Asymptotic Normalization Coefficient and the $S_{17}(0)$

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As part of an ongoing program to determine the astrophysical factor $S_{17}(0)$, we have extracted the asymptotic normalization coefficient (ANC) for the virtual transition $^{7}Be + p \to {}^{8}B$ using the proton transfer reactions $^{10}B(^{7}Be, {}^{8}B)^{9}Be$ and $^{14}N(^{7}Be, {}^{8}B)^{13}C$. The experiments were performed at the Cyclotron Institute using a radioactive beam of ^{7}Be. Details of the experimental procedure and results can be found in [1,2]. In this report we will focus on recent efforts to obtain a weighted average of the results reported in [1,2] folded with recent refinements in the optical model analysis and DWBA calculations.

Initially the choice of optical model potentials used to extract the value of the ANC for the $^{9}Be + p \to {}^{10}B$ was left open. This choice was recently narrowed down to only one potential [3]. Also presented in [3] is a more in depth analysis of uncertainties stemming from the DWBA calculations, reducing this uncertainty from 10% to 8%. Incorporating these new findings into our previous calculations we obtain a value of $S_{17}(0) = 18.4 \pm 2.5$ eV•b from the $^{10}B(^{7}Be, {}^{8}B)^{9}Be$ reaction. This corresponds to a 3.4% increase in the value of the S factor, while the uncertainty has been reduced from 15.7% to 13.6%.

A recent study has remeasured the ANC for the $^{13}C + p \to {}^{14}N$ system using the $^{13}C(^{3}He, d)^{14}N$ proton transfer reaction [4]. Combining their results with the previously measured values, they report adopted values of $C^2_{P_{1/2}} = 18.2 \pm 0.9\,\text{fm}^{-1}$ and $C^2_{P_{3/2}} = 0.91 \pm 0.14\,\text{fm}^{-1}$ for ^{14}N. Incorporating these new ANC's and the improved uncertainty from the DWBA calculations into the analysis of the data from the $^{14}N(^{7}Be, {}^{8}B)^{13}C$ reaction, we obtain $S_{17}(0) = 16.9 \pm 1.9$ eV•b. This is a 2% increase from the previously quoted value with no significant change in the uncertainty since the previous uncertainty already included the improved 8% DWBA uncertainty.

A detailed study of the correlation between the uncertainties of the two S factor values was performed in order to obtain a weighted average. Table I shows a breakdown of all sources of uncertainty and their percent contribution to the quoted values of $S_{17}(0)$.

Table I. Contributions to the uncertainties in $S_{17}(0)$.

Uncertainty Source	% Uncertainty	
	^{10}B	^{14}N
Statistical	3.9	2.5
Monte-Carlo	2.4	1.4
Absolute Normalization	6.4	5.0
ANC of Second Vertex	7.6	4.9
DWBA	8.1	8.1
Total	13.6	11.2

No correlation in the statistical uncertainties is expected since the two experiments were performed independently. Similarly, the Monte-Carlo simulation parameters were calibrated to the elastic scattering data individually for each experiment, hence, uncertainties due to the choice of simulation parameters were independent for each experiment and no correlations should exist. The absolute normalizations were calculated using the total number of beam particles and target density and are not correlated. ANC's of the second vertices were obtained from separate experimental results. However, the choice of optical model parameters for the elastic scattering and, in turn, for the transfer reactions was derived using the same methods [3]. Therefore, a 100% correlation for the uncertainties in the DWBA calculations was adopted.

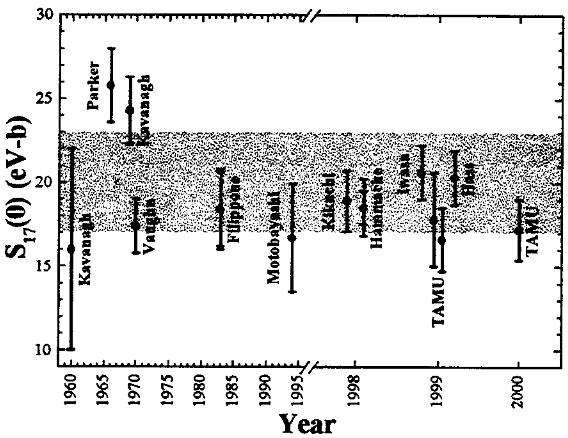

Fig. 1. World data set for $S_{17}(0)$.

Including the 100% optical model correlation into the averaging process, we obtain a weighted average value of $S_{17}(0) = 17.3 \pm 1.8$ eV•b. Figure 1 shows a comparison of this result, TAMU2000, to the available world data. Also shown are the two previously measured values in 1999. The shaded region represents the currently adopted value for the $S_{17}(0)$ [5]. Clearly this value is in agreement with all the other measurements except two. More important is the agreement with the two most recent measurements which employ both direct reaction and Coulomb excitation to measure $S_{17}(0)$ [6,7].

References

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