

Wonderful Cool Mira Stars Anchor an independent Rate of Cosmic Expansion

New study from IUCAA, with a Nobel laureate as a co-author, uses oxygen-rich Mira variable stars to achieve highly precise measurement of the Hubble constant.

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A recent groundbreaking study led by Professor Anupam Bhardwaj from the Inter-University Centre for Astronomy and Astrophysics (IUCAA) utilized 40 oxygen-rich Mira variable stars located in 18 stellar clusters of our galaxy.

The research team monitored these Mira stars over an extended period, establishing their mean luminosities and pulsation periods. The European Space Agency's *Gaia* mission played a key role by providing precise geometric distances to these star clusters, which are located between 13,000 and 55,000 light-years from Earth. This allowed for an absolute calibration of the stellar luminosities of the Mira variables, providing a new level of precision.

The resulting "absolute" period-luminosity relationship for these Mira variables provides an independent calibration of the supernovae used in the cosmic distance ladder, without using Cepheid variables. This achievement enabled the team to determine the Hubble constant with a remarkable 3.7% precision. The study has recently been published in the prestigious *Astrophysical Journal*.

"We used Miras in our galaxy as anchors for the first time to determine the most precise cosmic expansion rate based on these cool stars," said Prof. Bhardwaj, the study's lead author. "Like Cepheid variables, the Mira variables in our own galaxy allowed us to establish a three-anchor baseline calibration of the extragalactic distance ladder, with additional Mira variables from two external galaxies. This work highlights that metal-abundance affects Mira luminosity three times less than Cepheids, making Miras a promising alternative tool for Hubble constant determination."

Nobel Laureate Adam Riess, of the Space Telescope Science Institute and Johns Hopkins University is a co-author in this work. According to him, this new work offers a powerful resolution to the ongoing debate: "The consistency between Cepheid and Mira anchored Hubble constant values further suggests the Hubble tension is unlikely due to the measurement errors, and points to a more fundamental cause including the possibility of new physics."

Dr. Marina Rejkuba, another co-author and staff astronomer at the European Southern Observatory, echoed the significance of the study: "This study combines the fields of stellar astrophysics and cosmology. I would expect it to have a long-term impact as it ensures our understanding of the potential of Mira variable stars as a new well calibrated anchor for the Hubble constant determination."

While the calibration of Miras at the first step of the distance ladder now matches the precision of Cepheids, the overall uncertainty in the Mira-based Hubble constant measurement remains impacted by the limited number of galaxies with known Miras (only two supernovae host galaxies with known Miras). However, a large number of Miras are expected to be discovered in supernovae host galaxies with Rubin observatory, opening up a new way to precisely map the age and the size of the Universe.

Background

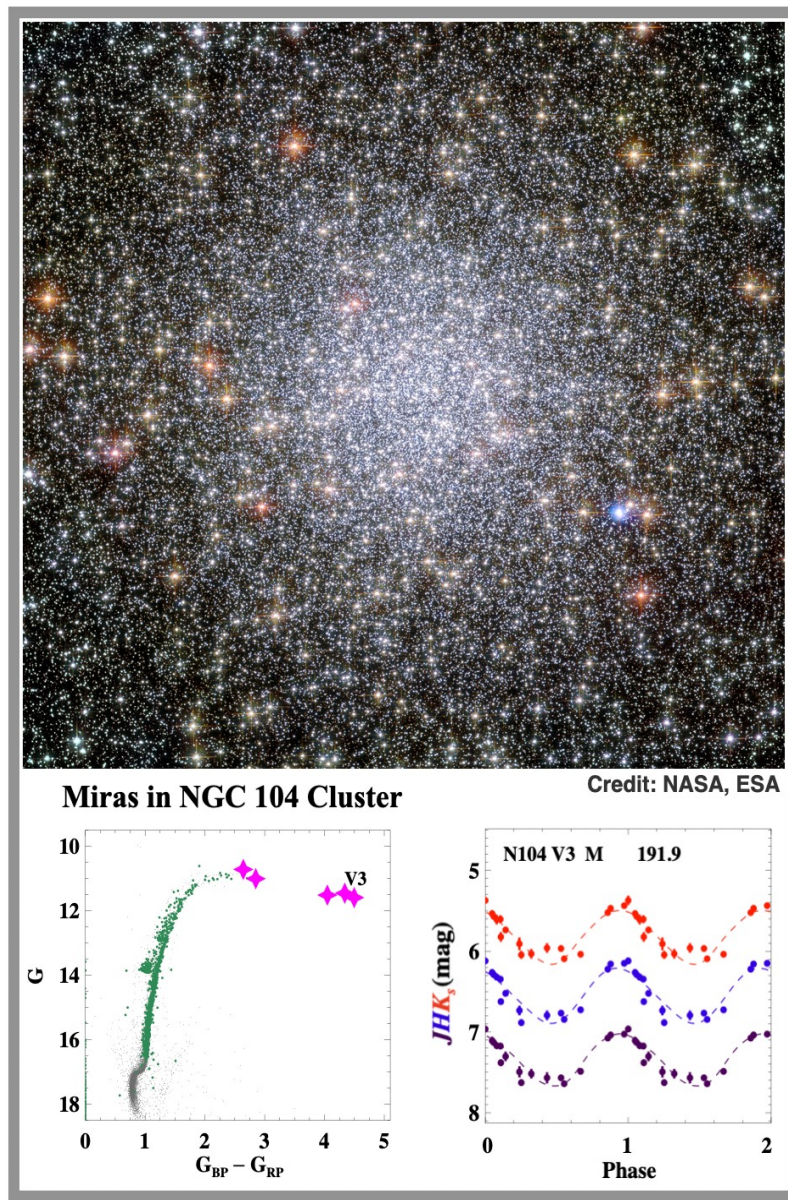
Mira, also known as Omicron Ceti, is a star that remarkably changes its brightness over time, in a regular pattern. With the variability first measured by astronomers in the 17th century, Mira was the first known example of a "variable star"—a star that doesn't shine with a constant brightness. The name, *Mira*, means "the wonderful" in Latin, and it lived up to that name by becoming the prototype for an entire class of stars known as Mira variables.

Mira variables are a type of giant star that go through regular cycles of expanding and contracting. These cycles cause their brightness to vary in a predictable way, typically over periods ranging from 100 to 1,000 days. These stars are relatively cool, with surface temperatures around 3,000 Kelvin (about half the temperature of the Sun's surface), and they are in the late stages of their life. One of the most important things about Mira variables is that there is a strong relationship between how bright they are and how long their pulsation cycles last. This relationship allows astronomers to use them as "standard candles."

A standard candle is an object in space whose true brightness is known. By comparing how bright the object appears from Earth to how bright it actually is, scientists can calculate how far away it is. This is a key method used to measure distances in the universe, forming part of what astronomers call the "extragalactic distance ladder." As we look farther and farther into space, astronomers use different types of standard candles to step up the ladder, eventually reaching distances where the expansion of the universe—known as the Hubble flow—can be measured.

The rate at which the universe is expanding today is called the Hubble constant. This value is extremely important in cosmology because it helps us determine the size and age of the universe. However, there's currently a major puzzle in the scientific community known as the "Hubble tension." When astronomers measure the Hubble constant using nearby stars like Cepheid variables and exploding stars called Type Ia supernovae, they get a higher value than when they calculate it based on observations of the early universe, using cosmic microwave background data and other indirect methods. The Hubble constant has been a focal point of debate in recent years, with different measurement methods yielding discrepant values, leading to what is known as the "Hubble tension."

This discrepancy suggests that the universe may be expanding faster in the present day than we would expect based on our standard models of cosmology. Scientists are actively trying to understand why this difference exists. It might point to unknown physics, or it could mean our current models need to be updated. Either way, discoveries like those involving Mira and other variable stars continue to play a key role in helping us unravel the mysteries of the cosmos.



Source: IUCAA

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