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

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The electron-positron annihilation during the expansion of nova envelope leads to the emission of a γ-ray line at 511 keV and a continuum below it [1]. To observe these γ-rays, it is proposed [2] to study the nuclear reactions that create and destroy the long-lived isotope ^{18}F (τ=158 min). It is synthesized in the HCNO cycle and its abundance may be influenced by the reaction rate for $^{17}F(p,\gamma)^{18}Ne$. 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}O will be sought through measuring the peripheral reaction $^{13}C(^{17}O,^{18}O)^{12}C$, and then transposed to the mirror states in ^{18}Ne with the same spectroscopic factors.

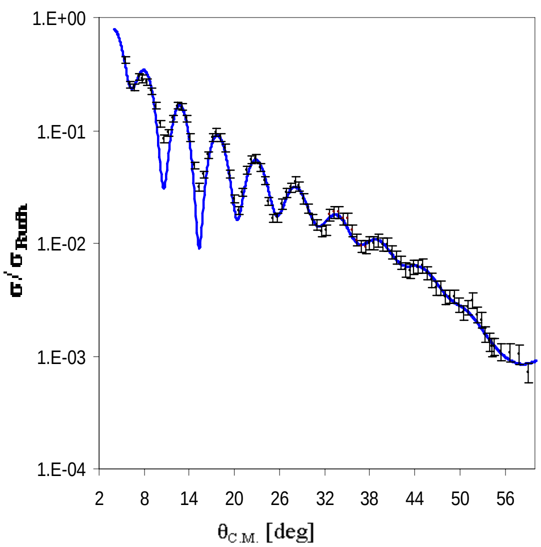

Figure 1. Fit of the elastic scattering cross section of 204 MeV ^{17}O on ^{13}C.

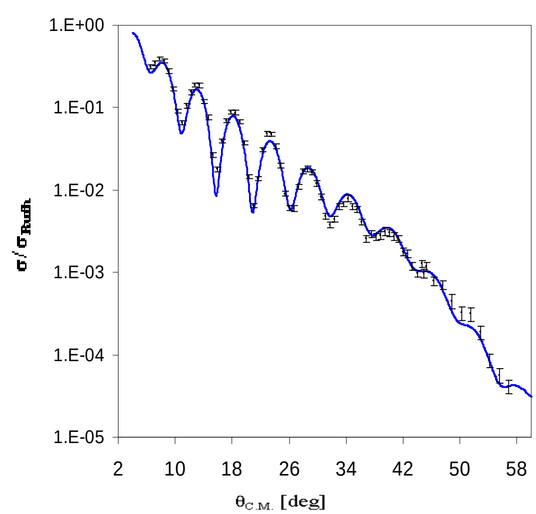

Figure 2. The angular distribution of the elastic scattering of 218 MeV ^{18}O on ^{12}C.

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 $^{13}C(^{17}O,^{18}O)^{12}C$, and of the elastic scatterings for the entrance ($^{17}O+^{13}C$) and exit channels ($^{18}O+^{12}C$). To do these, ^{17}O and ^{18}O beams at 12 MeV/A were impinged on thin ^{13}C and ^{12}C targets, respectively. The cross section values were measured in the ranges $\theta_{C.M} = 6^o$-58^o and $\theta_{C.M} = 5^o$-32^o 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 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.

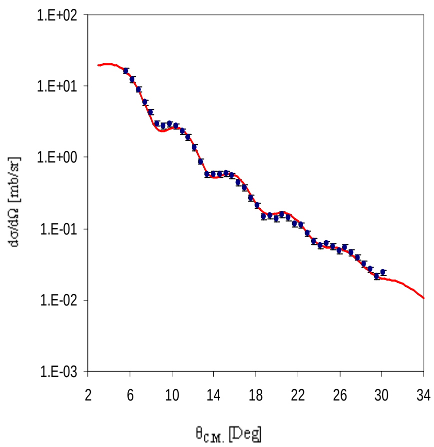

Figure 3. The angular distribution for ^{13}C(^{17}O,^{18}O*(2^{+}))^{12}C reaction. The curve shows the DWBA fit for $d_{5/2} \rightarrow 2^{+}$ and $d_{3/2} \rightarrow 2^{+}$ components.

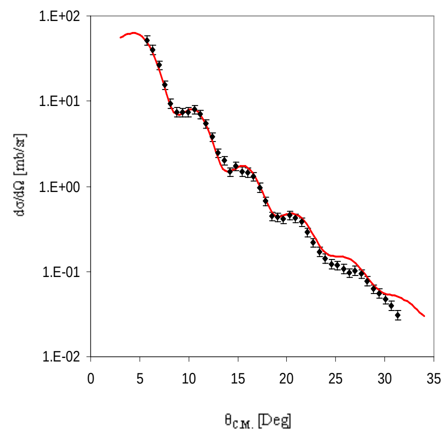

Figure 4. The angular distribution compared with DWBA calculations for the 4^{+} state.

[1] J. C. Blackmon, *et al*, Nuc. Phys. **A746**, 365 (2004).

[2] M. Hernanz, *et al*, Astrophys. J. Lett. **526**, 79 (1999).

[3] T. Al-Abdullah *et al*,(to be published).