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Measurement of the -3 keV resonance in the $^{13}C(\alpha, n)^{16}O$ reaction and its influence on the synthesis of A > 90 nuclei

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The $^{13}C(\alpha, n)^{16}O$ reaction is the neutron source for the main component of the main component of the s-process, responsible of the production of most nuclei in the mass range 90 < A < 204. It is active inside the helium-burning shell in asymptotic giant branch stars, at temperatures ~10^8 K, corresponding to an energy interval where the $^{13}C(\alpha,n)^{16}O$ is effective of 140 − 230 keV.

In this region, 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 of the S-factor. Notwithstanding that it plays a crucial role in astrophysics, no direct measurements exist inside the 140 − 230 keV range. The contribution of the -3 keV resonance is still controversial as extrapolations, e.g., through R-matrix calculations, and indirect techniques, such as the asymptotic normalization coefficient (ANC), yield inconsistent results. The discrepancy amounts to a factor of 3 or more right at astrophysical energies.

Therefore, we have applied the Trojan Horse Method (THM) to the $^{13}C(^6Li,n\ ^{16}O)d$ quasi-free reaction to achieve an experimental estimate of such contribution. For the first time, the ANC for the 6.356 MeV level has been deduced through the THM as well as the n-partial width, allowing to attain an unprecedented accuracy in the $^{13}C(\alpha, n)^{16}O$ study. The THM cross section is shown in Fig.1. Though a larger ANC for the 6.356 MeV level is measured, our experimental S(E) factor agrees with the most recent extrapolation in the literature in the 140 − 230 keV energy interval, the accuracy being greatly enhanced thanks to this innovative approach, merging together two well establish indirect techniques, namely, the THM and the ANC.

The results have been recently published in Physical Review Letters [1].

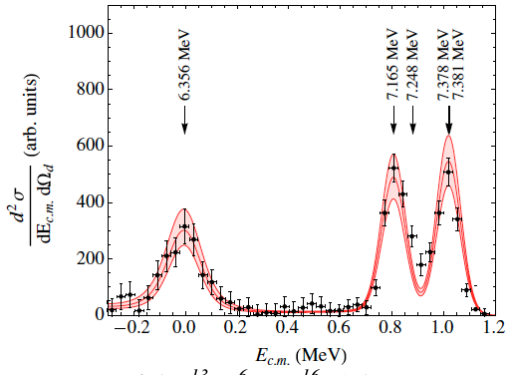

Figure 1: *Black points: cross section of the $^{13}C(^6Li,n\ ^{16}O)d$ THM reaction. The red bands show the modified R-matrix calculation used to deduce the ANC of the 6.356 resonance [1].*

[1] M. La Cognata et al., Phys. Rev. Lett. 109, 232701 (2012).