Far from home: Wayward cluster is both tiny and distant

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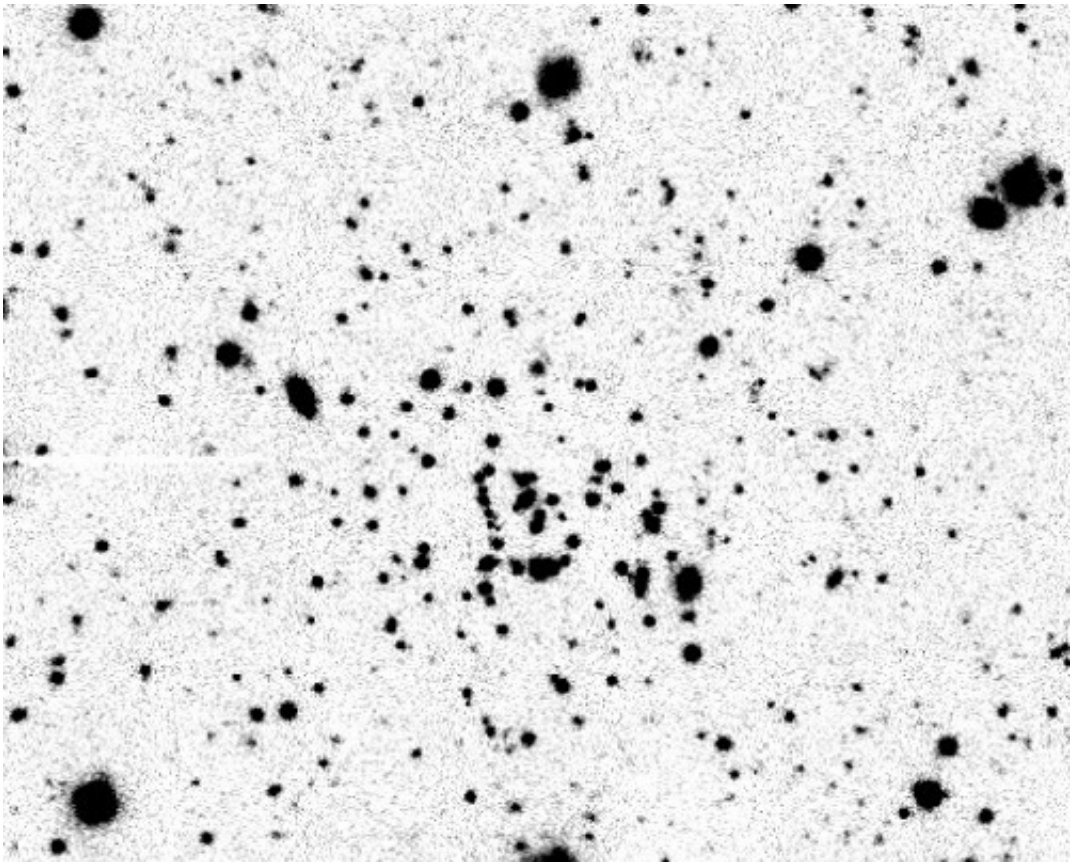

GMOS image of Kim 2, in g band. The image is 4 arcminutes across. Credit: GMOS image/Gemini Observatory

Like the lost little puppy that wanders too far from home, astronomers have found an unusually small and distant group of stars that seems oddly out of place. The cluster, made of only a handful of stars, is

located far away, in the Milky Way's "suburbs." It is located where astronomers have never spotted such a small cluster of stars before.

The new star cluster was discovered by Dongwon Kim, a PhD student at the Australian National University (ANU), together with a team of astronomers (Helmut Jerjen, Antonino Milone, Dougal Mackey, and Gary Da Costa) who are conducting the Stromlo Milky Way Satellite Survey at ANU.

"This cluster is faint, very faint, and truly in the suburbs of our Milky Way," said Kim. "In fact, this group of stars is about ten times more distant than the average globular star cluster in the halo of our galaxy—it's a lost puppy," Mackey adds. Globular clusters are spherical cities of stars that form a vast, extended halo around the core of our galaxy, the brightest of which are easily seen in amateur telescopes or even binoculars. However, this new discovery required one of the world's largest telescopes to confirm, "it's definitely a diminutive oddball," says Milone.

The oddly small, far-flung, cluster was discovered using the Dark Energy Camera (DECam) on the 4-meter Blanco Telescope at the Cerro Tololo Inter-American Observatory (CTIO) in Chile. "This discovery sheds new light on the formation and evolution of the Milky Way," said Daniel Evans, National Science Foundation program director for Gemini Observatory. "It's great to see so many telescopes come together to produce this result, not the least being Gemini Observatory with its incredible light-gathering power."

The team's first evidence of the unusually remote star cluster came when they ran detection algorithms on a 500 square-degree imaging data field obtained with DECam. "Such objects are too faint and optically elusive to be seen by eye. The cluster stars are sprinkled so thinly over the image, you look right through them without noticing (see image on

electronic release, URL above). They are hiding in the sea of stars from the Milky Way. Sophisticated computer programs are our tools to find them," said Jerjen.

Because it is so faint, ultra-deep follow-up observations using the Gemini Multi-Object Spectrograph (in imaging mode) confirmed that the new globular cluster is among the faintest Milky Way globular clusters ever found. Seven out of 150 known Milky Way globular clusters are comparably faint but none are located as far out toward the edge of the Milky Way. This new globular cluster has 10-20 times fewer stars than any of the other outer halo globular clusters. Also, its star density is less than half of that of other Milky Way globular clusters in the same luminosity (brightness) range.

The new star cluster, named Kim 2, also shows evidence of significant mass loss over its history. Computer simulations predict that, as a consequence of their evolution over many billions of years, including the slow loss of member stars due to the gravitational pull of the Milky Way, star clusters ought to be arranged such that their more massive stars are concentrated toward their centers. "This 'mass segregation' has been difficult to observe, particularly in low mass clusters, but the excellent Gemini data reveal that Kim 2 appears to be mass segregated and has therefore likely lost much of its original mass," said Da Costa. The finding suggests that a substantial number of low-luminosity globular clusters must have existed in the halo when the Milky Way was younger, but most of them might have evaporated due to internal dynamical processes.

The observed properties of the new star cluster also raise the question about how such a low luminosity system could have survived until today. One possible scenario is that Kim 2 is not actually a genuine member of the Milky Way globular cluster family, but a star cluster originally located in a satellite dwarf galaxy and was accreted into the Milky Way's

halo. This picture is also supported by the fact that the stars in Kim 2 appear to be more chemically enriched with heavier elements than the other outer halo globular clusters and are young relative to the oldest globular clusters in the Milky Way. As a consequence of spending much of its life in a dwarf galaxy Kim 2 could have largely escaped the destructive influence of tidal forces, thus helping it to survive until the present epoch.

There are many Milky Way globular clusters formerly and currently associated with satellite dwarf galaxies. It is possible that a significant fraction of the ancient satellite dwarf galaxies were completely disrupted by the tidal field of the Milky Way while the high density of the globular clusters allowed them to survive in our galaxy's halo. Indeed, Kim 2 is found close to the vast polar structure of Milky Way satellite galaxies, a disc-like region surrounding the Milky Way where satellite galaxies and young halo clusters preferentially congregate. A similar distribution of satellite galaxies is also found in the neighbouring Andromeda Galaxy.

A large fraction of the Milky Way's halo is thought to be populated with optically elusive satellite galaxies and star clusters. New discoveries of satellite galaxies and globular clusters will therefore provide valuable information about the formation and the structure of the Milky Way. Previous surveys like the Sloan Digital Sky Survey have contributed to many new discoveries in the northern sky. However, most of the southern sky still remains unexplored to date. The detection of Kim 2 suggests that there are a substantial number of interesting astronomical objects waiting to be discovered in the southern hemisphere and the Stromlo Milky Way Satellite Survey team plans to continue searching for them.

The team's paper, accepted for publication in the *Astrophysical Journal*, is available as a preprint at arxiv.org/abs/1502.03952

Provided by Gemini Observatory