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Neutron transfer (d,p) reactions to inform neutron capture

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Essentially all of the elements heavier than iron are synthesized via neutron capture through slow (s) and rapid (r) nucleosynthesis processes. Since both the neutron and many of the isotopes involved in these nucleosynthetic processes are unstable, direct measurements of neutron capture reactions are in most cases not feasible, especially when half-lives are much less than 100 days. Fortunately, with the advent of radioactive ion beam (RIB) accelerator facilities, neutron transfer reactions, such as (d,p), can be measured in inverse kinematics to inform both direct neutron capture and as a surrogate for (n,gamma) processes that proceed via a compound nucleus. The (d,p gamma) reaction in normal kinematics has been validated as a surrogate for (n,gamma) reactions that proceed through a compound nucleus (CN) [1].

To enable (d,p) reactions with RIBs, the Oak Ridge Rutgers University Barrel Array (ORRUBA) [2] of position-sensitive silicon strip detectors has been developed and mounted successfully in measurements with beams ranging in energy from 4 to 45 MeV/u interacting with CD2 targets. Beam-like recoils have been analyzed with ion chambers and magnetic spectrographs. The first measurements were performed near the N=50 and N=82 closed shells where direct neutron capture processes are expected to dominate. More recently, ORRUBA has been coupled to large arrays of gamma-ray detectors, Gammasphere and GRETINA, to realize GODDESS – Gamma-array ORRUBA: Dual Detectors for Experimental Structure Studies [2].

The present talk would present results from the first measurement of the (d,p) reaction with a fast (45 MeV/u) RIB of 84Se [3] that when combined with previous measurements at 4. 5 MeV/u [4] constrains the spectroscopic factors for states above the N=50 gap needed to inform direct neutron capture cross sections. In addition, we can separate the 85Se recoils from 84Se beam-like residues, data that could inform the statistical (n,gamma) rates using the surrogate reaction method. The talk would also present an overview of the capabilities to measure the (d,p gamma) reaction with GODDESS, including upcoming measurements of the (d,p gamma) reaction with 45 MeV/u 80Ge and 75Ga beams.

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2. S.D. Pain et al., Physics Procedia **90**, 455 (2017) and references therein.
3. H. Sims, Ph.D. dissertation Rutgers University (2020) and to be published.
4. J.S. Thomas et al., Phys. Rev. C **76**, 044302 (2007).

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