Elastic scattering of ^{8}B on ^{12}C and ^{14}N targets

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During the past year we have developed a ^{8}B beam that we will use to study both ^{8}B elastic scattering and the ^{14}N(^{8}B,^{9}C)^{13}C transfer reaction. A measurement of the transfer reaction will allow us to extract the ANC for $^8\text{B} + \text{p} \rightarrow {}^9\text{C}$. This, in turn, will fix the direct capture rate for the ^{8}B(p,γ)^{9}C reaction at astrophysical energies. This reaction plays a role in understanding the evolution of supermassive, low metallicity stars in the early universe. In order to extract ANC's using transfer reactions with radioactive beams, we must be able to calculate cross sections reliably. For this we need, among other ingredients, good optical model potentials. We have developed a technique to determine these optical potentials based on double-folding model calculations. Over the past few years, we have measured elastic scattering angular distributions involving loosely bound, but stable, p-shell nuclei, and then renormalized the real and imaginary optical potentials obtained from a double-folding procedure to fit the angular distributions [1]. We used the results for the renormalization coefficients to predict optical model parameters that were used to calculate both elastic scattering and proton transfer reactions involving the radioactive beams ^{7}Be [2] and ^{11}C [3]. A major uncertainty in the extraction of the ANC for $^7\text{Be} + \text{p} \rightarrow {}^8\text{B}$ [2] was our knowledge of the optical model parameters for ^{8}B on ^{9}Be and ^{13}C. To date, no data have been available that would allow us to check the parameters that were used in reference [2].

Early in 2001 we carried out our first measurements with the ^{8}B beam. We obtained elastic scattering data for ^{8}B on carbon and melamine targets and our first check on the cross section for the ^{14}N(^{8}B,^{9}C)^{13}C reaction. With the new data set, we will be able to extract the elastic scattering cross section on ^{12}C and ^{14}N nuclei. We can then check the optical model parameters that we have used in the past for ^{8}B. The measurements were done starting with stable beams from the K500 cyclotron and using MARS to obtain the radioactive ^{8}B beam. Several primary beam-target combinations were tried before we adopted a ^{10}B primary beam at 27 MeV/nucleon incident on our standard H_2 gas target, cooled to LN_2 temperature. The gas target pressure was 3 atmospheres, which required 2 mil Havar windows on the entrance and exit of the gas cell. An aluminum degrader foil was used at the exit of the gas cell to decrease the energy of the ^{8}B nuclei, produced via the p(^{10}B,^{8}B)t reaction, to 11.6 MeV/u. The ^{8}B reaction products were then separated from the beam and other reaction products, and focused on a secondary target using MARS. The energy defining slits in MARS were set to provide an energy resolution of 1.5%. Elastically scattered ^{8}B's and other reaction products were detected using a pair of detector telescopes that consisted of a front position sensitive 100 μm Si strip detector and a back 500 μm Si planar detector. The telescopes were situated symmetrically 20 cm behind the secondary target, as in references [2,3]. The secondary beam intensity was limited to between 4000-7000 ^{8}B/sec due to gas cell heating and the primary beam intensity available from the cyclotron. This rate allowed us to obtain a good measurement for the elastic scattering on both targets in a two week run. It was only adequate to allow us to get an estimate of the cross section of the proton transfer reaction ^{14}N(^{8}B,^{9}C), which is our primary goal for the ^{8}B beam. The analysis of the data obtained during the February run is in progress.

A number of improvements in the ^{8}B beam are being pursued. We expect to obtain a factor of two increase in intensity by providing turbulent flow in the gas cell that will reduce the effect of the beam "burning a hole" through the gas. We can also gain at least a factor of two in yield by tagging the energy of the secondary beam and then increasing the energy acceptance. A system is now being investigated that would measure the position of the secondary beam just after the energy defining slit in MARS. Since energy is correlated to position at this point, a measure of particle position to < 1 cm will provide sufficient energy resolution for us to run with larger energy acceptance.

References

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