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Distinguishing Multiple Populations of Globular Cluster Stars

This summer, I have been studying globular clusters with Professor Smolinski. Globular clusters are large regions of space where hundreds of thousands of stars are located. Many of these clusters contain some of the oldest stars in the galaxy. Until recently, it has been assumed that the stars in each globular cluster formed at the same time. However, recent discoveries hint otherwise.

The main way clusters are studied is through color magnitude diagrams (CMDs). These are graphs that plot either each star's luminosity versus their temperature, or their apparent brightness versus color. Most of the stars fall on a region of the graph called the main sequence. Stars stay on the main sequence until they burn through most of their hydrogen. Once they do this, stars enter their second stage of evolution and turn into red giants. Massive stars burn their hydrogen faster and therefore become red giants quicker than less massive stars. When a star turns to a red giant they increase in size and decrease in temperature, producing a turnoff point on the color magnitude diagram away from the main sequence. This creates another branch on the diagram, the red giant branch. One can tell the age of a cluster by looking at how low the turnoff point from the main sequence to the red giant branch is on the color magnitude diagram.

Our ultimate goal is to create a color magnitude diagram, and closely analyze the red giant branch. As technology improved, these CMDs have become more detailed and accurate. Recently, a separation between stars within the red giant branch has been discovered in many globular clusters. There is a group of stars that have turned off the main sequence slightly lower than the other group. The cause of this is primarily because of differences in chemical composition. Stars with high light element abundance appear redder than stars with less light elements. Additionally, in these high abundance stars, they are less luminous because of their increased opacity. As a result of this, they are lower on the CMDs than the bluer stars and one can see two "tracks" on the red giant branch. In order for some stars to have a higher abundance in light elements than others, they must have formed from different gas. It has been theorized that this gas has come from a previous generation of stars, meaning the redder stars must have formed after the bluer stars.

We spent most of last summer, and the beginning part of this summer creating the best procedure to create an accurate CMD. This took such a long time because the program we were using has many inputs we must manually enter that are very specific for each cluster. This program is not well documented, so we had to experiment with each parameter so that we can receive the most accurate measurements. For the most part, we have accomplished this. As we have collected more and more images of these clusters, we have been able to create more precise red giant branches on our CMDs. The next part of our research will be to analyze this branch. We will do this by creating a histogram of the stars on the red giant branch. Hopefully, we will see two peaks on this histogram, indicating two tracks and multiple populations in a globular cluster.

I am very happy to be where we are at right now. After a lot of hard, tedious work last year, we are finally seeing some of its pay-off. As a whole, I am incredibly happy to have participated in research during my time at Calvin. One of the reasons I went here was because they had many more opportunities for undergraduate students. I will be a senior next year, and I know grad schools will notice that I have some experience doing research during my four years here.