New extremely r-process-enhanced star detected

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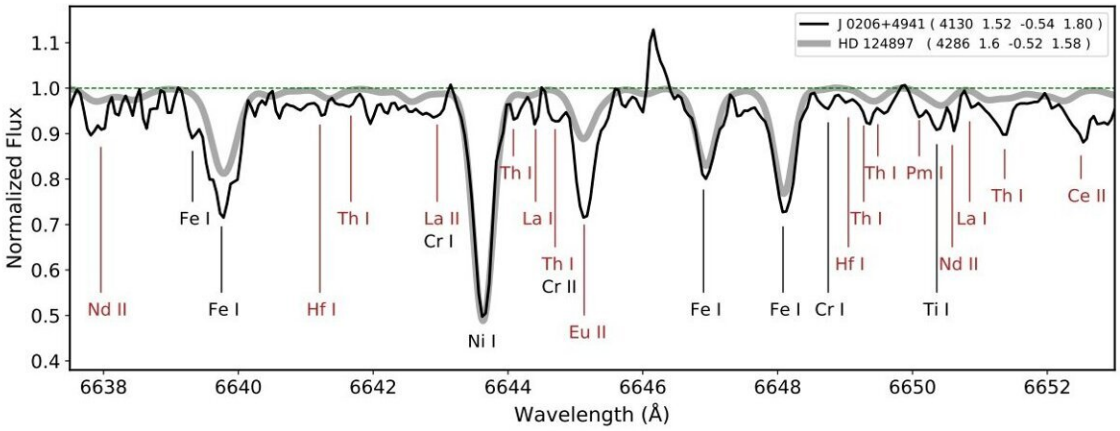

Comparison of high-resolution spectra of J 0206+4941 and a moderately r-process-enhanced (r-I) star, HD 124897 ([Eu/Fe] = +0.45, with similar stellar parameters. Credit: Xie et al., 2024.

Using the Gran Telescopio Canarias (GTC), astronomers from the Chinese Academy of Sciences (CAS) and elsewhere have discovered a new extremely r-process-enhanced star in the Milky Way's thin disk. The finding was reported in a research paper published July 16 on the pre-print server *arXiv*.

The r-process-enhanced (RPE) stars represent a small fraction of old, metal-poor stars, which exhibit large enhancements in elements (such as europium, thorium or uranium) produced in the rapid neutron-capture process. These stars, which mainly populate the galactic halo and Milky Way's dwarf satellite galaxies, are excellent laboratories for studying the r-process and could help us better understand the assembly history of our galaxy.

Now, a team of astronomers led by Xiao-Jin Xie of CAS reports the detection of a new RPE star. They employed GTC's High Optical Resolution Spectrograph (HORuS) to observe a star designated LAMOST J020623.21+494127.9 (or J 0206+4941 for short). The observational campaign led to the classification of this object as an extremely r-process-enhanced star.

"It [J 0206+4941] was originally selected from the LAMOST medium-resolution survey as a candidate RPE star, based on its unusually strong lines of europium," the researchers wrote in the paper.

The observations found that J 0206+4941 is a bright star that belongs to the Milky Way's thin disk. Based on the collected data, the astronomers managed to derive the abundances of 30 elements for this star and to determine its kinematics.

According to the new findings, J 0206+4941 has a metallicity at a level of -0.54, an effective temperature of approximately 4,078 K and an abundance ratio of europium to hydrogen of 0.78. In general, the abundances of the light elements in this star turned out to be comparable to other stars of similar metallicity and evolutionary phase, with a strong enhancement of europium and modest enhancement of barium.

The authors of the paper underlined that J 0206+4941 is therefore the most metal-rich highly r-process-enhanced star found to date. The age of

the star is uncertain, likely about 12.3 billion years, and further studies are required to confirm this.

Trying to explain the origin of J 0206+4941, the scientists do not exclude the possibility that it may have been born in-situ in the Milky Way's thin disk. They added that it may have formed from an interstellar medium (ISM) enriched in r-process elements by a single binary neutron star merger or core-collapsed supernovae (CCSNe).

In concluding remarks, the astronomers noted that in addition to J 0206+4941, they also identified a few other metal-rich RPE candidates that are worth further investigation using instruments such as HORuS.

More information: Xiao-Jin Xie et al, Discovery of an Extremely r-process-enhanced Thin-disk Star with [Eu/H] = +0.78, *arXiv* (2024). DOI: 10.48550/arxiv.2407.11572