STUDY OF THE ^{14}O$(\alpha, p)^{17}$F REACTION USING A ^{17}F BEAM AT ARGONNE NATIONAL LABORATORY

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The hot-CNO cycle of reactions is a major source of energy generation in explosive, hydrogen-rich environments such as novae and X-ray bursts, but the energy produced is limited by the slow β-decays of ^{14}O and ^{15}O. The ^{14}O$(\alpha, p)^{17}$F reaction may allow for increased energy generation in the hot-CNO cycle and provide a path to the synthesis of heavier masses by bypassing the slow decay of ^{14}O. However, the influence of this reaction is uncertain owing to incomplete information on the resonance structure of ^{18}Ne above the ^{14}O$+\alpha$ threshold.

We have performed measurements of the time-reversed ^{1}H(^{17}F,α)^{14}O reaction using a radioactive ^{17}F beam from the ATLAS accelerator at Argonne National Laboratory. The ^{17}F beam is produced by the in-flight technique from the ^{2}H(^{16}O,^{17}F)n reaction using a beam of ^{16}O onto a liquid-nitrogen-cooled deuterium gas cell. The secondary ^{17}F beam is collected with a superconducting solenoid and focused onto a CH$_2$ polymer target. A 22°-dipole magnet is used to select the ^{17}F^{9+} charge state and eliminate the primary oxygen beam. The ^{17}F current on target ranged between 2×10^5 and 2×10^6 pps, and the beam energy spread was less than 500 keV. The alpha particles were detected in an annular, double-sided silicon-strip detector that subtended scattering angles of $\theta = 13^\circ - 24^\circ$. The recoiling ^{14}O ions were detected in coincidence by a second similar detector further downstream subtending more forward angles. About 65% of all events were detected in coincidence.

The ^{1}H(^{17}F,α)^{14}O average cross section was measured at beam energies of 54, 57, 60, 63 and 66 MeV covering the range $E_x = 6.7 - 7.7$ MeV in ^{18}Ne in $\Delta E_{cm} = 170$ keV bites using a 480 μg/cm^2 CH$_2$ target. The ^{1}H(^{17}F,α)^{14}O average cross section was also measured between $E_x = 7.29 - 7.67$ MeV in $\Delta E_{cm} = 40$ keV energy bins using a thinner (100 μg/cm^2) CH$_2$ target. Two resonances were clearly observed in both the thin and thick target measurements. A third resonance was also observed at lower energies in the thick target measurement. The resonance energies of the observed states are consistent with states previously observed in transfer reactions,[6] but the measured cross sections differ dramatically from that expected from the incomplete spectroscopy of these states that is known from measurements using stable beams. These results indicate the previous spin-parity assign-

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ments and widths for the states in this energy region are incorrect; therefore, the ^{14}O$(\alpha, p)^{17}$F reaction rate at the high temperatures relevant for X-ray bursts, $T > 10^9$ K, differs substantially from previous estimates.[7,8] Further measurements using a thin CH_2 target and improved energy resolution are currently being made at Argonne National Laboratory which will extend the measurements to lower excitation energies, resulting in a significantly improved ^{14}O$(\alpha, p)^{17}$F reaction rate over a wide range energies relevant to explosive astrophysical environments.

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[7] K. I. Hahn *et al.*, *Phys. Rev. C* 54, 1999 (1996).

[8] D. W. Bardayan and M. S. Smith, *Phys. Rev. C* 56, 1647 (1997).