

# Some Globular Clusters May Be Leftovers From Snacking Galaxies

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Globular star clusters are like spherical cathedrals of light - collections of millions of stars lumped into a space only a few dozen light-years across. If the Earth resided within a globular cluster, our night sky would be alight with thousands of stars more brilliant than Sirius.

Our own Milky Way Galaxy currently holds about 200 globular clusters, but once possessed many more. According to the hierarchical theory of galaxy formation, galaxies have grown larger over time by consuming smaller dwarf galaxies and star clusters. And sometimes, it seems that the unfortunate prey is not swallowed whole but instead is munched like a peach, stripped of its outer layers to leave behind only the pit. New research by Paul Martini (Harvard-Smithsonian Center for Astrophysics) and Luis Ho (Observatories of the Carnegie Institution of Washington) shows that some globular clusters may be remnants of dwarf galaxies that were stripped of their outer stars, leaving only the galaxy's nucleus behind.

Martini and Ho reported their results in the July 20, 2004, issue of *The Astrophysical Journal*.

Their findings hint at an important yet puzzling connection between the largest globular clusters and the smallest dwarf galaxies. "Star clusters and galaxies are quite different from a structural standpoint - star clusters are much more centrally concentrated, for example - and so the mechanisms that form them must be quite different. Identification of star clusters in the same mass range as galaxies is a very important step

toward understanding how both types of objects form," says Martini.

For their investigation, the team studied 14 globular clusters in the large elliptical galaxy Centaurus A (NGC 5128) using the 6.5-meter-diameter Magellan Clay telescope at Carnegie's Las Campanas Observatory, Chile. The clusters were selected for their brightness, and since brighter clusters tend to contain more stars and more mass, were expected to be massive. Yet their results surprised even Martini and Ho, showing that the globular clusters of Centaurus A are much more massive than most globulars in the Local Group of galaxies (which includes the Milky Way and the Andromeda Galaxy).

"The essence of our findings is that these 14 globulars are 10 times more massive than the smaller globulars in our neighborhood, and whatever process makes them can produce some really huge objects - they begin to overlap with the smallest galaxies," says Martini.

Martini also points out the recent discovery of a suspected intermediate-mass black hole in the Andromeda Galaxy globular cluster known as G1, which offers further evidence linking globular clusters to dwarf galaxies. The presence of a moderate-sized black hole is more understandable if it once occupied the center of a dwarf galaxy - a galaxy that lost its outer stars to the pull of Andromeda, leaving it only a shadow of its former self.

Ho, a co-discoverer of the intermediate-mass black hole in G1, adds, "One of the most surprising findings is that the black hole in G1 obeys the same tight correlation between black hole mass and host galaxy mass that has been well established for supermassive black holes in the centers of big galaxies. This puzzling result is more understandable if G1 was once the nucleus of a larger galaxy. A very interesting question is whether some of the massive clusters in Centaurus A also contain central black holes."

Although most of our Galaxy's globular clusters are much smaller than those of Centaurus A, the largest Milky Way globulars (such as the omega Centauri star cluster) rival those of the elliptical galaxy. The similarities between massive globulars in both galaxies may point to similar formation mechanisms. Future studies of these most massive globular clusters will explore connections between the formation processes for star clusters and galaxies.

Centaurus A is located approximately 12.5 million light-years away. It is about 65,000 light-years across and is more massive than the Milky Way and Andromeda galaxies put together. Centaurus A possesses a total of about 2000 globular clusters - more than all of the galaxies in the Local Group combined. Recent Spitzer Space Telescope observations of Centaurus A uncovered evidence that it merged with a spiral galaxy about 200 million years ago.

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