Stars' orbital dance reveals a generation gap

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47 Tucanae, 16,700 light-years from Earth, is 10.5 billion years old and one of the brightest of our galaxy's globular clusters. Credit: NASA, Space Telescope Science Institute, and the University of British Columbia, Vancouver.

UBC astronomers have used NASA's Hubble Space Telescope to track the orbital motion of 33,000 stars in one of the Galaxy's oldest globular clusters, offering new insights into the formation of the Milky Way.

The careful examination of 'cosmic choreography' enabled researchers, for the first time, to link the movement of stars within the cluster to the stars' ages. The study reveals two distinct generations of stars within globular cluster 47 Tucanae, 16,700 light-years from Earth.

"When analyzing the motions of stars, the longer the time baseline for observations, the more accurately we can measure their motion," says UBC astronomer Harvey Richer, lead author on the paper published in the July issue of *Astrophysical Journal Letters*.

"The Hubble data are so good, we can actually see the individual motions of the stars within the cluster. The data offer detailed evidence to help us understand how various stellar populations formed in such clusters."

Richer and colleagues combined recent Hubble observations with eight years' worth of data from the telescope's archive to determine the motions of the stars in 47 Tucanae.

The Milky Way's globular clusters are the surviving relics from our galaxy's formation. 47 Tucanae is 10.5 billion years old and one of the brightest of our galaxy's more than 150 globular clusters. The cluster measures about 120 light-years wide. The two populations of stars in 47 Tucanae differ in age by 100 million years.

The first population consists of redder stars, which are older, less chemically enriched, and orbiting in random circles. The second population consists of bluer stars, which are younger, more chemically enhanced, and moving in more elliptical orbits.

Previous spectroscopic studies revealed many globular clusters contain stars of varying chemical compositions, suggesting multiple episodes of star birth. Richer's analysis supports those studies, but adds the stars' orbital motion to the analysis. Richer and his team used Hubble's Advanced Camera for Surveys to observe the cluster in 2010. They combined those observations with archival images to measure the change in position of more than 30,000 stars. Using these data, they could discern how fast the stars move. The team also measured the stars' brightness and temperatures.

The lack of heavier elements in the redder stars reflects the initial composition of the gas that formed the cluster. After the most massive of these stars completed their stellar evolution, they expelled gas enriched with heavier elements back into the cluster. This gas collided with other gas and formed a second, more chemically enriched generation of stars that was concentrated toward the cluster center. Over time these stars moved slowly outward into more elliptical orbits.

This is not the first time Hubble has revealed multiple generations of stars in globular clusters. In 2007, Hubble researchers found three generations of stars in the massive globular cluster NGC 2808. But Richer's team is the first to link stellar dynamics to separate populations.

Astronomers need to continue analyzing these multiple generations to better understand how stars formed in distant galaxies in the early universe.

More information: *Astrophysical Journal Letters*
iopscience.iop.org/2041-8205/771/1/L15/
Images and more information about 47 Tucanae:
hubblesite.org/gallery/album/o … /pr1997035c/npp/all/

Provided by University of British Columbia