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Elastic Scattering of ^{8}B on Pb, Liquid Hydrogen and Liquid Helium Targets and the ^{7}Be(p,γ)^{8}B S-Factor

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The solar $^{7}\mathrm{Be}(p,\gamma)^{8}\mathrm{B}$ reaction, occurring in the solar PPIII chain, is responsible for the high energy neutrino flux observed in such facilities as SNO and Super Kamiokande. This neutrino flux is sensitive to the astrophysical S-factor of this reaction, S_{17}. We have performed a ^{8}B Coulomb Dissociation (CD) experiment using Pb, liquid He, and liquid H_2 targets in an effort to extract S_{17}. Elastic scattering data of ^{8}B on these 3 targets will be presented along a discussion of their use in analyzing CD data.

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1. Introduction

The solar $^{7}\mathrm{Be}(p,\gamma)^{8}\mathrm{B}$ reaction has been the object of intense experimental and theoretical studies for more than 30 years. This reaction is responsible for producing the detectable high energy solar neutrino flux [1]; and is the source of the well-known solar neutrino problem. An outstanding problem in nuclear astrophysics is the determination of the zero-energy astrophysical S-factor for the $^{7}\mathrm{Be}(p,\gamma)^{8}\mathrm{B}$ reaction and, hence, precisely predict the solar neutrino flux to be observed on Earth. Through the principle of detailed balance, the cross section of the proton capture on ^{7}Be can be determined by measuring the Coulomb dissociation (CD) cross section of ^{8}B in the presence of a known photon flux provided by the Coulomb field of a high-Z target nucleus [2]. Studies of this sort have been previously performed employing Pb targets; however, as a result of such studies it has now become evident that the break-up cross section of ^{8}B on Pb, while dominated by *E1* electromagnetic interaction, also contains contributions from *E2*, *M1*, and perhaps non-negligible nuclear break-up contributions. Additionally, these previous break-up studies utilized an optical potential obtained from ^{17}O + Pb elastic scattering [4]; determining the suitability of this potential for the ^{8}B + Pb system is a necessary first step for future ^{8}B CD analyses that attempt to achieve greater sensitivity to the nuclear break-up contribution systematics.

To these ends, we have performed a Coulomb dissociation experiment of ^{8}B using Pb, liquid helium and liquid hydrogen secondary targets and have also obtained ^{8}B elastic scattering data from all 3 targets. We present here the preliminary results of the elastic data and discuss their application to our break-up data analysis.

2. Experiment

The experiment was was performed at RIKEN using the RIPS [3] fragmentation recoil separator facility. Production of ^{8}B was facilitated by bombardment of a 1.5 mm thick ^{58}Ni target with a 135 MeV/A ^{12}C beam from the RIKEN ring cyclotron. This target was positioned at the F0 focus of the RIPS facility. Positioned at the doubly achromatic focus, F2, of RIPS was a thin plastic scintillator; particle identification of the fragmentation products was achieved from the correlation of pulse height signals from this scintillator with the cyclotron rf-signal. It was found that the secondary beam was comprised of ^{8}B, ^{7}Be and ^{6}Li in the relative ratios of 73:20:7, respectively.

The ^{8}B beam was directed onto secondary targets comprised of Pb (57 mg/cm^{2}), liquid helium (116 mg/cm^{2}) and liquid hydrogen (62 mg/cm^{2}). Located $\approx$ 1.76 m upstream of the target were two PPAC detectors for determining the ^{8}B incident momentum vector along with its x-y position at the secondary target position. Approximately 4 m downstream of the secondary target position was located a 2 layer 1 m $\times$ 1 m plastic scintillator hodoscope detector array; the 1st layer segmented vertically and the 2nd layer segmented horizontally. Signals from the two layers, therefore, provided angular information, from x-y position measurements; simultaneously, the two layers provided ΔE-E particle identification of elastic and dissociation reaction products. The incident momentum measurement from the PPAC's combined with the hodoscope angular information allowed for determination of the scattering angle with an angular resolution (1σ) of 0.25°.

3. Elastic Scattering Results & Discussion

Shown, by the black datum points, in figure 1, are the laboratory-frame elastic scattering cross sections, $d\sigma/d\theta$, of the ^{8}B + H_2, ^{4}He, Pb systems. These experimental cross sections, for H_2 and ^{4}He targets, were fit using the ECIS79 code, utilizing a Woods-Saxon form for the optical potential. The initial values chosen for the optical potential parameters calculated from global optical parameter formulae [5, 6] under the assumption that the angular resolution was not too large to affect the resulting fits. Only the parameters for the real and imaginary central potentials were free for the fits. The resulting centre of mass frame angular distributions from the fits were then used as inputs for a GEANT simulation of our experiment. This simulation fully models the ^{8}B beam emittance distribution on the target, as constructed by the PPAC data, as well as the response of all scintillator segments of the hodoscope array. The red histograms in figure 1 show the GEANT simulation results. For the case of the Pb data, the ^{17}O + Pb optical potential parameters were directly used to generate an output center of mass angular distribution. The right panel of figure 1 shows the simulated result from the GEANT simulation; it is clear the ^{17}O + Pb optical potential adequately describes the ^{8}B + Pb system and is most likely not a source of error in past ^{8}B break-up analyses. These elastic data can provide invaluable information for constructing microscopic potential models for our CD analysis. Our H_2 elastic data can provide ^{8}B density distribution results, through the reaction cross section, σ_R, and it will impose tight constraints on folding model potentials utilizing either two-body folding potentials or more sophisticated 3-body models. Finally, our Pb elastic data demonstrate the ^{17}O + Pb is not a significant source of error in past CD analyses.

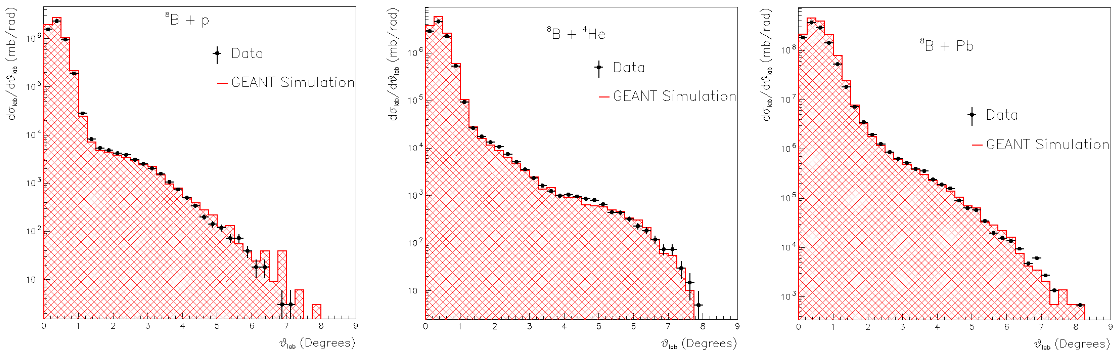

Figure 1: Laboratory frame ^{8}B elastic scattering cross sections, $d\sigma/d\theta$, of the ^{8}B + H_2 (left), ^{4}He (centre) and Pb targets (right).

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