A new astrophysical S factor for the $^{15}N(p,\gamma)^{16}O$ reaction via the ANC method

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The $^{15}N(p,\gamma)^{16}O$ reaction provides a path from the CN cycle to the CNO bi-cycle and CNO tri-cycle. The measured astrophysical factor for this reaction is dominated by resonant capture through two strong 1^- resonances at $E_R = 312$ and 962 keV and direct capture to the ground state. Asymptotic normalization coefficients (ANCs) for the ground and 7 excited states in ^{16}O were extracted from the comparison of experimental differential cross sections for the $^{15}N(^3He,d)^{16}O$ reaction with distorted-wave Born approximation calculations. Using these ANCs and proton and resonance widths determined from an R matrix fit to the data from the $^{15}N(p,\alpha)^{12}C$ reaction, we have carried out an two-level, two channel R matrix calculation to obtain the astrophysical factor for the $^{15}N(p,\gamma)^{16}O$ reaction shown in Fig. 1. The results indicate that the direct capture contribution was previously overestimated. We find the astrophysical factor to be S(0) = 36.0 ± 6.0 keVb, which is about a factor of two lower than the presently accepted value. Our astrophysical factor in the energy interval 150 − 300 keV goes along the lower limit of data reported in [1], agreeing with the data from [2]. We conclude that for every 2200±300 cycles of the main CN cycle, one CN catalyst is lost due to this reaction.

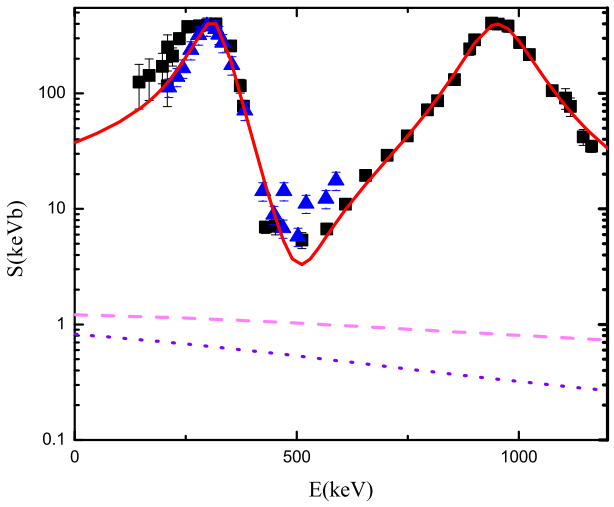

Figure 1. The astrophysical factor for the $^{15}N(p,\gamma)^{16}O$ reaction. The black squares are data from [1], the blue triangles are data from [2], solid red line is our total S factor, magenta dotted line is the nonresonant S factor for direct captures to 8 bound states and violet dotted line is the nonresonant S factor for capture to the ground state.

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[2] D. F. Hebbard, Nucl. Phys. **15**, 289 (1960).