STUDY OF ASTROPHYSICALLY IMPORTANT STATES IN ^{18}Ne VIA ^{17}F(p,p)^{17}F AT THE HRIBF

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The ^{17}F(p,γ)^{18}Ne reaction is important in the Hot CNO cycles which occur in stellar environments such as novae, supernovae, and X-ray bursts. Its reaction rate is uncertain, however, because of an expected 3^+ state in ^{18}Ne that has never been conclusively observed. This missing 3^+ state would provide a strong $\ell = 0$ resonance and, depending on its excitation energy, could dominate the ^{17}F(p,γ)^{18}Ne rate. Predictions of its excitation energy[8,9,10] vary by 300 keV, corresponding to a factor of 1000 variation in the resonant reaction rate.

Previous measurements of the ^{16}O(^{3}He,n)^{18}Ne and ^{20}Ne(p,t)^{18}Ne reactions did not find conclusive evidence for the existence of the 3^+ state.[9,11,12,13] These measurements were hindered by using reactions that suppress the population of states with unnatural spin and parity. We have, therefore, measured the ^{1}H(^{17}F,p)^{17}F excitation function with a radioactive ^{17}F beam at the HRIBF. This reaction is extremely sensitive to 2^+ and 3^+ states in ^{18}Ne, and our measurement provided the first unambigious evidence for the existence of the missing 3^+ state.

A ^{17}F beam was used to bombard a 48 μg/cm^2 polypropylene CH_2 target. Scattered protons were detected in the SIDAR ($25^\circ \leq \theta_{lab} \leq 51^\circ$), and recoil ^{17}F ions were detected in coincidence in an isobutane-filled ionization counter. Proton yields were measured at 12 beam energies between 10 and 12 MeV and are displayed in Fig. 1. The yield at each energy was determined by summing the coincident proton yields in all strips of the SIDAR and normalizing to the incident beam current. The coincident proton yields were used to eliminate background from betas and scattered beam ions. The resonance structure is clearly visible in Fig. 1, and a fit to the data yields resonance parameters of $E_r = 599.4 \pm 2.4$ keV and $\Gamma = 18 \pm 2$ keV. We conclude that we have observed the long sought 3^+ state in ^{18}Ne for the following two reasons. First, our measurement is only sensitive to 3^+

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and 2^+ states, and there are no 2^+ states in ^{18}O whose analogs have not been identified in ^{18}Ne. Second, the observed width is consistent with the expected width of the 3^+ state but is four times larger than that expected for a 2^+ state.

Using these new resonance parameters, the $^{17}F(p,\gamma)^{18}Ne$ rate is plotted in Fig. 2 and compared to the rates using previous estimates of the resonance properties. While discovery of the 3^+ state resolves the greatest uncertainty in the $^{17}F(p,\gamma)^{18}Ne$ rate, the total rate is still somewhat uncertain because the direct capture cross section and partial gamma width of the 3^+ state have not been measured. These problems could be solved with a direct measurement of the $^{17}F(p,\gamma)^{18}Ne$ resonance strength.

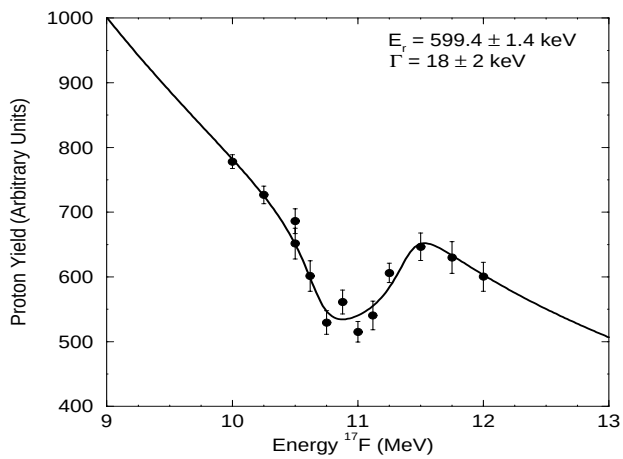

Figure 1: Normalized proton yields and a Breit-Wigner fit.

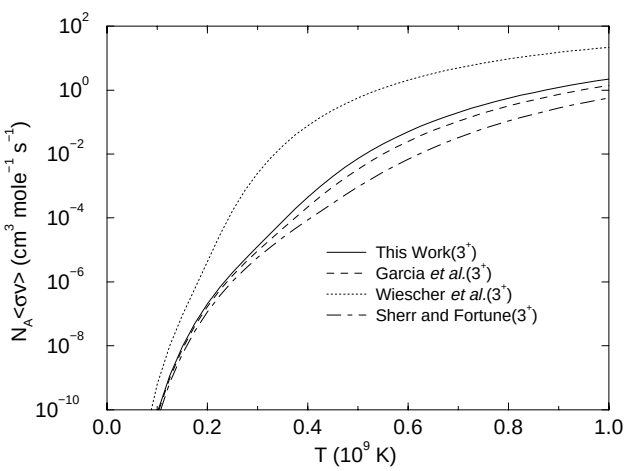

Figure 2: The $^{17}F(p,\gamma)^{18}Ne$ reaction rate contribution from the 3^+ state is compared to estimates of the rate from previously published predictions of the resonance parameters.