ISYA VO Exercise

H-R Diagram of a Globular Cluster

Background:

At the beginning of the 1900s, scientists closed in on a picture of stellar evolution. Physicists worked out the theory of nuclear fusion and realized that fusion provided enough energy to power stars. They realized that eventually, stars would run out of fuel for fusion and would burn out. So all stars would eventually die. But what would happen to stars during their lives? The first clue came soon after astronomers on two continents. In 1911, Ejnar Hertzsprung, a Danish astronomer studying at the University of Leiden in the Netherlands, plotted the luminosities of stars against their colors. Luminosity is measure of how the total energy a star gives off. The color, as you may have learned in the Color project, tells you the star's surface temperature. So, essentially, Hertzsprung graphed how much energy a star gave off as a function of the star's temperature. He noticed some distinct and unexpected patterns. In 1913, Henry Norris Russell of Princeton University plotted the luminosities of stars against their spectral types. Spectral types are also a measurement of temperature (see the Spectral Types project for more information), so essentially, Russell made the same diagram that Hertzsprung made. The diagram became known as the Hertzsprung-Russell (or "H-R") diagram. By studying H-R diagrams, later astronomers figured out the life cycles of stars.

Procedure:

In this exercise, you will make your own Hertzsprung-Russell diagrams. You will learn what the various points represent, and you will also learn some of the difficulties in making H-R diagrams. All of the clusters seen by the SDSS are globular clusters, thick clusters containing millions of stars that lie just above and just below the plan of our galaxy. The two clusters we'll work with were both found by the Palomar Sky Survey in the 1950's, hence the names **Pal 3** and **Pal 5**. Their coordinates are given below.

Name	Ra	Dec	Radius
Pal 3	151.3801	0.072	0.7 arcmin
Pal 5	229.0128	-0.1082	3 arcmin

The SDSS uses slightly different filters than the traditional **B**, **V**, and **R** filters, so when you make your H-R diagram, you can't use the traditional **B-V** color. Instead, use the **g** and **r** filters, which happen to lie in the visible part of the spectrum, to calculate **g-r** color for your H-R diagram.

1. Use the **Navigation Tool** to make an H-R diagram of Palomar 5.

   http://cas.sdss.org/dr7/en/tools/chart/navi.asp

2. Enter the coordinates for **Pal 5** (RA = 229.0128, Dec = -0.1082) and click "Get Image."

3. **Pal 5** will appear in the main window. You can zoom in or out in the image with the zoom bar below Get Image.

4. Click the plus sign to zoom in or the minus sign to zoom out. You can also move around in the sky by clicking the **NWSE** buttons around the image.

5. When you click on any star in the image, a green square will come up around it. A close-up of the object will appear in the top right, and the object's data will appear at the right. Click "**Add to Notes**" to save the star's data in your notebook.

6. Try to get at least 20 to 30 stars for your diagram.

7. When you finish choosing stars and saving them to your notebook, save your entire notebook to your computer. To do that, click on the radio button next to "CSV," then click the "Export" button to download the data as CSV (comma-separated value).

8. Open the CSV file in VO tool – **VOPlot** or **TOPCAT** .

9. Use the data to make an H-R diagram of the globular cluster. Put the **r** magnitude on the y-axis and the **g-r** color on the x-axis.

10. Try to take stars only from the cluster. Stars that appear dramatically different may be at different distances along the same line of sight. You should also be careful not to accidentally record the information for a galaxy.

11. Try to get answers for following questions – (a) What type(s) of stars do you see on this H-R diagram? (b) What types of stars do you not see? (c) Why don't you see all types of stars in this cluster? (Hint : Could it be due to a limitation imposed by our equipment?) (d) Can you see the main sequence on this diagram? (e) Can you see any of the giants and supergiants? If so, identify these groups of stars on your diagram.

12. **Repeat above steps for Pal 3.**