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Testing theoretical r-process models with observed abundances of thorium, uranium, and lead in an old, metal-poor star HE 1523-0901

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Rapid (r-) neutron capture process(es) are responsible for the production of elements heavier than Fe in the Universe. About 5% of old, metal-poor stars are known to have a strong enhancement in r-process elements. One of the best examples is HE 1523-0901, an old, metal-poor giant star with enhanced r-process elements ([r/Fe] = 1.8). In this study, we examine a new high-resolution (R~85,000), extremely high S/N spectrum (~450 at 4000A) of HE 1523-0901 to measure the abundances of Th, U, and Pb (lead). The extremely weak strength of the Pb I absorption line can only be detected in such data. Only one other r-process star, CS 31082-001, has a Pb measurement. But that star is an actinide boost star which suggests that its r-process origin is not well understood. Therefore, HE 1523-0901 is the only star appropriate for constraining the universal main r-process pattern with abundances of Th, U and Pb. Among r-process elements, Pb is important for constraining theoretical models of the r-process. During an r-process, Pb forms through direct decay of neutron-rich isotopes from the trans-uranium region, as well as the decay of U and Th over the following billions of years. Thus, our results on these three abundances will provide the strongest self-consistency constraints on r-process models that have to reproduce these two production channels. A better understanding of r-process models based on observations can help us to figure out how and where the r-process elements are generated, to ultimately understand the chemical evolution of the Universe.

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