A New ^{17}F(p,γ)^{18}Ne Reaction Rate and Its Astrophysical Implications *

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The ^{17}F(p,γ)^{18}Ne reaction is important in stellar explosions such as novae, X-ray bursts, and X-ray pulsars. This reaction influences the amount of ^{17}O and ^{18}O synthesized in novae, and is part of a crucial reaction sequence in X-ray bursts which leads to the synthesis of isotopes with mass greater than 20 and to a peak in the X-ray luminosity. It was thought that an unnatural parity, $J^{\pi} = 3^{+}$ state in ^{18}Ne provides an $\ell = 0$ resonance in ^{17}F + p capture which, depending on its excitation energy and resonance strength, could dominate the ^{17}F(p,γ)^{18}Ne stellar reaction rate at stellar explosion temperatures. This level was expected from the structure of the ^{18}O isobaric analog nucleus, but never conclusively observed despite nine previous experimental studies of the relevant ^{18}Ne excitation energy region. Calculations of the properties of this level resulted in an uncertainty of more than a factor of 100 in the ^{17}F(p,γ)^{18}Ne reaction rate.

We have observed [1,2] this missing 3^{+} state by measuring the ^{1}H(^{17}F,p)^{17}F excitation function with a radioactive ^{17}F beam produced with the isotope separator on-line (ISOL) technique at ORNL's Holifield Radioactive Ion Beam Facility. We find that the state lies at a center-of-mass energy of $E_r = 599.8 \pm 2.5$ keV ($E_x = 4523.7 \pm 2.9$ keV) and has a width of $\Gamma = 18 \pm 2$ keV. Our measurement resolves the greatest uncertainty in the reaction rate, and indicates that the 3^{+} resonance dominates the capture rate at temperatures above 0.5 GK while the non-resonant direct capture dominates at lower temperatures. Details of the measurement will be presented. Further measurements to determine the direct capture rate and the gamma-width of the 3^{+} level will also be discussed.

We have used this new rate in calculations of the nucleosynthesis occurring in nova explosions on CO and ONeMg white dwarf stars. We find that the new rate changes the abundances of some isotopes (e.g., ^{17}O) synthesized in the hottest zones of the explosion by over a factor of 1000 compared to some previous estimates, and up to a factor of 5 when averaged over zones of all temperatures [3]. Details of these nucleosynthesis calculations will also be presented.

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