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## Using (d,p) Transfer Reactions at OEDO-SHARAQ to Measure Astrophysical Reactions Important in $r$ - and $\nu p$ - processes

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The rapid ( $r$ ) neutron-capture process produces half the elements heavier than iron and is located on the neutron-rich side of the nuclear chart. Promising site candidates such as core-collapse supernovae (CCSNe) and neutron star mergers still show large discrepancies between observed and calculated abundances. The calculations mostly rely on theoretical neutron-capture cross sections which depend on two reaction processes: direct radiative capture and compound nuclear (CN) mechanism. Neutron capture on  $^{130}\text{Sn}$  strongly influences final abundances around the second and third  $r$ -process peaks, however, the CN mechanism lacks empirical data.

Turning attention to the neutron-deficient side of the nuclear chart, light nuclei in this region may be produced in the neutrino-induced rapid-proton capture ( $\nu p$ ) process, proposed to occur in the innermost ejecta of CCSNe. This is a promising solution to synthesize isotopes not adequately produced in the proton capture ( $p$ ) process (occurring within the O/Ne layer of CCSNe), particularly  $^{92,94}\text{Mo}$  and  $^{94,96}\text{Ru}$ . The  $^{56}\text{Ni}(n,p)^{56}\text{Co}$  reaction is a crucial branching point between the  $\nu p$ - and  $p$ - processes and thus governs the abundances of heavier elements, however, its cross section lacks measurement.

To address these knowledge gaps of the  $^{130}\text{Sn}(n,\gamma)$  and  $^{56}\text{Ni}(n,p)$  reactions, the surrogate technique was employed using (d,p) transfer reactions on  $^{130}\text{Sn}$  and  $^{56}\text{Ni}$ , respectively. This experiment campaign was led by the SAKURA collaboration using the BigRIPS-OEDO beamline housed at RIBF in RIKEN, Japan. The heavy radioactive ion beams were produced and separated by the BigRIPS accelerator. Using OEDO the  $^{130}\text{Sn}$  ( $^{56}\text{Ni}$ ) beam was decelerated to  $\sim 22$  (15) MeV/u and focused onto a CD2 solid target, thus populating excited states under inverse kinematics. Light charged particles were detected at backward lab angles using the TiNA array. Heavy reaction products were momentum-analyzed at forward angles by the SHARAQ spectrometer and identified using the Bp-dE-range technique. This approach has a distinct advantage whereby the gamma-emission probabilities of compound nuclear states may be determined with no gamma-ray detection necessary. In this talk, the experimental procedure and preliminary results are presented, with an emphasis on the capabilities of OEDO.

### Collaboration

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