On the measurement of the $^{13}C(\alpha,n)^{16}O$ *S*-factor at negative energies and its influence on the *s*-process

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The $^{13}C(\alpha,n)^{16}O$ reaction is the neutron source for the main component of the s -process, responsible for the production of most of the nuclei in the mass range $90 \leq A \leq 208$. This reaction takes place inside the helium burning shell of asymptotic giant branch stars, at temperatures $\leq 10^{8}$ K, corresponding to an energy interval where the $^{13}C(\alpha,n)^{16}O$ reaction is effective in the range of 140–230 keV. In this regime, the astrophysical S (E)-factor is dominated by the − 3 keV sub-threshold resonance due to the 6.356 MeV level in ^{17}O, giving rise to a steep increase in the S -factor. Its contribution is still controversial as extrapolations, e.g., through the R -matrix and indirect techniques such as the asymptotic normalization coefficient (ANC), yield inconsistent results. The discrepancy amounts to a factor of three or more precisely at astrophysical energies. To provide a more accurate S -factor at these energies, we have applied the Trojan horse method (THM) to the $^{13}C(^{6}Li,n^{16}O)d$ quasi-free reaction. The ANC for the 6.356 MeV level has been deduced through the THM as well as the n -partial width, allowing us to attain unprecedented accuracy for the $^{13}C(\alpha,n)^{16}O$ astrophysical factor. A larger ANC for the 6.356 MeV level is measured with respect to the ones in the literature $(\tilde{C}_{\alpha\,^{13}C}^{^{17}O(1/2^{+})})^{2} = 7.7 \pm 0.3_{stat} \pm^{1.6}_{1.5\,norm}$ fm^{-1}, yet in agreement with the preliminary result given in our preceding letter, indicating an increase of the $^{13}C(\alpha,n)^{16}O$ reaction rate below about 8×10^{7} K if compared with the recommended values. At $\sim 10^{8}$ K, our reaction rate agrees with most of the results in the literature and the accuracy is greatly enhanced thanks to this innovative approach. The work has been published in Astrophysical Journal, **777,** 143 (2013).