University of Florida
AST 6215 Spring 2021
“Stars and the Galaxy”
MWF 1:55 pm – 2:45 pm
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Star Cluster Luminosity Functions Using ***Gaia*** Data Release 3

In this project, you will use data available from the third data release (i.e. DR3) of the ***Gaia*** satellite to analyze a sample of star clusters in order to construct color-magnitude diagrams and luminosity functions for them. Please hand in your project report (typed) along with tables, figures fully labeled and with figure captions, and any other relevant materials. Neatness and organization count so please pay attention to detail.

1. Enter the ***Gaia*** Data Release 3 archive web site at https://gea.esac.esa.int/archive/ and click on the Search menu and then the “Advanced (ADQL)” button near the top.

2. Extract the data around the following open clusters: M67, NGC 188, M44, and NGC 6791, along with the globular cluster M71 using the following script:

```
SELECT source_id, ra, dec, parallax, parallax_error, pmra, pmra_error, pmdec, pmdec_error,
phot_g_mean_mag, phot_bp_mean_mag, phot_rp_mean_mag
FROM gaiadr3.gaia_source
WHERE 1=CONTAINS(
  POINT('ICRS',ra,dec),
  CIRCLE('ICRS',RA,Dec, R))
```

where “RA” and “Dec” are the J2000.0 Right Ascension and Declination of the center of the cluster in decimal degrees and “R” is the search radius in degrees. Download the results in CSV format. You will need to experiment with the value of R to derive an optimum value.

3. Convert the ***Gaia*** photometry to the V and I pass bands using the conversions in

https://gea.esac.esa.int/archive/documentation/GDR2/Data_processing/chap_cu5pho/sec_cu5pho_calibr/ssec_cu5pho_PhotTransf.html

making sure to use Table 5.8 (Johnson-Cousins relationships)

4. Construct a (V, V–I) color magnitude diagram (CMD) for each cluster making sure to select an axis scaling that exemplifies the appearance of the principle sequences of the diagram.

5. Construct the proper motion diagram for each cluster by plotting the RA proper motion on the abscissa ($\mu_{RA} \cos \delta$) and the Dec (δ) proper motion (μ_{Dec}) on the ordinate. Select a scaling for the axes that exemplifies the separation between the cluster and its surrounding field.

6. From the proper motion diagram, quantitatively determine a center and an optimum radius for the cluster proper motion distribution. Explain how you determined the center and why you chose the optimum radius that you did.

7. Plot a (V, V–I) CMD for the stars that have proper motions within this radius so as to construct a CMD that is composed almost purely of stars belonging to the open cluster.

8. Construct a binned histogram and a generalized histogram of the parallaxes of these probable cluster members. Use these to determine a robust parallax for each cluster and its error. Use this to calculate the distance modulus of each cluster and compare it to the values from the refereed literature.

9. Use the parallax of each probable member star along with the distance modulus equation (i.e. photometric parallax) to convert the V magnitude of each star to Mv adopting a reddening for each cluster and Av = 2.5E(V–I). Also convert (V–I) to (V–I)o using the adopted reddening. Make sure to propagate all the errors that you know. Plot the resulting distance and reddening corrected CMD.

10. Do the same procedure but this time use the cluster parallax computed in point 8 above. Compare the appearance of the [Mv, (V–I)o] CMDs constructed using the individual stellar parallaxes and the calculated cluster parallax. Which ones appears "better?" Which one has Main Sequences that are better defined?

11. Compare and contrast the main features of the cluster CMDs constructed in point 9 above. Indicate the location of the main sequence, red giant branch, and white dwarfs if they exist. How are the CMDs different and how are they the same in appearance?

12. Construct a Mv-band luminosity function for each cluster using a generalized histogram and a cumulative histogram.

13. Normalize the luminosity functions using a specified vertical scaling and then compare their appearance with each other. Can you find any trends of how this appearance varies with cluster properties such as age or metallicity (which you can obtain from the literature)?