Neutron-transfer reactions with exotic neutron-rich beams: Surrogates for neutron-capture reactions

J.A. Cizewski, K.L. Jones, S.D. Pain, J.S. Thomas *(Rutgers University)*; D.W. Bardayan, J.C. Blackmon, M.S. Smith (*Oak Ridge National Laboratory*); R.L. Kozub (*Tennessee Technological University*); M.S. Johnson (*Oak Ridge Associated Universities*)

Neutron-capture reactions on neutron-rich nuclei are important for r-process nucleosynthesis and for stewardship science. However, because of the short half-lives of these species, it is not possible to measure these reactions directly with neutron beams on unstable targets. At the same time, it is not appropriate to extrapolate the properties of, and reactions on, stable nuclei to these exotic systems. Single-neutron properties of exotic neutron-rich nuclei are predicted (e.g., [1]) to differ from those of more stable isotopes as the nuclear surface becomes increasingly more diffuse and the last neutron becomes increasingly less bound. Also, when the neutron-separation energies are reduced, direct, rather than compound, neutron capture may become the dominant process. To inform neutron-capture cross sections and probe the single-neutron properties of neutron-rich nuclei, we have begun a program to study the (d,p) reactions with neutron-rich rare isotope beams at the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory. The first measurements[2,3] focused on the (d,p) reaction with beams of the N=50 isotones ^{82}Ge and ^{84}Se. These are the first neutron-transfer reaction measurements on nuclei along the r-process nucleosynthesis path. We are poised to measure the (d,p) reaction with ^{130,132}Sn beams, following a successful benchmark[4] of the techniques with a stable ^{124}Sn beam. We are also developing the methods to use the (d,pγ) reaction as a surrogate for neutron-capture reactions on nuclei far from stability, by measuring gamma rays in coincidence with (d,p) reaction protons measured in inverse kinematics reactions.

This talk would present an overview of the current and proposed efforts at HRIBF to study neutron-transfer reactions with neutron-rich beams and how these measurements inform neutron-capture processes on nuclei far from stability.

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