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Two Stellar Populations in The Distant Milky Way Globular Cluster NGC2419

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Abstract

The distant Milky Way globular cluster NGC2419 holds the fossil record of dark matter in the early universe. NGC2419 is 13 Gyr old. It is thought that globular clusters are the remnants of giant spherical star systems that formed under the gravitational influence of dark matter 13 Gyr ago. Winds from supernovae and/or rotating asymptotic giant branch stars remove, in less than 1 Gyr, most of their stars and much of the gas from which new stellar generations form. These winds enriched the interstellar gas in carbon, nitrogen, and oxygen and helium. The amount of gas that remained determined how many more generations of stars would form. The degree of enrichment determined the chemical makeup of the globular cluster stars. It is thought that progenitors containing warm dark matter result in globular clusters in which second generation of stars formed relatively late. The majority of progenitors with moderate initial mass will hold enough residual gas a second generation of stars to form. However, many globular clusters harbor multiple populations containing wide differing fractions of carbon, nitrogen, and oxygen and helium.

NGC 2419 is one of a handful of clusters with two prominent star populations that differ moderately in chemical makeup. It is an ideal system in which to look for the signature of warm dark matter. This work seeks to use the chemical differences between the generations to determine the amount of warm dark matter in the early universe.

The helium enrichment causes the second generation to be bluer (for the same luminosity) than the first generation. This behavior was seen in eight colors from the ultraviolet to the infrared. This paper will investigate the two stellar populations by comparisons of stellar evolution models and color-magnitude diagrams constructed from photometry in the Hubble Legacy Archive.

NGC 2419 contains two generations of stars. The first generation is approximately 12.5 Gyrs old. The second is 10.5 Gyrs old. The first generation is enriched in total carbon, nitrogen and oxygen compared to the values in solar-type stars. The second generation shares this enrichment and also has an overabundance of helium. This is evidence that there are two populations of red giant stars that have different spatial distributions.

The Data

The data consists of measurements of the brightness of the stars inside the orange rectangles in twelve central filters from the ultraviolet (275 nm) to the infrared (214 nm). This data is available at the Hubble Legacy Archive. The camera used was the Wide Field Camera 3 (WFC3) on the Hubble Space Telescope. It was centered on NGC2419 and covered about one-quarter of area of the cluster. This included the dense core where more than half of the stars in the cluster reside. The original images were taken for WFC3 photometric calibration carried out by Jason Kalrai at the Space Telescope Science Institute (proposal ID 12801). The data was taken from 2010-05-14 to 2011-05-17 UT. The high precision pointing of HST means that all the pictures cover exactly the same area on the sky. The exposure durations vary from 100 to 1450 s.

Results

A combination of the F390W and F438W filters will likely provide a larger separation of these generations and be a more sensitive indicator of stellar evolution.

The Signature of Two Stellar Populations

These plots show the ratio of the number of stars on the blue side of the red giant branch to the number on the red side at various distances from the center of NGC2419. The left panel shows that there are more blue side giants than red side giants near the center, and that the reverse is true near the edge of the field of view (~110 seconds of arc from the center). The right panel shows the reverse trend. This is evidence that there are two populations of red giant stars that have different spatial distributions.

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