Determination of ^{8}B(p,γ)^{9}C reaction rate from ^{9}C breakup

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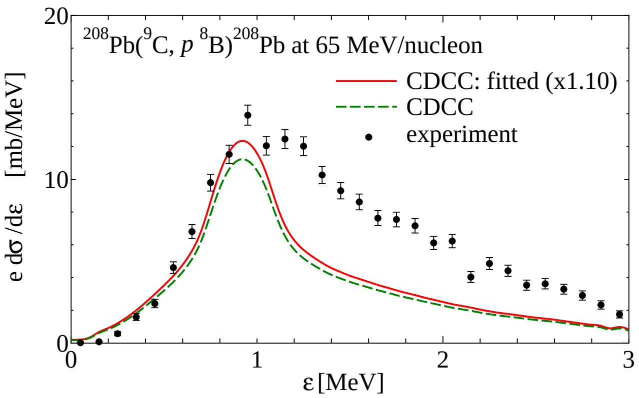
In low-metallicity supermassive stars, the proton capture reaction of ^{8}B, ^{8}B(p,γ)^{9}C is expected to be important to synthesize the CNO elements. Because of the difficulties in measuring the ^{8}B(p,γ)^{9}C cross section $\sigma_{p\gamma}$ at very low energies, several alternative reactions have been proposed [1, 2, 3] to indirectly determine the astrophysical factor $S_{18}(\varepsilon)$, which is defined by $S_{18}(\varepsilon) = \sigma_{p\gamma}\varepsilon \exp[2\pi\eta]$ (ε; the p-^{8}B relative energy in the center-of-mass frame, η; the Sommerfeld parameter). There is, however, a significant discrepancy of about 50% between the $S_{18}(0)$ obtained by the Coulomb dissociation method [3] and the ANC method [1, 2].

In this paper, we reinvestigate the Coulomb dissociation [3] (elastic breakup) and the proton removal process [2] of ^{9}C by means of coupled-channel calculation with a three-body ($p + {}^8$B + target) model. we use the ANC method [4] for both reactions. The main purpose of the present study is to show the consistency between the two values of $S_{18}(0)$ extracted from these two types of breakup, and thereby determine $S_{18}(0)$ with high reliability. The detail of our calculation is shown in the Ref. [5].



Target	^{12}C		^{27}Al	
	calc.	expt.	calc.	expt.
σ_{-p} [mb]	44.9	48(8)	53.9	55(11)
$S_{18}(0)$ [eVb]	65.2		62.2	

Figure 1: (left) Breakup spectrum of the ^{208}Pb(^{9}C,p^8B)^{208}Pb reaction at 65 MeV/nucleon. (right) Results of the one-proton removal reactions on ^{12}C and ^{27}Al targets.

First, we analyze the elastic breakup ^{208}Pb(^{9}C,p^8B)^{208}Pb at 65 MeV/nucleon. In Fig. 1, we show the breakup cross section as a function of ε.We have included the experimental efficiency $e(\varepsilon)$ [6] and resolution Γ in the calculation. In order to determine $S_{18}(0)$ we fit the theoretical result (dashed line) to the experimental data [3], and the solid line is obtained. The renormalization factor is 1.10, which results in $S_{18}(0) = 67.3$ eVb.

Second, we analyze the one-proton removal reaction of ^{9}C at 285 MeV/nucleon on ^{12}C and ^{27}Al targets. The calculated cross section σ_{-p} is renormalized to fit the experimental value taken from Ref. [7], which determines $S_{18}(0)$. These values are summarized in the right panel of Fig. 1. One sees that the two results of $S_{18}(0)$, corresponding to ^{12}C and ^{27}Al targets, agree well with each other. By taking an average of the two values, we obtain $S_{18}(0) = 63.7$ eVb.

We here remark that in our three-body coupled-channel analysis, the values of $S_{18}(0)$ extracted from two different breakup reactions, 67.3 eVb (elastic breakup) and 63.7 eVb (proton removal), show very good agreement. This indicates reliability of the present analysis and the result of $S_{18}(0)$. As a principal result of the present study, we obtain $S_{18}(0) = 66 \pm 10$ eVb. The detailed discussion concerned with the difference of the result between present and previous is given in Ref. [5].

References

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