

The low-energy cross section of the ${}^7\text{Be}(p,\gamma){}^8\text{B}$ reaction determined via Coulomb dissociation of ${}^8\text{B}$

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Coulomb dissociation (CD) is an interesting tool to derive low-energy radiative-fusion cross sections of astrophysical interest that are difficult or impossible to measure directly (e.g. when unstable nuclei are involved). The application of this method requires, however, that the multipolarity composition relevant in CD (which is in general different from the one involved in the direct-capture process) is known experimentally.

Current interest focusses strongly on the ${}^7\text{Be}(p,\gamma){}^8\text{B}$ fusion reaction due to its relevance for solar-neutrino and elementary-particle physics. It turns out that zero-energy astrophysical S factors $S_{17}(0)$ from the most recent ${}^7\text{Be}(p,\gamma)$ direct-capture experiments [1,2,3,4] do not all agree within their errors, thus it is desirable to cross check their results by indirect methods such as CD.

To solve the problem of E2-contribution in CD experimentally, we have performed an *exclusive* CD experiment that allows to analyze the distributions of the breakup particles (p and ${}^7\text{Be}$) in the moving frame of the excited ${}^8\text{B}$ nucleus prior to breakup (${}^8\text{B}^*$). We have performed first-order perturbation-theory (PT) calculations in the semi-classical approach to interpret such distributions. An example is shown in Fig. 1 where the transverse in-plane momenta of the proton are plotted for three different cuts in the classical Rutherford scattering angle (θ_8), equivalent of impact parameters of 30 fm, 18.5 fm, and 7 fm, respectively. The full (dashed) theoretical curves in Fig. 1 demonstrate what is expected for pure E1 (E1-plus-E2) multiplicities. It is obvious that pure E1 multipolarity fits our data points much better, therefore we derive the S_{17} factors for the different E_{rel} bins under this assumption.

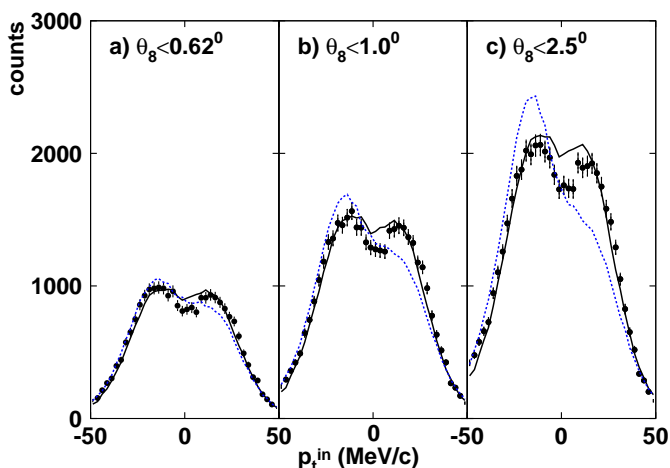


Figure 1: In-plane transverse momenta, p_t^{in} , of the protons in the frame of ${}^8\text{B}^*$ for three different cuts in θ_8 . The full lines depict our perturbation-theory calculation with only E1 multipolarity, the dashed curves the same with E1 and E2 multipolarity.

The resulting $S_{17}(E_{rel})$ are shown in Fig. 2. They are in good agreement with those from our first experiment (Ref. 5) and for the lowest E_{rel} bins also with those of Ref. 6. The data points of Davids *et al.* [7], where an E2 contribution was subtracted, are substantially lower than ours. It is interesting to note that the most recent ${}^7\text{Be}(p,\gamma)$ experiment [4] agrees very well with our data even up to 1.1 MeV. More high-precision measurements are still needed, however, to decide which theory is the best to extrapolate S_{17} to solar energies. Our data up to $E_{rel} = 1.5$ MeV fit best to our PT theory (full line), the resulting zero-energy S factor amounts to $S_{17}(0) = 18.6 \pm 0.5$ eV b. But the bulk of the data can be equally well described by the cluster-model prediction of Descouvemont [8] (dashed curve); fitted to our data, we obtain $S_{17}(0) = 20.8 \pm 0.6$ eV b.

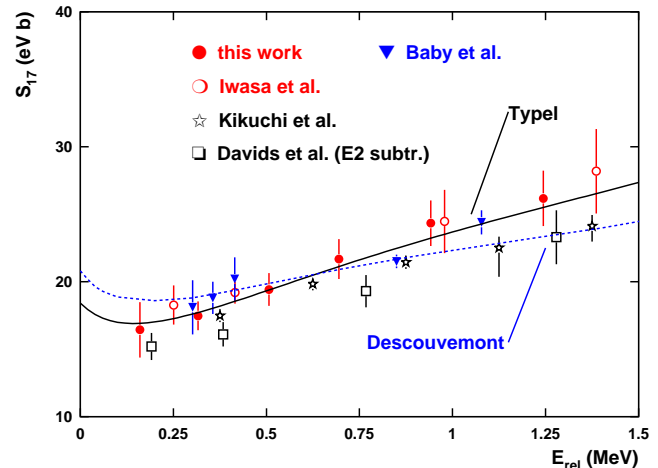


Figure 2: Comparison between S_{17} values from Coulomb dissociation experiments. The full (open) circles denote the present (previous [5]) GSI Coulomb dissociation experiment. Open stars (squares) are plotted for the results of Ref.[6] (Ref.[7]). Triangles indicate the most recent (p, γ) experiment by Baby *et al.* [4].

References

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