Breakup and finite-range effects on the $^8\mathrm{B}(d,n)^9\mathrm{C}$ reaction

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In order to determine the reaction rate of the astrophysical reaction $^8\mathrm{B}(p,\gamma)^9\mathrm{C}$, which ignites the hot pp chain [1], an indirect determination of the rate using the $^8\mathrm{B}(d,n)^9\mathrm{C}$ reaction was done [2]. However, because a reaction model in their analysis is rather primitive, in terms of neglect of excitation to the continuum states of both d and $^9\mathrm{C}$ in particular, a reanalysis with a precise model which takes into account the excitation is demanded.

We carry out the coupled-channels Born approximation (CCBA) calculation employing the continuum-discretized coupled-channels (CDCC) [3] method based on the $p + n + {}^8\mathrm{B}$ three-body model. The CDCC describes the scattering of the d-$^8\mathrm{B}$ (n-$^9\mathrm{C}$) system including the breakup of d ($^9\mathrm{C}$) into $p + n$ ($p + {}^8\mathrm{B}$) in the initial (final) channel. As explained in detail in Ref. [4] we adopt phenomenological interactions for each subsystems.

In Fig. 1 the calculated cross section with including (neglecting) the breakup of both d and $^9\mathrm{C}$ is shown by the thick solid (thin solid) line. We can see that both breakup significantly enhance the angular distributed cross section by about 58% at $\theta = 0°$, where θ is the emitting angle of n. From a detailed analysis we find that the breakup effect of d ($^9\mathrm{C}$) is about 23% (38%) on the cross section at the forward angles as shown by the dashed (dotted) line. By comparing the calculated cross section with the experimental data [2], we extract the asymptotic normalization coefficient (ANC) of $^9\mathrm{C}$ in the p-$^8\mathrm{B}$ configuration as $0.59 \pm 0.15\ \mathrm{fm}^{-1}$. It corresponds to the astrophysical factor S_{18} at zero energy of 22 ± 6 eVb. This value is almost half of the previous one [2] which is extracted from the same transfer reaction as in the present work. We have clarified that, due to the breakup effects of d and $^9\mathrm{C}$, the resulting value of S_{18} becomes small compared with the previous work. However this value is not consistent with other values evaluated from $^9\mathrm{C}$ breakup reactions [5–7]. Further investigation, for example the CCBA analysis of the mirror reaction $^8\mathrm{Li}(d,p)^9\mathrm{Li}$ [8], is necessary. In Ref. [4] a new procedure of the finite-range correction to the zero-range form factor also has been proposed.

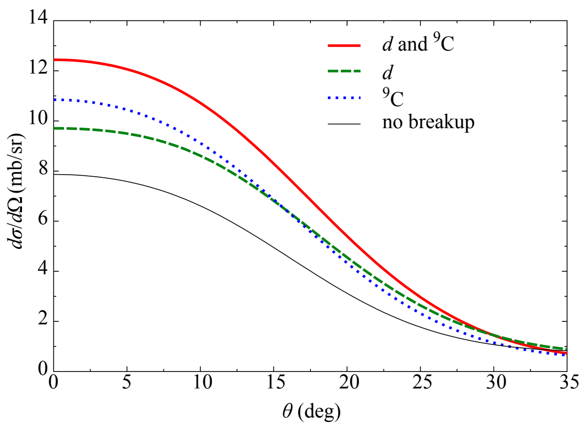

Figure 1: Breakup effects of d and $^9\mathrm{C}$ on the cross section of $^8\mathrm{B}(d,n)^9\mathrm{C}$ at 28.8 MeV. The thick solid and thin solid lines are the results with and without the continuum states of both d and $^9\mathrm{C}$, respectively. The dashed (dotted) line shows the result with the breakup states of d ($^9\mathrm{C}$) only.

References

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