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Studies of radioactive nuclei and their role in the cosmos

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Radioactive nuclei play an important role in many astrophysical phenomena, particularly in stellar explosions where the rates of nuclear reactions can be much faster than the lifetimes of most radioactive isotopes. Accelerated beams of radioactive ions are being used to address uncertainties in some key reaction rates. We will review recent progress in the field, focusing on results from the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory.

The production of gamma-rays from electron-positron annihilation in novae is particularly sensitive to the rate of the 18F(p,alpha)15O reaction. Uncertainties have remained in the 18F(p,alpha)15O reaction rate due to the uncertain contributions of low-energy resonances and the nature of interferences between resonances. We will report on recent measurements of the 18F(p,alpha)15O cross section at the HRIBF using an experimental approach similar to previous measurements. [1] The new data provide some of the first constraints on the nature of interferences between resonances in the 18F(p,alpha)15O reaction.

We will present a novel experimental technique that we have developed to allow improved sensitivity for studies of low energy (p,alpha) resonances. In this new approach a heavy ion beam bombards a large, windowless chamber filled with hydrogen gas. Alpha particles and recoiling heavy ions are detected in coincidence in arrays of silicon strip detectors operating inside the hydrogen gas. While each element of the detector array simultaneously views reaction products over a wide range of angles, the relative kinematics of the two reaction products allows the vertex of the reaction to the accurately determined on an event-by-event basis. We will present results from a measurement applying this technique to the 183-keV resonance in the 17O(p,alpha)14N reaction that was first reported using a more conventional approach last year. [2] The strength of this resonance is also crucial for understanding the production of 18F in novae as well as the Galactic origins of the rare 17O isotope. This approach will next be applied to low energy resonances in 18F(p,alpha)15O.

Results from recent measurements using 7Be beams at the HRIBF will also be presented. Accurate measurements of the neutrino flux originating from the decay of 8B in the solar core provide a powerful probe of the properties of the solar interior and neutrinos themselves. [3] While recent measurements have substantially improved our understanding of the 7Be(p,gamma)8B reaction rate that impacts the interpretation of solar neutrino observations [4], the experimental situation is less than completely resolved. We are performing direct measurements of the 7Be(p,gamma)8B cross section in inverse kinematics, using a radioactive 7Be beam on a windowless hydrogen gas target. This alternative approach at direct measurement of the 7Be(p,gamma)8B cross section is interesting since it provides an independent check on potential systematic uncertainties. We will present results from the first measurements at the HRIBF that have demonstrated the advantages and limitations of the approach, though not yet competitive statistically with 7Be target experiments. We will also present measurements of 7Be+p elastic and inelastic scattering cross sections at center-of-mass energies ranging between 0.5 to 3.4 MeV that provide new information

on the properties of excited states in 8B and 7Be+p s-wave phase shifts, which can influence extrapolations of the 7Be(p,gamma)8B cross section to solar energies in some models. [5]

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