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Observations of r-process elements including thorium in the galactic disk and halo stars

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Half of the elements heavier than iron are synthesized by the r-process. The origin of the r-process is still a major matter of debate. Recent studies have shown that the origin of the r-process is neutron star mergers. On the other hand, from the studies of galactic chemical evolution, assuming neutron star mergers as the only r-process sites, it is difficult to explain stellar observations of Europium abundances. In addition, investigations of stellar abundances have found stars with high [Thorium(Th)/Europium(Eu)] (so-called actinide-boost stars). The existence of such stars suggests that the r-process has more than one origin (Holmbeck et al., 2018, Yong et al., 2021). Actinide boost stars have been mainly observed in very metal-poor stars ([Fe/H] < -2.5). However, observations are not sufficient for mildly metal-poor stars ([Fe/H] > -2) for the studies of galactic chemical evolution. Therefore, it is necessary to observe stellar Thorium abundances in a wide range of [Fe/H] to investigate the origin of the r-process. We obtained the spectra of 44 stars with -2 ≤ [Fe/H] ≤ +0.4 using Nayuta/MALLS, Gunma/GAOES, and Subaru/HDS, and derived the abundances of r-process elements. In -2 ≤ [Fe/H] ≤ 0, [Th/Eu] is almost constant, and no actinide boost stars were found. These results suggest that Thorium and Europium are synthesized in the same ratio, which implies a single origin. In 0 ≤ [Fe/H], four stars show high [Th/Eu], and chemical evolution models cannot explain these stars. These results of Thorium observations in a wide range of metallicity could be important for the studies of the origin of the r-process.

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