Recent results in nuclear astrophysics using radioactive fluorine beams at the HRIBF[1]

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In explosive stellar environments such as novae and X-ray bursts, proton-rich radioactive nuclei are produced from proton-capture reactions on stable “seed” nuclei. Owing to the high temperatures and densities present in these explosions, further processing of these radioactive nuclei can occur before they decay. Charged particle induced reactions on radioactive nuclei therefore have a profound effect on the characteristics of the explosions influencing observables such as the energy generation rate, the nucleosynthesis, and the amounts of radioisotopes synthesized. Knowledge of the reaction rates on proton-rich radioactive nuclei is vital to the understanding of these cataclysmic stellar events.

At the ORNL Holifield Radioactive Ion Beam Facility (HRIBF), we are making some of the first measurements of critical reaction cross sections and properties of astrophysically important states using radioactive beams of fluorine atoms. A ^{17}F beam has been used in a measurement of the ^{1}H(^{17}F,p)^{17}F excitation function to find and measure the properties of an important 3^{+} state in ^{18}Ne. States in ^{18}Ne in the relevant energy region had been studied for over 30 years, but this critical state was not found until the radioactive ^{17}F beam became available. We have also studied the ^{1}H(^{17}F,α)^{14}O reaction, the time-inverse of the ^{14}O(α,p)^{17}F$_{g.s.}$ reaction, over the energy range of interest for astrophysics, allowing the ^{14}O(α,p)^{17}F$_{g.s.}$ reaction rate to be determined with reasonable certainty for the first time. In addition, we have used beams of ^{18}F atoms to measure the ^{1}H(^{18}F,p)^{18}F and ^{1}H(^{18}F,α)^{15}O cross sections for a resonance near $E_{c.m.}$ = 665 keV in ^{19}Ne. Our results resolved a discrepancy in previous measurements which resulted in up to a factor of 3 uncertainty in the ^{18}F(p,α)^{15}O rate. Our experimental methods and results will be presented along with plans for future measurements at the HRIBF.

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