Glue, Gaia and the Exoplanet Archive

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This hands-on session will use the Glue visualization tool.

If not already done:

- Install Glue:
  - Glue can be installed as a standalone application on either a Mac or a PC: https://glueviz.readthedocs.io/en/stable/installation/standalone.html
  - It can also be installed through Anaconda: https://glueviz.org/install.html
- Download ancillary data required for examining Gaia and the Exoplanet Archive here:
  - https://catcopy.ipac.caltech.edu/ssw/hands-on/GCNS_cat.fits.zip
  - https://catcopy.ipac.caltech.edu/ssw/hands-on/GCNS-Matched-DR3.fits.zip
  - https://catcopy.ipac.caltech.edu/ssw/hands-on/Exoplanet-Archive-GCNS-Matched.fits.zip
    The first file is the Gaia Catalog of Nearby Stars (GCNS), while the second one is the GCNS matched with DR3; the third file is a recently downloaded version of the Exoplanet Archive database. You will need to download these files to your computer.

Saving the Session in Glue:

As you work through the visualizations below and would like to save your current session in Glue, click “Export Session” on the top left menu bar and save it as a file with extension “.glu” on your computer.

Then, when you launch Glue again, click “Open Session” on the top left menu bar and read in your .glu file. This will restore your session, and you can continue where you left off.

Part 1

1. Open the GlueViz application either through the standalone application, through the Anaconda Navigator, or by typing “glue” at the command line. Read in the GCNS_cat.fits into Glue by clicking “Import Data” on the top left and navigating to where you have saved the file to.
2. The “GCNS_cat[HDU1]” should now be listed underneath “Data” in the “Data Collection” box on the far left of your screen. Grab that filename and drag it into the main plotting box called “Drag Data to Plot” at the center of Glue.
3. The Data Viewer now asks you what kind of plot you wish to create. For the first test plot, choose: “2D scatter” and then select “OK”. This will bring in a new plotting box and you can change the axis as you see fit.
4. With the plotting box highlighted, move to the left and far bottom where it says “Plot Options - 2D Scatter”. It is here you can change all aspects of a plot. For the x-axis, select the dropdown menu and choose “RA”. For the y-axis select the dropdown menu and select “DEC”. You can leave the “type” as rectilinear”. This is the physical distribution of stars within the Gaia Catalog of Nearby Stars.

VIDEO ON HOW TO COMPLETE PART 1:
https://caltech.box.com/s/9jwxu1xs2tdl2f3q2xdndagv41uow4xh

Part 2

5. Next, let's play with the calculation component of Glue. At the top of the screen along the line of selection buttons, choose "Arithmetic attributes". This brings up a new screen within the "Arithmetic editor". At the top of this there is a dropdown menu for "Dataset". You should have "GCNS_cat[HDU1]" selected. If you have multiple datasets loaded you will need to choose between them at this step.
6. Under the "Arithmetic editor" select "New arithmetic attribute". This brings up an Equation editor. It is python sensitive to your mathematical language.
7. At the top where it says "New attribute name" in gray, label a new parameter called "Distance". Then in the main box create the equation for distance using parallax. Under the "Available attributes" dropdown select "Parallax" and click "Insert". The value comes in milli arcseconds so you want to type in 1000./{Parallax}. Click "OK" and then "OK" again within the Arithmetic editor. This value of "Distance" is now available in your dropdown menu of components for plots.
8. Once again select the "GCNS_cat[HDU1]" file from the "Data" box under "Data Collection". Drag that once again into the main plotting area in Glue. This time select "1D histogram" as your new Data viewer. Move over to the "Plot Options" box at the far left bottom and change the x-axis to "Distance". All new arithmetic attributes you create in Glue will be at the very bottom of your table so you will have to scroll down to find it.
9. ANALYSIS QUESTION: Have a look at the distribution. The parallax was in milli-arcsec so the distance should be in parsecs. What is the max distance that you see for this distribution?

VIDEO ON HOW TO COMPLETE PART 2:
https://caltech.box.com/s/wmbkwhfn0n632q4t23vh8mkik95j0dwt

Part 3

10. Now let's make a color magnitude diagram – the hallmark of Gaia. Click "Arithmetic attributes" again. Label this new parameter as "M_G". The equation for the absolute magnitude is a combination of the apparent magnitude and the parallax (or distance) to the object. Use the following:
    {PHOT_G_MEAN_MAG}-5*np.log10((1000./{PARALLAX})/10.) You should see "valid expression" at the bottom of the attributes box. Click "OK"
11. Calculate the G - RP color for the stars. Click "New Arithmetic attribute" again. Label this new parameter as "GmRP". The equation for this should be: {PHOT_G_MEAN_MAG}-{PHOT_RP_MEAN_MAG}. Click OK twice to return to the main screen.

12. Once again drag the “GCNS_cat[HDU1]” label from the Data collection box into the main Glue plotting box. Choose a 2D scatter plot. Move to the plot options and select the newly created GmRP for the x-axis and M_G for the y-axis.
13. To make the diagram resemble a standard CMD, you will need to reverse the limits on the y-axis so that it goes from the small value at top to large values at bottom. Under the Plot options click "Limits' and then click the back forth arrow by the "y-axis" button.

VIDEO ON HOW TO COMPLETE PART 3:
https://caltech.box.com/s/ym44tgyf2ggczvp96niww9ppdm5agngl

Part 4

14. Let’s practice using the lasso tool that allows you to interact with the data across different plots and parameters. Grab and drag the GCNS_cat[HDU1] into the plotting area and select 1D histogram. On the plot options box choose “WD_Prob” in the dropdown. This is the probability (from 0 to 1) of an object being a white dwarf.
15. On the top of the new plot you have created there is a rectangular box. Select that and then click and drag over the probability you would like to see. Choose for instance 0.8 and larger. Hit enter after you have finished the selection.
16. You will see that the objects are highlighted on each of the plots you have created showing you where these objects are located across each plot. This is extremely useful when you have multiple parameters such as what comes with Gaia.

VIDEO ON HOW TO COMPLETE PART 4:
https://caltech.box.com/s/dpmcr8vxvx5ja4zpzrmwleq3u0j2863o

DATA CHALLENGE!!! Explore the Exoplanet Archive Catalog in Gaia DR3

17. Open the Exoplanet-Archive-GCNS-Matched.fits file in Glue. This brings it into two formats; Primary and Joined. You want to work with the “Joined” version. This file is the Exoplanet Archive matched to the Gaia Catalog of Nearby Stars Matched to Gaia’s DR3 catalog. You have a LOT to work with within the file.
18. Create the Gaia Color Magnitude diagram from this file. You can select “g_rp” as the x-axis and “mg_gsphot” as a starter.
19. Now for the challenge: Explore the parameters that you are given to see how Gaia DR3 has improved our understanding of these nearby worlds. Look at Temperature vs. Radius. Temperature vs. Metallicity, age, or logg. Do you believe all the values you are seeing? Any trends in the data?