

NGC 6624 cluster's advanced age in razor-sharp focus

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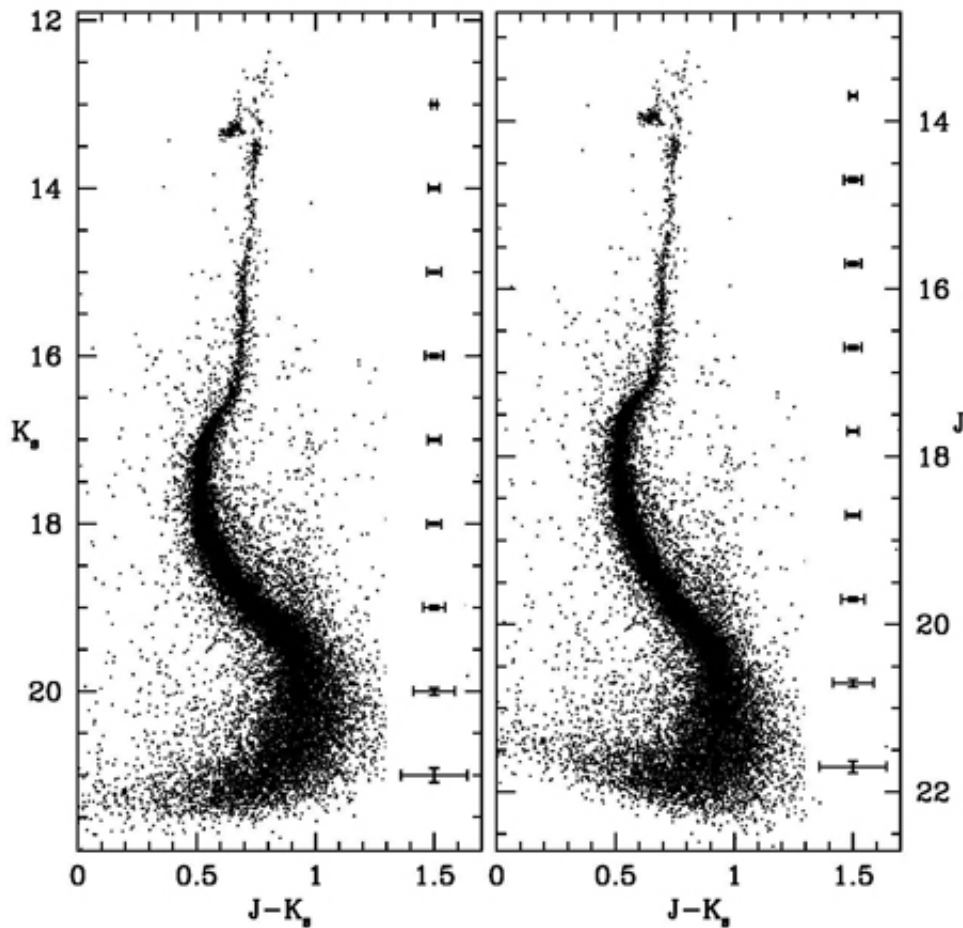
Gemini Observatory GeMS image of NGC 6624 revealing individual stars to the cluster's core. The Cluster's age as determined with this study is between 11.5-12.5 billion years old, which confirms that it formed when the Universe was only a fraction of its current age of about 13.8 billion years. Composite color

image by Travis Rector, University of Alaska Anchorage. Credit: Gemini Observatory/AURA

An international team of astronomers, using the Gemini Multi-conjugate adaptive optics System (GeMS) and the high resolution camera GSAOI, brought the ancient globular cluster NGC 6624 into razor-sharp focus and determined its age with very high accuracy—a challenging observation even from space. In addition to producing a beautiful image, this work will ultimately help astronomers to better understand the formation and evolution of our Galaxy during its earliest development when the Universe was less than two billion years old.

Researchers using advanced [adaptive optics](#) technology at the Gemini South telescope in Chile probed the depths of the highly compact globular cluster NGC 6624, revealing pinpoint images of thousands of stars. The sharpness of the near-infrared images is competitive with that obtained from space with the Hubble Space Telescope in optical light. "With images this sharp, astronomers can do things that we never dreamed were possible from the ground," says team member Douglas Geisler of the University of Concepción in Chile.

The team obtained the imaging data using two filters that are sensitive to specific wavelength bands of near-infrared light, then plotted them on a color-magnitude diagram – a technique that reveals details about the evolutionary history of the cluster's stars. The results of this research will be published in the *Astrophysical Journal*. According to first author Sara Saracino from the University of Bologna, this is the most accurate, and deepest, near-infrared color-magnitude diagram ever produced of this cluster and indeed perhaps the best-ever made for any bulge cluster.



CMDs of NGC6624 obtained from the Gemini observations. All the main evolutionary sequences of the cluster are well visible. These NIR diagrams turn out to be comparable to the HST optical ones, both in depth and in photometric accuracy. The photometric errors for each in of K_s and J magnitudes are shown on the right side of the panels. Credit: Gemini Observatory

The observations provide a clear detection of the so-called "main-sequence knee," a distinctive bend in the evolutionary track of low mass main sequence stars (those that burn hydrogen into helium at their cores). This feature is extremely faint and therefore difficult to detect. This is the first time this feature has been identified in this globular

cluster. "Analysis of these razor-sharp images, and the very deep color-magnitude diagram, allows us to determine the age of the cluster to extremely high precision," says Saracino. In turn, this helps to better understand the formation and evolution of our Milky Way bulge, which may well be the oldest component of the Galaxy. The new Gemini data reveal that the age of NGC 6624 is between 11.5-12.5 billion years old, almost as old as the Universe itself – estimated to be about 13.8 billion years old.

NGC 6624 is also interesting because it has been classified as what astronomers call a post-core collapse cluster, meaning that this is a highly evolved system. The high quality of the data also allowed the researchers to perform a detailed study of the distribution of main-sequence stars of different masses outward from the center. As expected for such a highly evolved system, the team found evidence of a significant increase in low-mass stars at increasing distances from the cluster center.

This study is part of a much larger research program aimed at shedding new light on the still debated processes that formed the Milky Way's bulge using its globular cluster population. Due to the large amount of absorption by material between the stars in the Milky Way Galaxy, detailed studies of bulge globular clusters have been severely hampered until now. Geisler notes that the advent of the GeMS instrument now allows astronomers to penetrate the dust and study these clusters in the great detail they deserve. "It will certainly continue to provide us with very important clues about how our Galaxy formed and evolved," he says.

More information: Ultra-deep GEMINI near-infrared observations of the bulge globular cluster NGC 6624. arxiv.org/abs/1609.02152

Provided by Gemini Observatory

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