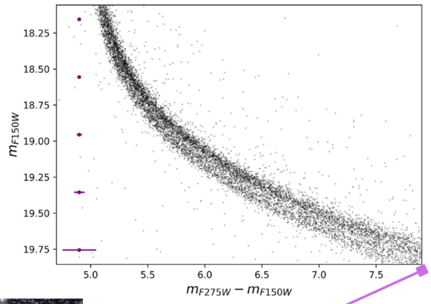
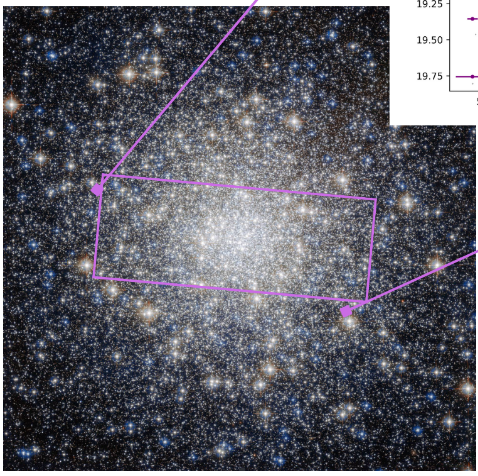
JWST uncovers the smallest stars in our Galaxy and helps solving star cluster mystery





Using observations from the James Webb Space Telescope, an international team of astronomers led by Tuila Ziliotto, a PhD student at the University of Padova, analyzed the smallest stars of the ancient star cluster M92.
As building blocks of galaxies, star clusters play a pivotal role in their formation and evolution, yet much about their origin remains shrouded in mystery. One intriguing discovery was the existence of different groups of stars with varying chemical compositions within the same cluster. The origin of this phenomenon represents one of the biggest open problems in stellar astrophysics, and very low-mass stars are one of the keys to solve this enigma.

In the past, astronomers thought that all the star clusters were composed of a simple stellar population alone: all stars in the clusters were formed from the same molecular cloud simultaneously, having the same chemical composition. Now, we know that the picture is far more complex: almost all clusters display variations in chemical composition.

Astronomers have developed several hypotheses to try to explain this intriguing phenomenon, which can be categorized into two competing groups. The first, known as the multi-generation scenario, suggests that the clusters underwent successive bursts of star formation. The first stars formed within the cluster would release material into the surrounding gas. This enriched gas would collapse forming new generations of stars, which would then display the chemical variations compared to the first generation that we observe today.

The second scenario proposes a single generation of stars within the cluster, attributing the observed chemical variations to the accretion of material ejected by more massive stars onto the stars within the cluster. According to this hypothesis, the amount of accreted material is proportional to the star's mass, with higher-mass stars accreting more material than their lower-mass counterparts due to the influence of gravity. Consequently, the chemical variations we currently observe among stars would exhibit distinct patterns between low- and high-mass stars under this scenario.

“The problem was that before the JWST, due to instrumental limitations, most of the studies of star clusters were focused on the most massive stars. Now, with the JWST, we are being able to study with high precision the least massive stars in our Galaxy, down to the hydrogen-burning limit, which marks the boundary between stars and brown dwarfs”, says Tuila Ziliotto, who led the study published in The Astrophysical Journal. “In that way, we can measure the chemical variations among low-mass stars and compare them with those of high-mass stars to determine which scenario is correct”, she concludes.

The team of astronomers used observations taken with photometric filters of the Near-Infrared Camera of JWST to measure oxygen and helium variations among low-mass stars of M92. “These very small stars have surfaces cool enough to harbor water vapor in their atmospheres. Within these stars, most of the oxygen content is present in water molecules. This is why we utilize the infrared filters of JWST, which are very sensitive to water molecules, to infer the oxygen content of these stars”, explains Anjana Mohandasan, a PhD student in Padova, who co-authored the work.

“The chemical variations among very low-mass stars of M92 align with those found in giant stars” concludes Ziliotto. This finding presents a significant challenge to accretion scenarios and lends support to hypotheses advocating multiple episodes of star formation within the cluster, marking a step forward in our understanding of the intricate formation processes of star clusters.

More information

This research was presented in the paper “Multiple Stellar Populations in Metal-Poor Globular Clusters with JWST: a NIRCam view of M92” published in The Astrophysical Journal (doi: 10.3847/1538-4357/acde76).

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This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Grant Agreement No. 101034319 and from the European Union – NextGenerationEU

Links

Research paper
https://iopscience.iop.org/article/10.3847/1538-4357/acde76/meta

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