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Using (d,p) Transfer Reactions at OEDO-SHARAQ to Measure Astrophysical Reactions Important in r- and νp- 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 130Sn 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 (*νp*) 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 92,94Mo and 94,96Ru. The 56Ni(n,p)56Co reaction is a crucial branching point between the *νp*- and *p*- processes and thus governs the abundances of heavier elements, however, its cross section lacks measurement.

To address these knowledge gaps of the 130Sn(n,γ) and 56Ni(n,p) reactions, the surrogate technique was employed using (d,p) transfer reactions on 130Sn and 56Ni, 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 130Sn (56Ni) beam was decelerated to ~ 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 Bρ-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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