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Discovery of the first metal-poor star with a combined r- and s-process element signature

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We report the discovery of J0949-1617, the first bonafide CEMP-r+s star identified. This class of objects has previously been suggested to explain stars with neutron-capture element patterns that originate from neither the r- or s-process alone. We find J0949-1617 to be a CEMP stars with s-process enhancement that must have formed from gas enriched by a prior r-process event. The light neutron-capture elements follow a low-metallicity s-process pattern, while the heavier neutron-capture elements above Eu follow an r-process pattern. The Pb abundance is high, in line with an s-process origin. Thorium is also detected, as expected from an r-process origin. We employ nucleosynthesis model predictions that take an initial r-process enhancement into account, and then determine the mass transfer of carbon and s-process material from a putative, more massive companion onto the observed star. The resulting abundances agree well with the observed pattern. We speculate that J0949-1617 formed in an environment similar to those of ultra-faint dwarf galaxies like Tucana III and Reticulum II, which were enriched in r-process elements by one or multiple neutron star mergers at the earliest times.

This star was found as part of the R-Process Alliance, a new effort to uncover metal-poor halo stars with enhancements in neutron-capture elements. We thus present the results of a high-resolution (R~35,000), high signal-to-noise (S/N>200) Magellan/MIKE spectrum of the star RAVE J094921.8-161722, a bright (V=11.3) metal-poor red giant star with [Fe/H] = -2.2, identified as a carbon-enhanced metal-poor (CEMP) star from the RAVE survey.

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