format to VOTable in the `Preferences` panel. Click on the `Submit` button again. This will download the data file. Keep it somewhere you can find it again, as we will use it later in the tutorial.

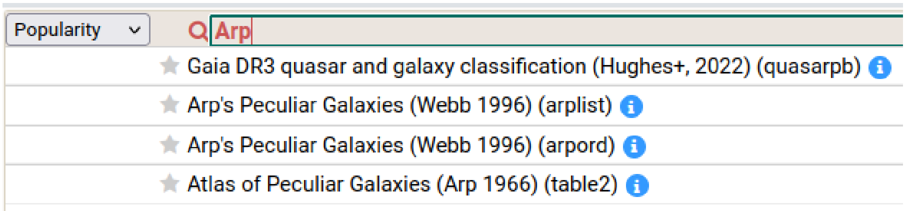

Figure 12: The search bar allows to retrieve specific catalogs.

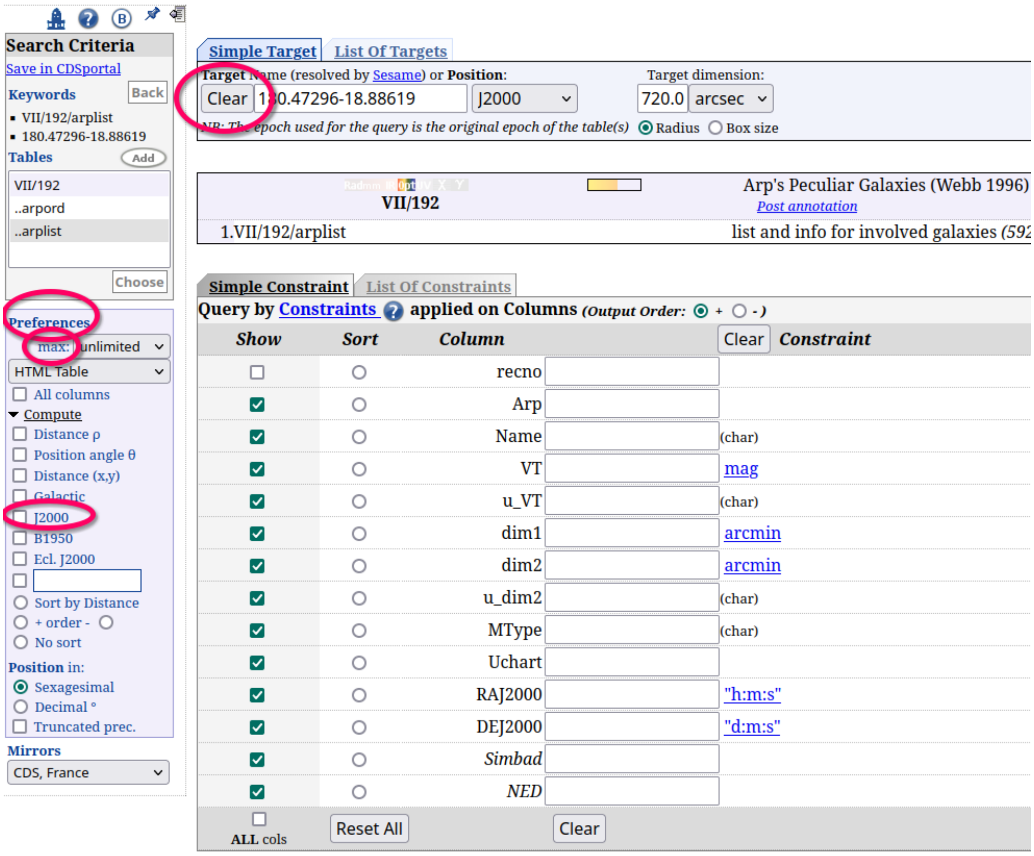

Figure 13: A query in a catalogue can be adapted to specific instructions: additional columns, number of rows, position conditions...

3.4 How do the data get into the CDS databases?

As you have seen in the last sections, the CDS databases (SIMBAD, VizieR, the HiPS server for images) host large amounts of a variety of data products. To provide these data to the astronomical community, about 12 data stewards curate the data. This involves collecting data from journal papers, receiving data directly from large surveys (such as e. g. Gaia), assessing and assuring the data quality and cross-matching sources described by newly published papers/data with sources already available in the databases. You can make this a smooth process by making sure that all sources in your papers appear with correct coordinates and names already known by SIMBAD.

4 Search for data on NGC4039 in Aladin desktop

Let's first install Aladin desktop.

⇒ Click on **Aladin** Tab on the top of the CDS website.

⇒ Click on **Download Aladin Desktop** button and these choose the option that suits you (don't hesitate ask for help if needed, [cds-question@unistra.fr]) and download the necessary file.

⇒ Open Aladin with at least 1GB memory allocated to the save virtual machine. To do so, use the following command line: `java -Xmx1024m -jar Aladin.jar`.

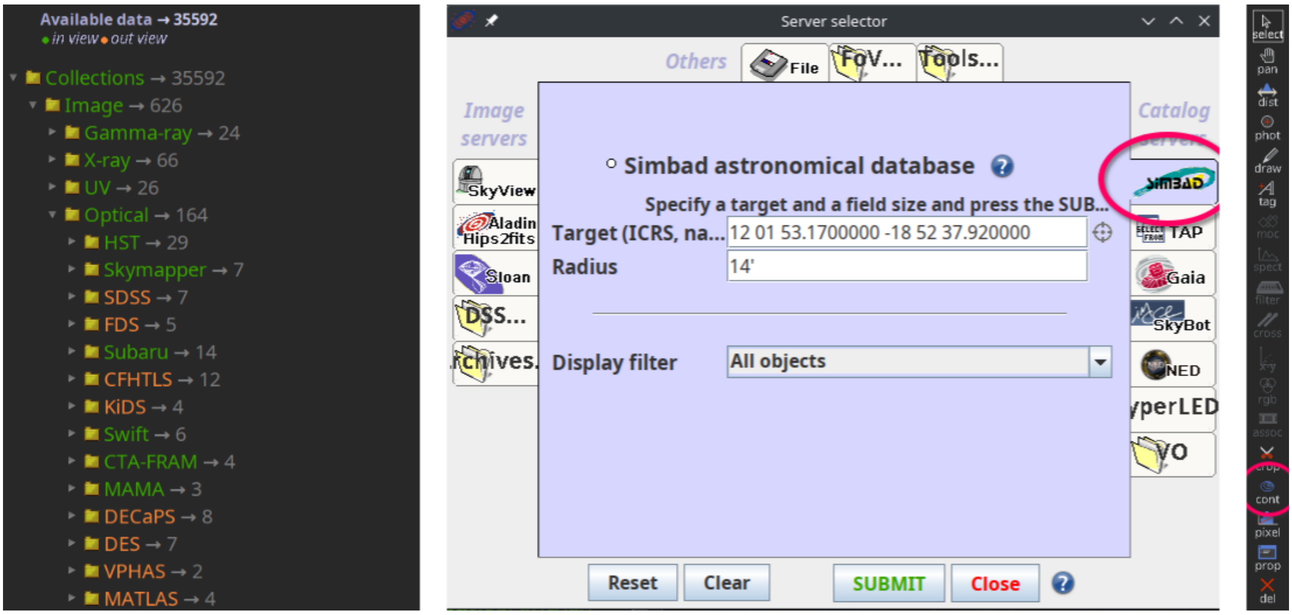

Figure 14: (A) In the Aladin DATA TREE the green entries show that some data is available in the current view. (B) The SERVER SELECTOR allows to retrieve data from external databases (here SIMBAD is selected). (C) On the right side of the view, there are options to edit the view. The contour tool is highlighted.

⇒ Aladin offers two ways to retrieve data: through the DATA TREE on the left-hand side of the Aladin window and through the SERVER SELECTOR window, which can be opened via **File** → **Open server selector...** or with `CTRL + L`. See figure 14.

⇒ Datasets in the DATA TREE are colour coded in green or orange depending on whether they are available in the region currently visible in the main viewing window, see left side of figure 14.

⇒ Start by typing "NGC4039" in the **Command line** (on top of the view) and press **Enter**. In the main viewing window, the coloured DSS image of the Antennae galaxies appears. As for the Aladin Lite window in the CDS portal you can zoom in and out by scrolling with your mouse.

⇒ Make a contour map of the image using the **cont** button on the right-hand side of the main viewing window. Increase the number of contours to better represent the image, see the right side of figure 14C.

⇒ Overlay a SIMBAD plane showing only the galaxies by selecting the **SIMBAD** tab in the SERVER SELECTOR and choosing **Galaxy** as the **Display filter**. See figure 14B.

⇒ Change the colour of the contours in the SIMBAD layer using the **Properties** button, see figure 15.

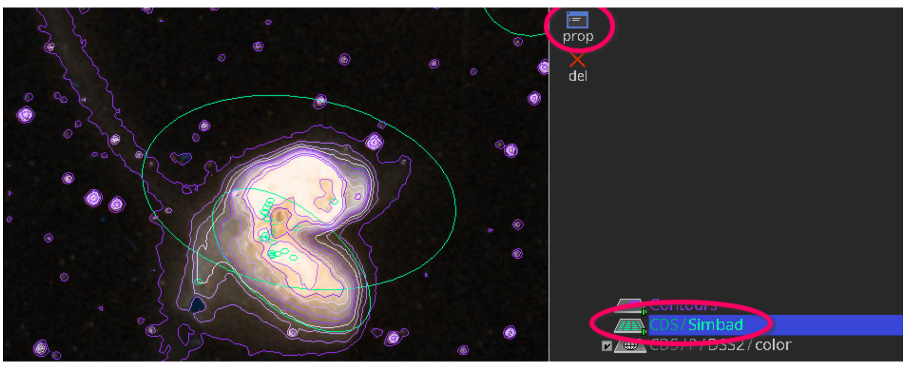

Figure 15: The layers can be edited separately.

⇒ Using the **Select tool**, select some of the SIMBAD points, either by clicking on one point or by holding the left mouse button and drawing a rectangle. The sources within the rectangle are then selected and displayed as a table below the image. This window can be detached with the icon with two squares drawn in the bottom right corner of the table window. Note that the data point belonging to a row in the table blinks in the main viewing window when hovering over the table row with the mouse.

⇒ In the DATA TREE, go to **Images** → **Infrared** → **2MASS** and load the 2MASS colour image. To do so click on the 2MASS colour image entry and the loading window appears **(see Figure 12)**. In the loading window, check that the box for **progressive** loading is ticked and load the image by clicking the **Load** button. See figure 16.

Figure 16: Adding images from the DATA TREE.

⇒ Once the 2MASS image is loaded it appears in the stack, which is located to the right of the main viewing window. The stack informs you of all planes that are currently loaded into Aladin, see bottom right of figure 15. These layers are shown in the main viewing window as if you were looking from top to bottom through the stack. As it was most recently loaded, the 2MASS plane is now shown as the "background" image in the main viewing window. If you want to go back to the DSS colour image being the "background" image, tick the little grey box next to the DSS image entry in the stack. If you now use the **opacity** slider next to the 2MASS plane in the image stack, you can change the opacity of the 2MASS plane and thus compare it easily to the DSS image. If you wanted to overlay the DSS image on the 2MASS image, you would have to change their order in the stack by drag-and-drop.

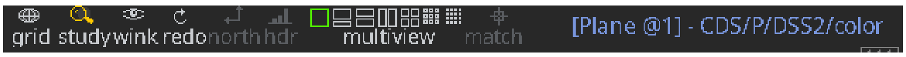

Figure 17: The multiview button is at the bottom of the screen.

⇒ Now add more colour images from the DATA TREE, for example, the allWISE (infrared) and the XMM Newton (X-rays) colour images. You can compare the images in different ways:

- Multiview: **View** → **Create one view per image**, or via the **multiview** icon at the bottom left of the Aladin image window, see figure 17. After selecting for eg. the four-by-four grid, drag and drop the images into the panels, where you want to see them.
- Align and scale all images by using the **match** icon below the image window.
- Transparency overlays: return to single view mode. Change the transparency of planes in the stack with the opacity sliders as before. Remember that you can move the location of the planes in the stack and thus change the order in which the images are shown.

⇒ All the colour images we have loaded so far are pre-computed. Aladin also allows you to compute your own RGB colour images.

⇒ For this task, we need FITS images rather than the HiPS tiles we have worked with so far. Those FITS images may come from your own data or from the Virtual Observatory. We will now search and load images at the location of the Antennae galaxies from the VO using the simple image access (SIA) protocol.

⇒ – First, we look for a far-ultraviolet image from GALEX: Enter "GALEX Atlas of nearby galaxies" in the **Select** line below the DATA TREE. In the DATA TREE, you will find the entry "GALEX Atlas of nearby galaxies" under **Others** → **SIA (image)** → **mast.stsci**. Load this entry **in view**. A table appears in the stack.

⇒ The newly loaded table contains a row for every image available from this image service in the vicinity of NGC 4039. Find the entry for the file ”$h\_ngc4038 - fd - int.fits.gz$” and click on the URL in the first column. This will load the corresponding FITS image into your stack.

⇒ Next, we are after an infrared image: search for ”2MASS large galaxy atlas” in the **Select** line, load the table from **Others** → **SIA (image)** → **irsa.ipac** → **2MASS Large Galaxy Atlas** and select any one of the three entries in the table to load into the stack.

⇒ Finally let's add an X-ray image to the collection: search for ”Chandra X-ray Observatory” in the **Select** line. There will be two services available, we will want to use the SIA service. Load the table ”in view” from **Others** → **SIA (image)** → **cxc.harvard.edu** → **Chandra X-ray Observatory Data Archive** and select one of the observations with the longest ”exptime”.

⇒ – To create the RGB image, open the **RGB image generator**, see figure 18. Enter the images you want to use for each colour component and click **CREATE**. If you want to adjust flux scale and transfer function of the individual images, use the **pixel menu**.

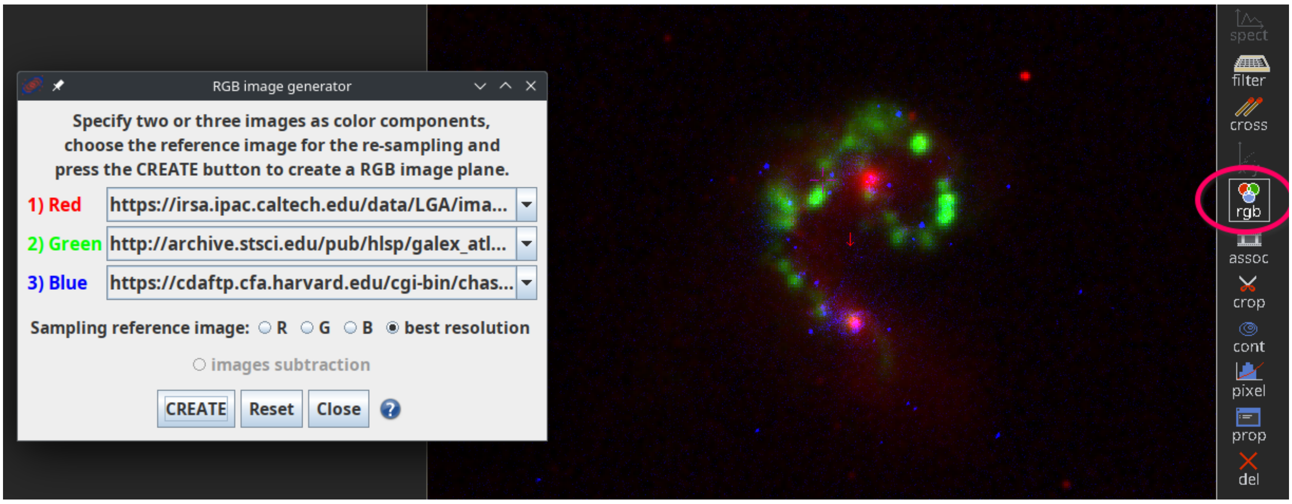

Figure 18: Generate an RGB image with the rgb tool.

⇒ Now we can search for more data from the VO on NGC4039.

⇒ To restrict the collections that the DATA TREE is showing, use the Select line below the DATA TREE. For eg. when searching for transients within the Antennae galaxies you might restrict the search to ”transient” and find that the Palomar Transient Factory photometric catalogue has data for transient events in the area. Load the catalogue and find the data points in the main viewing window.

⇒ More elaborate filters can be created using the **Data Discovery Tree Filter** window, accessed with the button next to the **Select** line at the bottom left of the screen, see figure 19.

Figure 19: More filters can be applied to the data discovery tree.

⇒ As before, entries in the DATA TREE, which are coloured in green, have data available in the region currently visible in the main viewing window.

⇒ Now delete all the planes in your stack before continuing. This is not mandatory, but it will free some useful memory space and allow you to proceed more easily with the next steps.

5 Compare the coverage of Sky Surveys and select interacting galaxies that have SDSS and GALEX data

Many large sky surveys in Aladin are stored in the **HiPS** format (Hierarchical Progressive Survey), which allows for easy access, browsing and visualisation of image and catalogue data. To describe (non-trivially shaped) regions on the sky **MOC** (Multi-Order Coverage) maps are used. In the following, we will make use of the advantages of these two data structures to easily assess which galaxies in the Arp catalogue of peculiar galaxies have been observed by SDSS and GALEX. If you would like to have an overview of currently available HiPS, have a look at this list. You can load any of them in Aladin by entering their base URL in the **Command** line.

⇒ Select the **SDSS 9 colored (Image → Optical → SDSS)**, see figure 20 and **GALEX All Sky Imaging Survey (GALEX GR6_7 Color) (Image → UV → GALEX)** surveys in the DATA TREE and load both the imaging data, using the **progressive** button and the MOC of the survey by clicking on the **coverage** button. For the moment, make the two MOC planes invisible by clicking on their **opacity slider** button.

Figure 20: Selection of the SDSS 9 coloured survey and Space-Time MOC.

⇒ Click on the coordinate **grid** (at the bottom left of the view panel), zoom out, and use the **pan** tool (located on the right of the main viewing window, just below the arrow) to explore the whole sky.

⇒ Now turn the MOC planes back on (click again on the opacity slider). Zoom onto the edges of the surveys and note the way the MOC represents the coverage of the surveys, see figure 21.

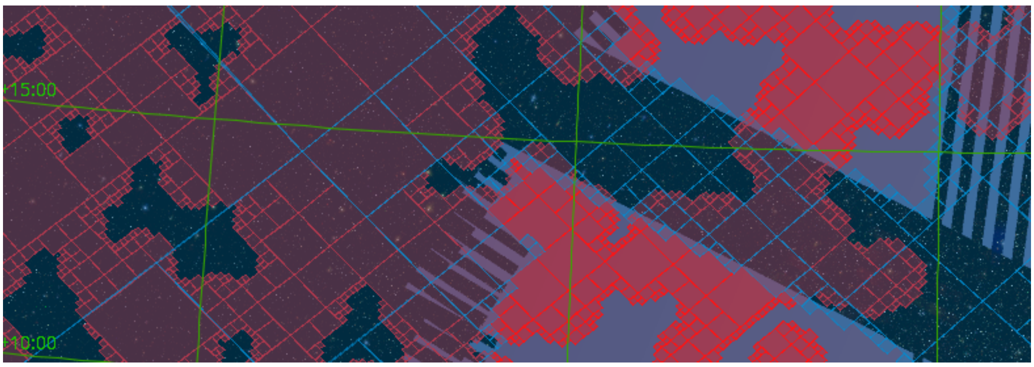

Figure 21: The MOCs are made of HEALPix pixels at different depths/precisons

⇒ Calculate the intersection of the coverage maps of the SDSS and GALEX surveys using the buttons bar above **Coverage → Logical operations** or the **MOC** button on the right of the main viewing window. See figure 22.

⇒ In the MOC operations box, load the plane with the MOCs of SDSS9 and GALEX. Click on intersection, and select the desired quantities to calculate the intersection. This will create another MOC containing the intersecting regions of the first two MOCs.

⇒ Load the full Webb 1996 Arp catalogue that you saved earlier. You can do this in one of the following three ways:

- **File → Load local file...** .
- Drag and drop on the stack.

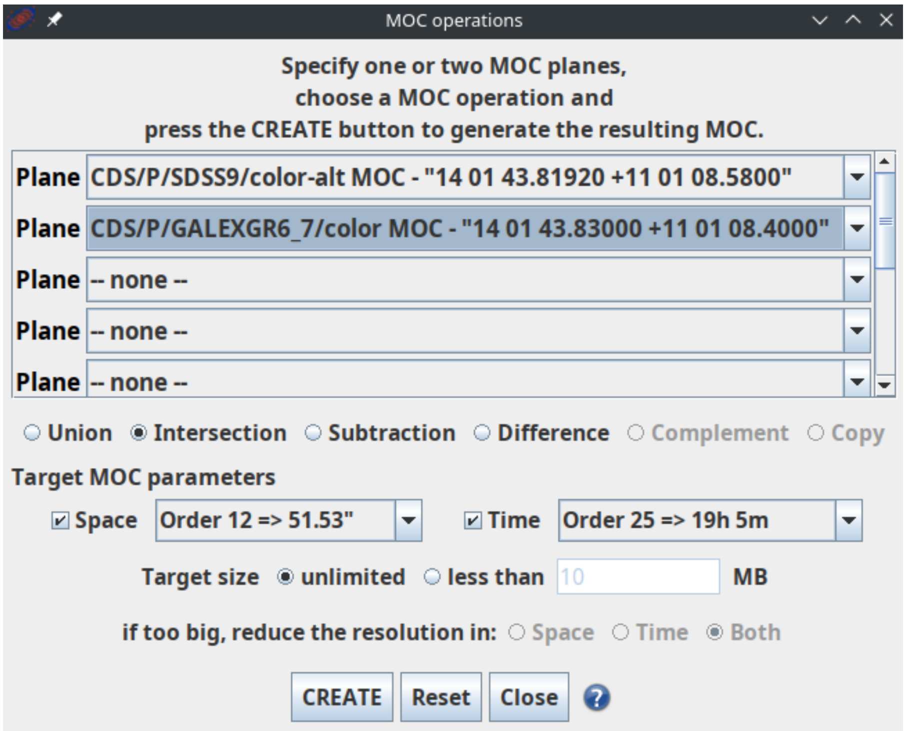

Figure 22: Calculating logical operations between Space-Time MOCs. You can do intersections, unions, differences and much more.

- Broadcast the catalogue from the VizieR page that shows the HTML version of the table. To do so, click on the **Antenna** or **Broadcast** button respectively and allow the browser to connect to the SAMP hub. You additionally have to click on the newly appeared grey Broadcast button. Now the data appears in Aladin.
- Alternatively, you can download the catalogue from VizieR through the `DATA TREE`, enter "Arp Webb" in the **Select** line below the DATA TREE, select the "arplist" table and **Load** the **Whole data**.

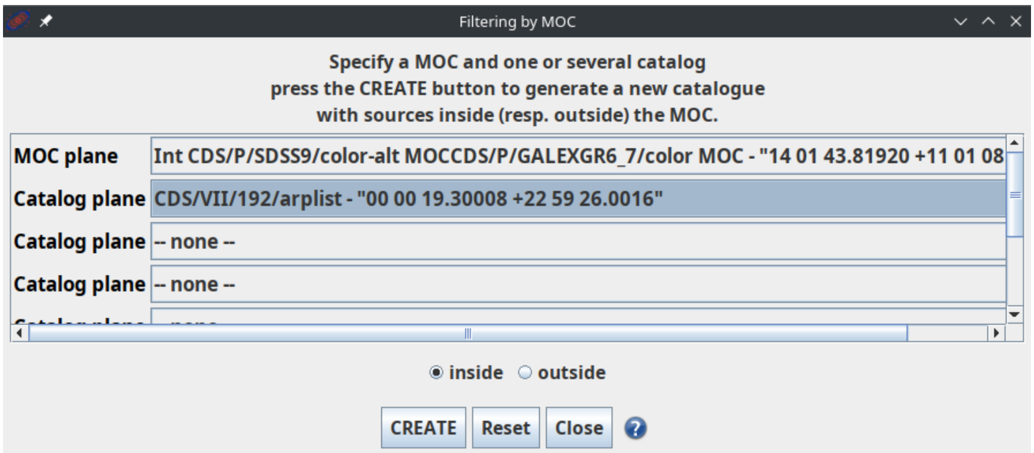

Figure 23: Select the Spate-Time MOC and the catalog to filter.

⇒ Filter the catalogue to select only the sources that fall within the SDSS+GALEX MOC: **Coverage → Filter a table by MOC**. Once the **Filtering by MOC** box opens, fill the **MOC plane** section with the intersection MOC you created previously, and the **Catalog plane** section with the arplist catalogue you just added. A new catalogue plane appears, and the filtered catalogue contains 425 sources. You can find the number, for eg., in the little information text that appears on the top of the stack when hovering the mouse over an entry in the stack.

N.B. that you can also filter a table by MOC by clicking on the **by region & MOC** button when loading the table initially (instead of loading the entire table). This works, previous doesn't

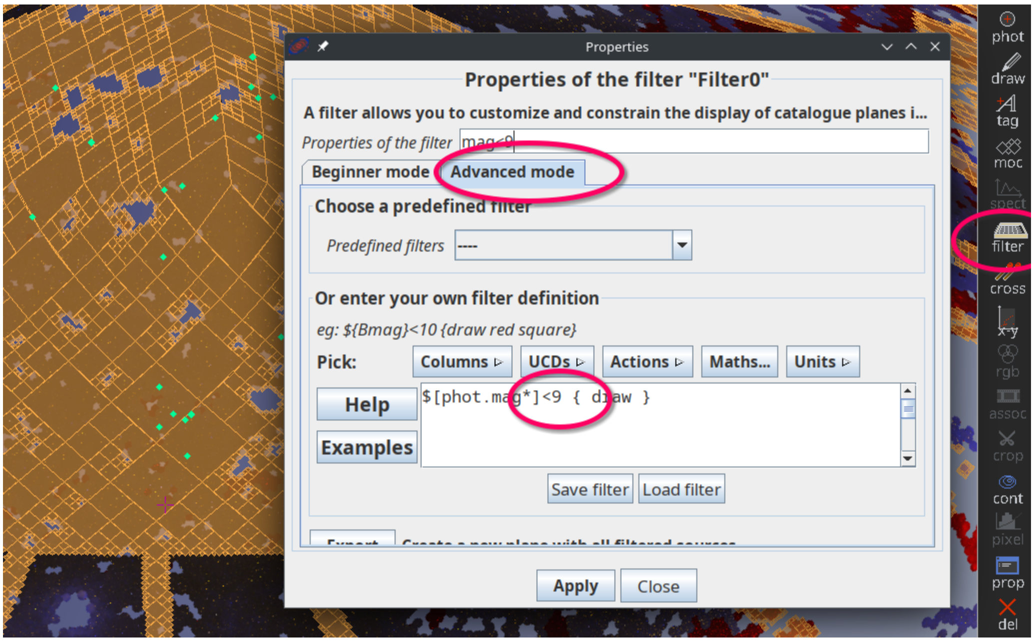

Figure 24: The filter plane properties.

You can also visualise the brightest (> 9 mag) galaxies of the selected sources by extracting small images from the SDSS survey:

⇒ Select the brightest galaxies using the **filter** tool, found in the right-hand side of the main viewing window, see figure 24,: select the **Show brightest stars** predefined filter and edit it with the **Advanced mode** to select object with magnitude below 9. Note that the column is automatically identified with the Unified Content Descriptor (UCD) `phot.mag*`.

⇒ Make sure that only the MOC-filtered catalogue is active in the stack and visible in the main viewing window (or other sources may also be filtered). An easy way to ensure that is to delete every catalogue not useful anymore.

⇒ – Click on **Apply** and then **Export** to create a new plane consisting only of sources selected by the filter. There are 19 sources with magnitudes below 9.

⇒ Make thumbnails of the selected brightest sources: in the tabs **Tool → Thumbnail view generator**, set the thumbnail size to 14 arcmin. See figures 25 and 26.

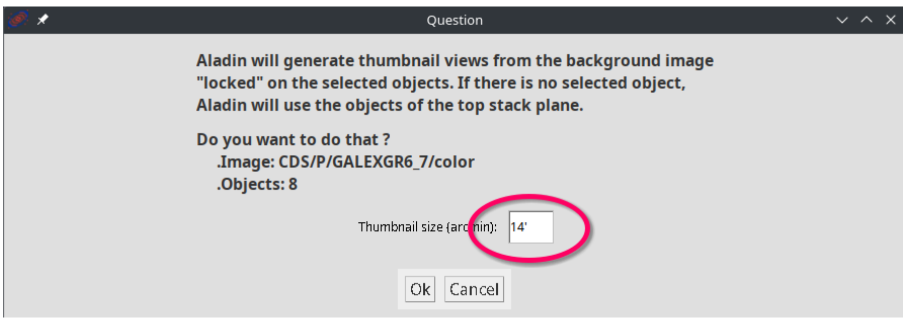

Figure 25: Create thumbnails from a catalog

This time we keep some of the planes that we created. In particular, please do not clean away the table of the seven brightest galaxies.

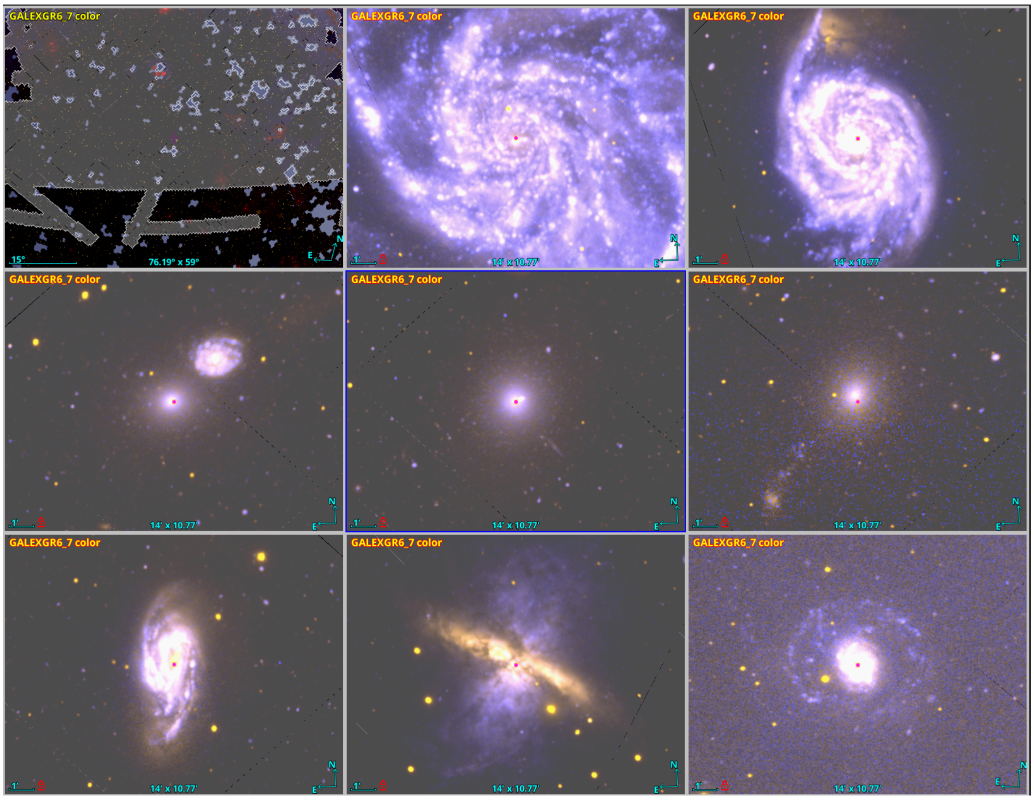

Figure 26: The resulting thumbnails

6 Aladin automation [Optional]

When samples become larger, it is useful to automate some tasks. In this optional section, we will explore how to execute some tasks with Aladin scripts. If you want to learn more about the Aladin script language, the documentation in on Aladin pages here.

6.1 Collect information on a sample of galaxies using Aladin

Use an Aladin script to obtain DSS and SDSS image with HST, Chandra, ESO observation log overlays for each of the selected bright galaxies.

⇒ Copy the script `Arp script.ajs` from the link to your computer or create a new file with the script shown in code block 1.

⇒ Create a folder called 'Arp' and edit the script Arp script.ajs to insert a path in order to save the output files, e.g. `~/Desktop/Arp`.

⇒ Open the Aladin macro controller and load the script:

- **Tool** → **Macro Controller** then **File** → **Load script**
- or cut and paste the script into the top panel of the MACROS window

⇒ • Select the table with the seven brightest sources from the peculiar galaxy catalogue:

- Right click on the plane and **Select all objects in the selected planes**
- In the MACROS window: **File** → **Use selected plane sources as params**

```
#AJS
#
reset
grid on

# DSS image:
"ARP-$2_DSS" = get DSS.STScI(POSS2UKSTU_Red,15,15) $3

# SDSS image:
# "ARP-£2_SDSS" = get SDSS(keyword=Filter g) £3

# SIMBAD plane
# "ARP-£2_Simbad" = get Simbad £3 5'

# Observation Logs
viz_logHST=get vizier(logHST) $3
viz_logESO=get vizier(logESO) $3
viz_logChandra=get vizier(logChandra) $3

sync
pause 1

# Write results to files
# export B/hst/hstlog /Users/angm/Desktop/Arp/Arp-£2_HST.xml
save /Users/angm/Desktop/Arp/Arp-$2_chart.png
backup /Users/angm/Desktop/Arp/Arp-$2_stack.aj
#adapt ^^^^^^^^^^^^^^^^^^^^^^^ to your own path
```

Listing 1: The example Aladin script

- Note how the catalogue columns are shown as parameters which can be referred to as $1, $2, etc within the script.

⇒ Click on the first row of the parameters table and execute the script for this row: Exec current params, see figure 27.

⇒ Optional: add an SDSS image: remove the '#' to enable download of a SDSS g-band image for each source. Note that this results in, *Could not find any data corresponding to your request* message for objects not covered by SDSS.

⇒ Inspect the output in the Aladin window and also the files written in the Arp folder.

⇒ Execute the script for all sources: **Exec all from current**

⇒ Note that the saved stack files (*_stack.aj) can simply be dragged and dropped into Aladin for inspection, see figure 28.

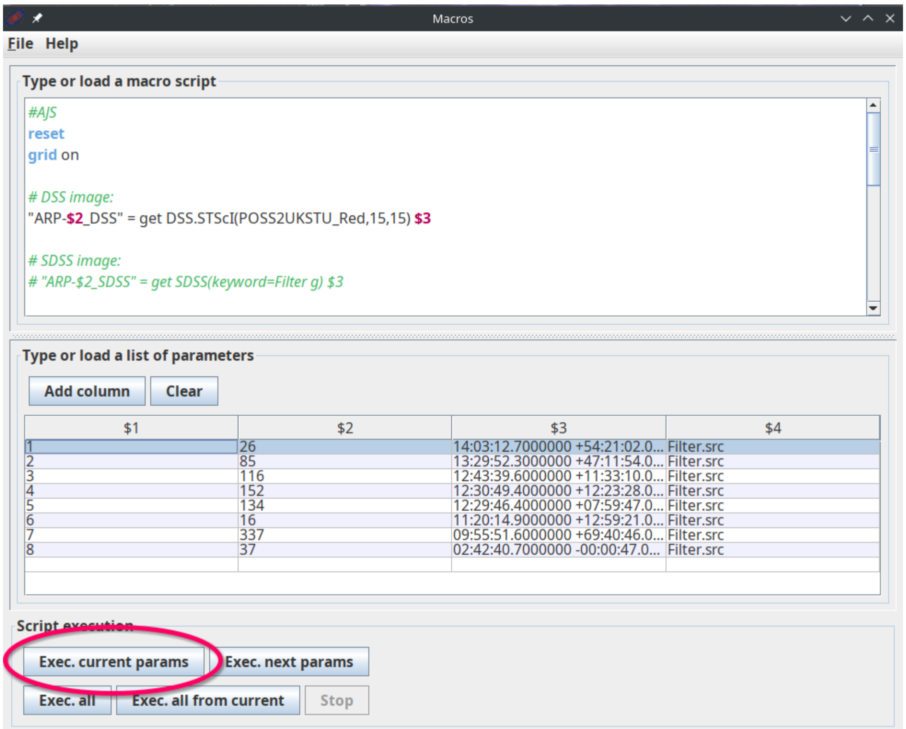

Figure 27: The macros window.

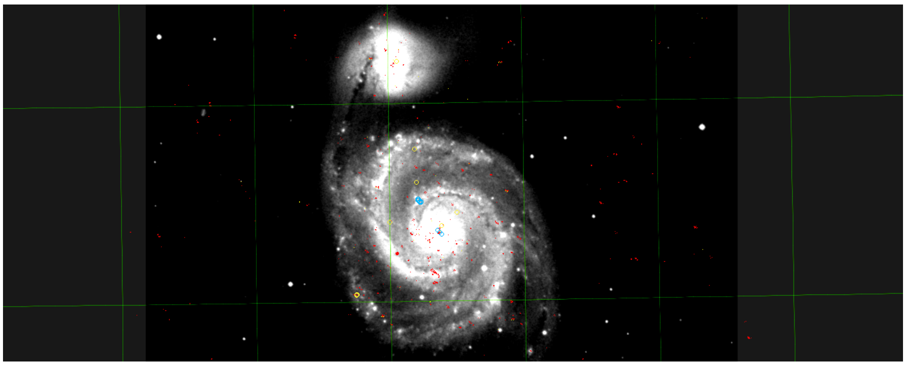

Figure 28: One of the charts generated with the script

7 Automation with Python

Most Virtual Observatory services are available through Python. You can find a sample of example Jupyter notebooks in the CDS github reporitory of tutorials.

To follow this part of the tutorial, you have three options:

- **Preferred option** Install everything on your personal computer.

  1. Python is already installed on a lot of operating systems. To check if you already have it, open a terminal and type:

     ```
     python --version
     ```

     If the version is comprised between 3.8 and 3.12 (as of June 2024, these are the currently valid python versions [1].)
     If the version number starts by 2, try:

     ```
     python3 --version
     ```

[1] you can always check which version is currently valid – meaning either in bugfix or security state – on Python's life-cycle page.

If this works, then on your computer you will have to replace every `python` in the next instructions by `python3`. If you are running Windows, it is also possible that you'll have to type `py` instead of `python`.

You are good to go and you can go to the second point.

If neither of these work, follow the installation instructions for Python.

2. Then, it is good practice to always have one virtual environment per project.

   What problem does a virtual environment solve? The more Python projects you have, the more likely it is that you need to work with different versions of Python libraries, or even Python itself. Newer versions of libraries for one project can break compatibility in another project. Virtual environments are independent groups of Python libraries, one for each project. Packages installed for one project will not affect other projects or the operating system's packages. Python comes bundled with the `venv` module to create virtual environments, we will use it here[2].

   To do this, move in a directory where you want to work, and in a terminal, do (note that the point at the end is important):

```
python -m venv .
```

   This will create the files needed for this virtual environment. We can activate the environment with:

On windows:

```
# In cmd.exe
venv\Scripts\activate.bat
# In PowerShell
venv\Scripts\Activate.ps1
```

On Linux and MAC:

```
source bin/activate
```

   The virtual environment is now activated. You can check it by looking at the list of python packages currently installed in this virtual environment[3] with pip, the Python package manager:

```
pip list
```

   You should only have pip.

   We can install the libraries we need in this fresh environment[4].

```
pip install jupyterlab>=4.0 mocpy>=0.14.0 ipyaladin>=0.3.0 astroquery>=0.4.7
```

   And launch jupyterlab with

```
python -m jupyterlab
```

   And voilà, you are ready to code in python! When you want to switch off Jupyterlab and the virtual environment, you can do `ctrl + C` in the terminal from which you launched the notebook, say `y` to confirm that you want to leave. When the prompt is available, do `deactivate` to leave the virtual environment.

- **If you cannot install libraries on your computer** You can go onto https://cds-astro.github.io/jupyterlite. You should see a jupyterlite instance, see figure 29. You can select the notebook TODO when the notebook is ready, we add it in jupyterlite

[2]If you already use an other virtual environment package, such as `miniconda` or `uv`, use your own rather than `venv`.
[3]Chances are that if you have to write `python3` you also have to write `pip3` here.
[4]doing `pip list` after this will return a lot of packages. These are all the dependencies of these 4 libraries.

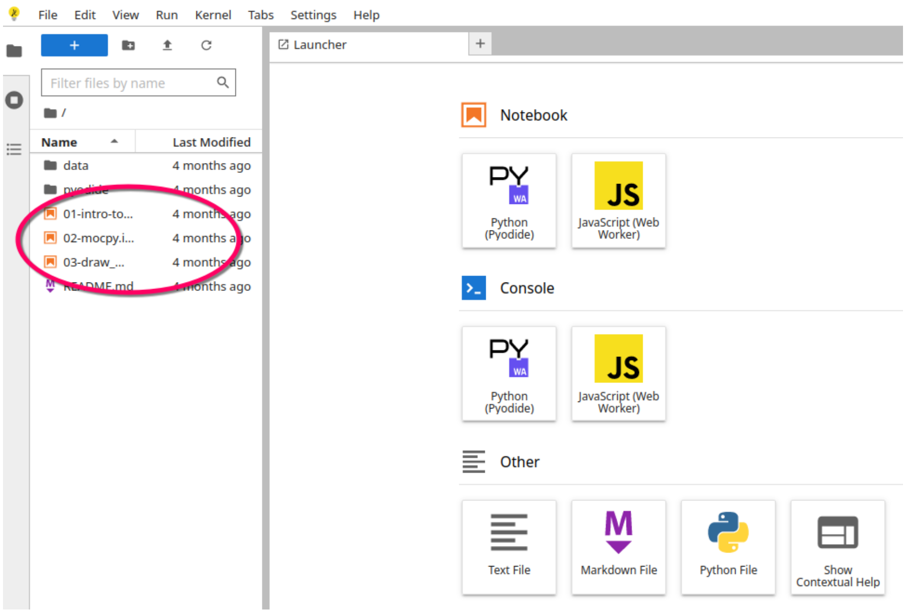

Figure 29: The Jupyterlite page. You can find pre-loaded notebooks in the left side of the screen.