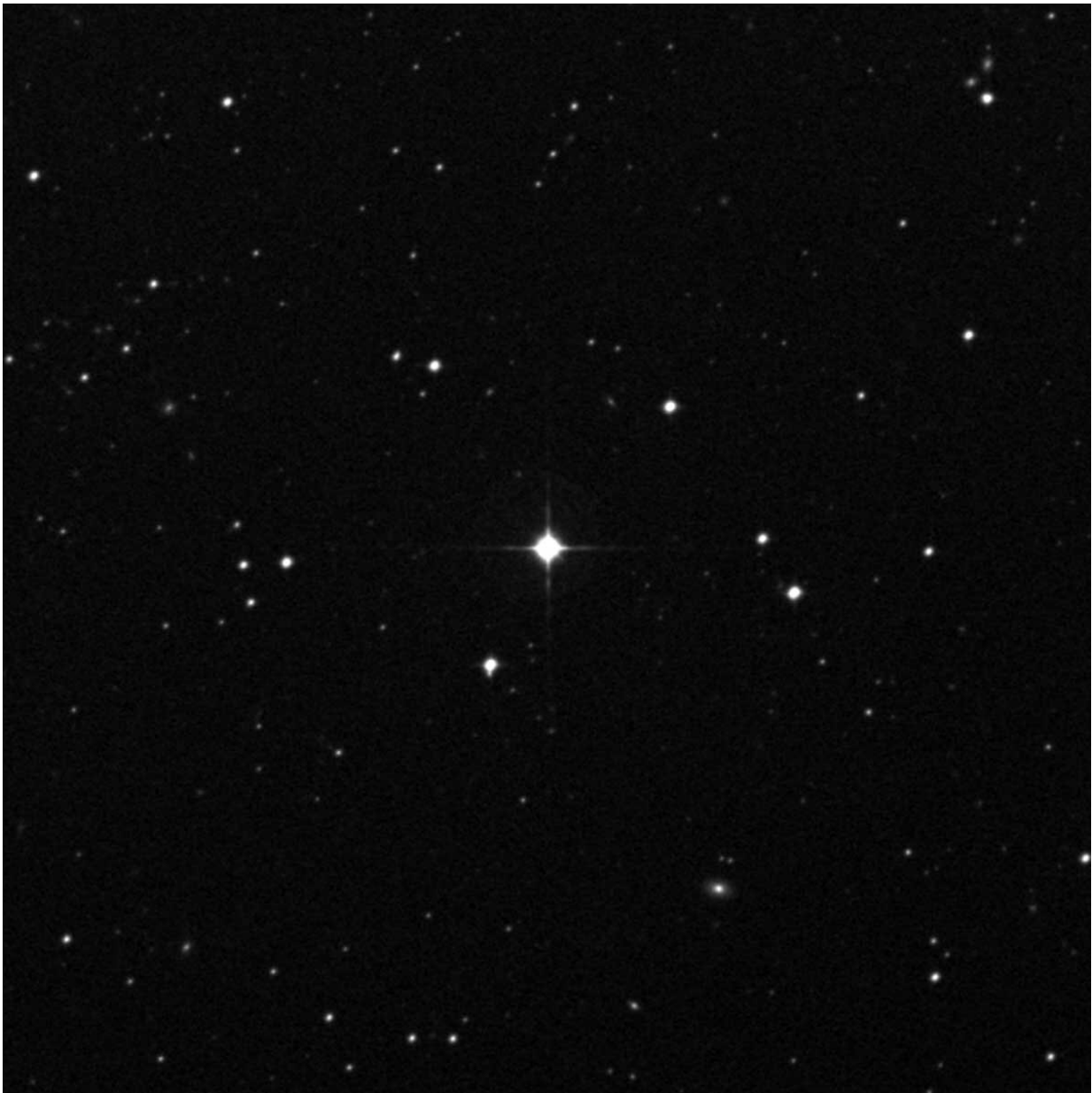


# Astronomers find 'gold standard' star in Milky Way

May 11 2022, by Morgan Sherburne

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The star HD 222925 is a ninth-magnitude star located toward the southern constellation Tucana. Credit: The STScI Digitized Sky Survey

In our sun's neighborhood of the Milky Way Galaxy is a relatively bright star, and in it, astronomers have been able to identify the widest range of elements in a star beyond our solar system yet.

The study, led by University of Michigan [astronomer](#) Ian Roederer, has identified 65 elements in the star, HD 222925. Forty-two of the elements identified are [heavy elements](#) that are listed along the bottom of the periodic table of elements.

Identifying these elements in a single star will help astronomers understand what's called the "rapid neutron capture process," or one of the major ways by which heavy elements in the universe were created. Their results are posted on arXiv and have been accepted for publication in *The Astrophysical Journal Supplement* series.

"To the best of my knowledge, that's a record for any object beyond our solar system. And what makes this star so unique is that it has a very high relative proportion of the elements listed along the bottom two-thirds of the periodic table. We even detected gold," Roederer said. "These elements were made by the rapid neutron capture process. That's really the thing we're trying to study: the physics in understanding how, where and when those elements were made."

The process, also called the "r-process," begins with the presence of lighter elements such as iron. Then, rapidly—on the order of a second—neutrons are added to the nuclei of the lighter elements. This creates [heavier elements](#) such as selenium, silver, tellurium, platinum, gold and thorium, the kind found in HD 222925, and all of which are

rarely detected in stars, according to the astronomers.

"You need lots of neutrons that are free and a very high energy set of conditions to liberate them and add them to the nuclei of atoms," Roederer said. "There aren't very many environments in which that can happen—two, maybe."

One of these environments has been confirmed: the merging of [neutron stars](#). Neutron stars are the collapsed cores of supergiant stars, and are the smallest and densest known celestial objects. The collision of neutron star pairs causes gravitational waves and in 2017, astronomers first detected [gravitational waves](#) from merging neutron stars. Another way the r-process might occur is after the explosive death of massive stars.

"That's an important step forward: recognizing where the r-process can occur. But it's a much bigger step to say, 'What did that event actually do? What was produced there?'" Roederer said. "That's where our study comes in."

The elements Roederer and his team identified in HD 222925 were produced in either a massive supernovae or a merger of [neutron](#) stars very early in the universe. The material was ejected and thrown back into space, where it later reformed into the star Roederer is studying today.

This star can then be used as a proxy for what one of those events would have produced. Any model developed in the future that demonstrates how the r-process or nature produces elements on the bottom two-thirds of the periodic table must have the same signature as HD 222925, Roederer says.

Crucially, the astronomers used an instrument on the Hubble Space Telescope that can collect [ultraviolet spectra](#). This instrument was key in

allowing the astronomers to collect light in the ultraviolet part of the light spectrum—light that is faint, coming from a cool star such as HD 222925.

The astronomers also used one of the Magellan telescopes—a consortium of which U-M is a partner—at Las Campanas Observatory in Chile to collect light from HD 222925 in the optical part of the light spectrum.

These spectra encode the "chemical fingerprint" of elements within stars, and reading these spectra allows the astronomers not only to identify the elements contained in the star, but also how much of an element the star contains.

Anna Frebel is a co-author of the study and professor of physics at the Massachusetts Institute of Technology. She helped with the overall interpretation of the HD 222925's element abundance pattern and how it informs our understanding of the origin of the elements in the cosmos.

"We now know the detailed element-by-element output of some r-process event that happened early in the universe," Frebel said. "Any model that tries to understand what's going on with the r-process has to be able to reproduce that."

Many of the study co-authors are part of a group called the R-Process Alliance, a group of astrophysicists dedicated to solving the big questions of the r-process. This project marks one of the team's key goals: identifying which elements, and in what amounts, were produced in the [r-process](#) in an unprecedented level of detail.

**More information:** Ian U. Roederer et al, The R-Process Alliance: A Nearly Complete R-Process Abundance Template Derived from Ultraviolet Spectroscopy of the R-Process-Enhanced Metal-Poor Star

HD 222925. arXiv:2205.03426v1 [astro-ph.SR],  
[arxiv.org/abs/2205.03426](https://arxiv.org/abs/2205.03426)

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