Professor Jason Smolinski
Alex Van Kooten

Distinguishing Stellar Populations within Milky Way Globular Star Clusters

Globular clusters are tightly packed groups of hundreds of thousands of stars found within our galaxy. Until recently, astronomers believed that each cluster was composed of a single population of stars; that is, each cluster's stars were formed at roughly the same time out of the same interstellar gas. More recently, though, some clusters have been found to contain multiple populations. In these clusters, a first generation of stars was born out of pure interstellar gas. These stars, through nuclear fusion, created heavier elements such as carbon, nitrogen, and oxygen, among others. These elements escaped from the first generation of stars and mixed with the interstellar gas, enriching that gas. A second generation of stars was then born out of this enriched gas, leaving the second generation of stars with a slightly different chemical composition than the first. Our research has focused on detecting these two populations in several different clusters.

One way these two populations are distinguished is through Color Magnitude Diagrams, or CMDs. On these diagrams, a star's magnitude, or brightness, is plotted against its color. Plotting these values for all the stars in a single population results in a very distinct shape known as the Red Giant Branch, or RGB. Plotting these values for all the stars in two populations, then, would create two overlapping RGBs.

However, we do not easily see two Red Giant Branches in the clusters we have looked at. One of the reasons for this is that it is difficult to include only stars that are within a cluster in a CMD. A star might be in front of or behind the cluster we are looking at, but we can't immediately tell just by looking at the image. To weed out these contaminating stars, we implement several cuts to eliminate them. This leaves us with a much cleaner CMD, but we still can't visually see two separate Red Giant Branches. Instead, we have to rely on a statistical test known as the Kolmogorov–Smirnov Test. This test tells us the percent chance that the stars we chose belong to a single population. Using this test, we have found that one cluster, M13, does have two populations, and that another cluster, NGC 6791, does not. These are results that have been found by other researchers in the past, so they help confirm that the process we are following does indeed work. Next, we will apply these techniques to two other globular clusters, M56 and NGC 6712, which have not been studied to find multiple stellar populations.

The results we get will hopefully allow astronomers to better understand how stars evolve. Globular clusters are excellent places to study stars because all the stars they contain have similar chemical compositions and similar ages, meaning there are fewer variables that can affect how a star evolves. By detecting multiple populations in globular clusters, we can help future astronomers control more variables and be more certain of how stars change over the courses of their lives. In addition, the chemical compositions of stars born in globular clusters is unique in the galaxy. By better understanding these compositions, astronomers can look to see how many stars in the galaxy were born in globular clusters but eventually escaped. This can also help astronomers estimate how many globular clusters were originally in the galaxy that may have already dissolved as more and more of their stars escaped.

Doing research this summer has done a couple of different things for me. First off, it has given me a glimpse into the world of professional astronomy that I never could have gotten through classes, which has made me more confident that I want to continue in this field. Second, I have learned some valuable skills, such as some problem solving, critical thinking, and some computer skills, which will be useful for me regardless of what kind of career I end up in.