Astrophysical *S* factor for the $^{15}N(p,\gamma)^{16}O$ reaction

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The *R*-matrix approach has proved to be very useful in extrapolating the astrophysical factor down to astrophysically relevant energies, since the majority of measurements are not available in this region. However, such an approach has to be critically considered when no complete knowledge of the reaction model is available. To get reliable results in such cases one has to use all the available information from independent sources and, accordingly, fix or constrain variations of the parameters. In this paper we present a thorough *R*-matrix analysis of the $^{15}N(p,\gamma)^{16}O$ reaction, which 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 $J^{\pi}=1^{-}$ resonances at E_R = 312 and 962 keV and direct capture to the ground state. Recently, a new measurement of the astrophysical factor for the $^{15}N(p,\gamma)^{16}O$ reaction has been published [1]. The analysis has been done using the *R*-matrix approach with unconstrained variation of all parameters including the asymptotic normalization coefficient (ANC). The best fit has been obtained for the square of the ANC C^2 = 539 fm^{-1}, which exceeds the previously measured value by a factor of ≈3. We have performed a new *R*-matrix analysis of the Notre Dame–LUNA data with the fixed within the experimental uncertainties square of the ANC C^2 = 200.34 fm^{-1}. Rather than varying the ANC we add the contribution from a background resonance that effectively takes into account contributions from higher levels. Altogether we present ten fits, seven unconstrained and three constrained. For the unconstrained fit with the boundary condition $B_c = S_c(E_2)$, where E_2 is the energy of the second level, we get $S(0) = 39.0 \pm 1.1$ keVb and normalized $\chi^2 = 1.84$, i.e., the result which is similar to LeBlanc *et al.* From all our fits we get the range $33.1 \le S(0) \le 40.1$keVb, which overlaps with the result of LeBlanc *et al.* We address also the physical interpretation of the fitting parameters. The paper has been published in Phys. Rev. C.

[1] P. J. LeBlanc *et al.*, Phys. Rev. C **82**, 055804 (2010).