Study of ^{8}Li and the Astrophysical $S_{17}(0)$ Factor

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In the framework of our nuclear astrophysics program we evaluated the astrophysical S-factor for the reaction ^{7}Be(p,γ)^{8}B – the main source of solar neutrinos - using an indirect method (ANC method). We studied proton transfer reactions involving the radioactive beam ^{7}Be to obtain information about the asymptotic behavior of the wave function of the ground state of ^{8}B. The method, the experiments and the results are presented in several publications of last year's [1,2] and in the present Progress Report [3]. The ANC for the $p_{3/2}$ component of the ^{8}B g.s. was extracted, but due to the limited quality of the data allowed by the use of radioactive beams, we could not extract the ANC for the $p_{1/2}$ component. We had to infer the ratio from untested microscopic calculations. It is likely that information about he structure of ^{8}B could also be obtained from the study of its mirror nucleus ^{8}Li. Therefore, in addition to our previously reported proton transfer reactions (^{7}Be,^{8}B) we investigated the mirror neutron transfer reaction (^{7}Li,^{8}Li) for the study of ^{8}Li. To assure a peripheral transfer, a target nucleus with low neutron binding energy must be chosen.

We studied the neutron transfer reaction ^{13}C(^{7}Li,^{8}Li)^{12}C using a ^{7}Li beam from the K500 superconducting cyclotron and the MDM spectrometer. The experimental setup and the data analysis were similar to those used in other experiments and were described earlier [4]. The experiment was carried out using a 63 MeV $^{7}Li^{+1}$ beam (prepared with the beam analysis system) incident on a 300 μg/cm^{2} ^{13}C self-supported carbon target sitting in the target chamber of the MDM spectrometer. Using the Oxford detector in the focal plane of the spectrometer we measured the reaction products allowed in by a 4° (horizontal) x 1° (vertical) acceptance window of the spectrometer. In the same run we measured the elastic scattering of ^{7}Li at a few large angles (θ_{lab}=30° to 54°), to complete earlier measurements and we measured the neutron transfer reaction ^{13}C(^{7}Li,^{8}Li)^{12}C. The energy resolution obtained was ΔE_{exc}=120 keV and the angular resolution was $\delta\theta$=0.18°. Moving the spectrometer from 0° to 32° we have measured the angular distributions for the neutron transfer to the ground state ($J^{\pi}=2^{+}$) and first excited state of ^{8}Li (0.981 MeV, 1^{+}) (Figure 1) in the range θ_{cm}=0°-54°. The angular distribution obtained for the ground state is shown in Figure 2. The data allowed us to disentangle the relative contributions of the $p_{3/2}$ and $p_{1/2}$ orbitals to the ground state of ^{8}Li. This is

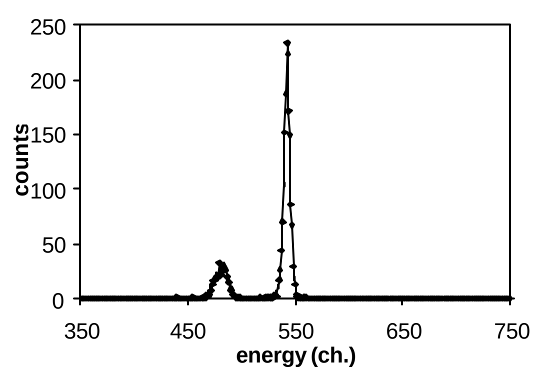

Figure 1 Spectrum from the reaction ^{13}C(^{7}Li,^{8}Li)^{12}C taken at 6°. The ground state and the first excited state in ^{8}Li are populated.

done comparing the measured angular distribution with DWBA calculations. For the DWBA calculations we used several optical model potentials. In the entrance channel we generally used the empirical Woods-Saxon potentials extracted from elastic scattering of $^{7}Li+^{13}C$ measured earlier [4]. For the outgoing channel $^{8}Li+^{12}C$ we used either the same potential as for the ingoing channel, or we used the double folding potential calculated with the method described in Ref. [4] and using the JLM1 effective nucleon-nucleon interaction. We find the ratio of the squares of the asymptotic normalization coefficients for the two orbitals to be:

$$C^2_{p1/2}/C^2_{p3/2}=0.13(2).$$

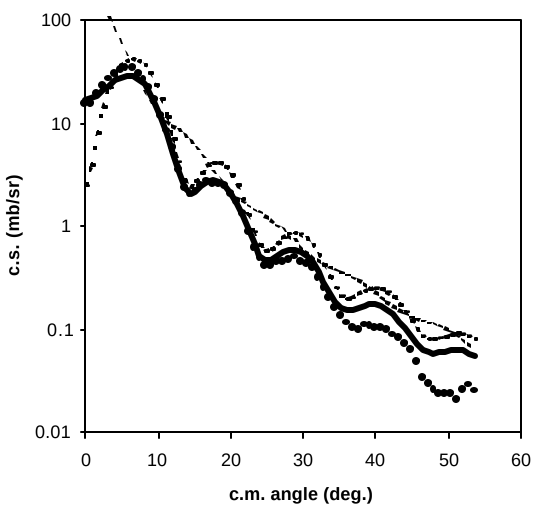

Figure 2. The angular distribution measured for $^{13}C(^{7}Li,^{8}Li)^{12}C$ (g.s.). The points represent data and the line represents the DWBA best fit. The components $p_{1/2} \rightarrow p_{3/2}$ (dashed) and $p_{1/2} \rightarrow$ à$p_{1/2}$ (dotted) are also shown.

The uncertainty of the ratio is estimated based upon the variation of the results with the optical potentials employed and the angular range used in the fit. The ratio should be the same in the mirror nucleus ^{8}B and is indeed in good agreement with the calculated value of Ref. [5]. Therefore, the present determination represents a very good experimental support for the value 0.157 used in Refs. [1,2] for the determination of $S_{17}(0)$. Unfortunately, so far, uncertainties in the determination of the absolute cross section do not allow us to unambiguously extract the individual values of these ANCs.

References

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