Determination of the Proton Radiative Capture Rate for $^{17}\text{F}(p,\gamma)^{18}\text{Ne}$ Using the Neutron Transfer Reaction ($^{17}\text{O},^{18}\text{O}$)

T. Al-Abdullah, F. Carstoiu, X. Chen, C.A. Gagliardi, Y.-W. Lui, G. Tabacaru, Y. Tokimoto, L. Trache, R.E. Tribble, and Y. Zhai

The electron-positron annihilation during the expansion of nova envelope leads to the emission of a $\gamma$-ray line at 511 keV and a continuum below it [1]. To observe these $\gamma$-rays, it is proposed [2] to study the nuclear reactions that create and destroy the long-lived isotope $^{18}\text{F}$ ($\tau=158$ min). It is synthesized in the HCNO cycle and its abundance may be influenced by the reaction rate for $^{17}\text{F}(p,\gamma)^{18}\text{Ne}$. Since direct measurements have not been performed, the ANC method is applied to determine this rate at astrophysical energies. The ANCs for the $2^+$ excited states at 1.98 MeV and 3.92 MeV in the nucleus $^{18}\text{O}$ will be sought through measuring the peripheral reaction $^{13}\text{C} (^{17}\text{O}, ^{18}\text{O}) ^{12}\text{C}$, and then transposed to the mirror states in $^{18}\text{Ne}$ with the same spectroscopic factors.

The experiment was performed using the MDM spectrometer and the Oxford detector to analyze the reaction products. The experiment was divided into three parts: measurement of the cross section values for the neutron transfer reaction $^{13}\text{C} (^{17}\text{O}, ^{18}\text{O}) ^{12}\text{C}$, and of the elastic scatterings for the entrance ($^{17}\text{O}+^{13}\text{C}$) and exit channels ($^{18}\text{O}+^{12}\text{C}$). To do these, $^{17}\text{O}$ and $^{18}\text{O}$ beams at 12 MeV/A were impinged on thin $^{13}\text{C}$ and $^{12}\text{C}$ targets, respectively. The cross section values were measured in the ranges $\theta_{c.m} = 6^\circ$-$58^\circ$ and $\theta_{c.m} = 5^\circ$-$32^\circ$ for elastic and transfer, respectively. The angular distributions for both the elastic scattering data sets were fit separately with volume Wood-Saxon forms to obtain the OMP, which are used as input files for the incoming and outgoing reaction channels in

**Figure 1.** Fit of the elastic scattering cross section of 204 MeV $^{17}\text{O}$ on $^{13}\text{C}$.

**Figure 2.** The angular distribution of the elastic scattering of 218 MeV $^{18}\text{O}$ on $^{12}\text{C}$.
the DWBA calculations. The elastic scattering fits are shown in Figures 1 and 2.

The first excited states in $^{18}$O, $J^\pi = 2^+$ at 1.98 MeV and $J^\pi = 4^+$ at 3.55 MeV, have been successfully populated and separated in the transfer measurements. Two components, $p_{1/2} \rightarrow d_{5/2}$ and $p_{1/2} \rightarrow d_{3/2}$, contribute to the $^{13}$C($^{17}$O, $^{18}$O$(2^+))^{12}$C reaction. Results of the DWBA calculations using the code Ptolemy are shown in figures 3 and 4 for the $2^+$ and $4^+$ states, respectively. The ANC in $^{13}$C, which represents the other vertex in the reaction, was previously determined from the reaction $^{12}$C($^{13}$C, $^{12}$C)$^{13}$C [3]. Data analysis to extract the ANCs in $^{18}$O is in progress. This is a particularly unique and interesting case because we were able to determine the optical potentials in both entrance and exit channels.