# Isomer Producution Ratio of $^{113}$Cd Following Neutron-Capture Reactions to Investigate the Origin of $^{115}$Sn

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The astrophysical origin of a rare isotope $^{115}$Sn has remained still an open question [1,2]. An isomer $^{113}$Cd$^m$ ($T_{1/2}$ = 14.1 y) in $^{113}$Cd is an *s*-process branching point from which a nucleosynthesis flow reaches to $^{115}$Sn (see Fig. 1). The *s*-process abundance of $^{115}$Sn depends on the isomer production ratio in the $^{112}$Cd(n, $\gamma$)$^{113}$Cd reaction. Hayakawa *et al.* [3] measured the $^{112}$Cd(n, $\gamma$)$^{113}$Cd$^m$ reaction cross section at the thermal energy with neutrons provided from a nuclear reactor, and pointed out that the *s*-process abundance of $^{115}$Sn depends on the ratio of the $^{112}$Cd(n, $\gamma$)$^{113}$Cd$^m$ reaction cross section to the $^{112}$Cd(n, $\gamma$)$^{113}$Cd$^{gs}$ reaction cross section in typical *s*-process energies of 1–50 keV. However, the isomer production ratio has not been measured in the energy region higher than the thermal energy. Thus, we have measured $\gamma$ rays following neutron capture reactions on $^{112}$Cd using two cluster HPGe detectors in conjunction with a time-of-flight method at J-PARC [4].

The experiment was performed using the accurate neutron-nucleus reaction measurement instrument (ANNRI) installed at a neutron beam line of BL04 at the MLF in the J-PARC. Proton beams with an average beam power of 200 kW were injected into the mercury target at a repetition rate of 25 Hz. The proton beams were operated with the double bunch mode. High flux pulsed neutrons were generated by spallation reactions on the mercury target. A $^{112}$Cd foil enriched to 98.27 % was placed at the center of the $\gamma$-ray detector array. The $\gamma$-rays from the $^{112}$Cd target were measured by two cluster HPGe detectors. In the neutron energy region higher than the thermal energy, we observed both $\gamma$ rays decaying to the ground state and the isomer of $^{113}$Cd. The $\gamma$ rays decaying to the ground state with energies of 299 and 316 keV were clearly observed, whereas a $\gamma$ ray with an energy of 259 keV which decays to the isomer was also observed. We have obtained the result that the relative $\gamma$-ray intensity ratio of the isomer except for 737 eV is almost constant in the energy region of up to 5 keV. The isomer production ratios calculated by a statistical model were consistented with these ratios. The present result supports the previous conclusion that the contribution of the *s*-process from the $^{113}$Cd isomer to the solar abundance of $^{115}$Sn is minor in the previous study [3]. The astrophysical origin of $^{115}$Sn has remained still an open question.

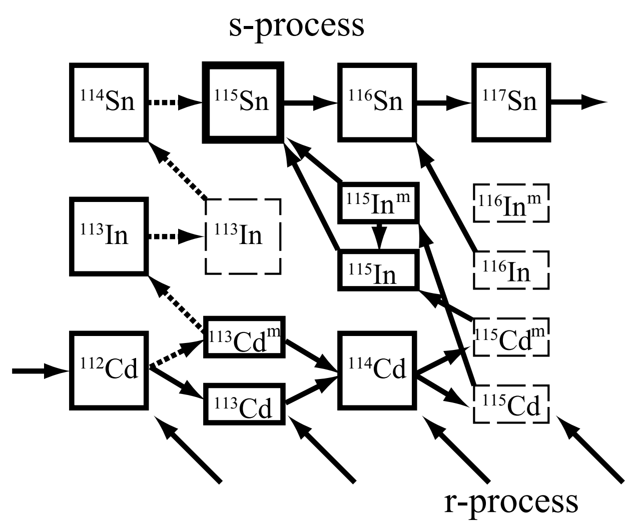


**Figure 1**: Nuclear chart around $^{113}$Cd.

## References

[1] Nemeth, Zs., et al.: 1994, *ApJ*, **426**, 357.
[2] Theis, Ch., et al.: 1998, *ApJ*, **500**, 1039.
[3] Hayakawa, T., et al.: 2009, *ApJ*, **707**, 859.
[4] Hayakawa, T., et al.: 2016, *Phys. Rev. C*, **94**, 055803.