Measurement of the -3 keV resonance in the reaction $^{13}C(\alpha,n)^{16}O$ of importance in the s-process

M. La Cognata,[1] C. Spitaleri,[1,2] O. Trippella,[1,3] G. G. Kiss,[1,4] G.V. Rogachev,[5] A. M. Mukhamedzhanov, M. Avila [5] G. L. Guardo,[1,2] E. Koshchiy,[5] A. Kuchera,[5] L. Lamia,[2] S. M. R. Puglia,[1,2] S. Romano,[1,2] D. Santiago,[5] and R. Sparta[1,2]

[1]*Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud, 95123 Catania, Italy*

[2]*Dipartimento di Fisica e Astronomia, Universita` di Catania, 95123 Catania, Italy*

[3]*Istituto Nazionale di Fisica Nucleare, Sezione di Perugia, Perugia, Italy and Dipartimento di Fisica, Universita` di Perugia, 06123 Perugia, Italy*

[4]*Institute of Nuclear Research (ATOMKI), 4026 Debrecen, Hungary*

[5]*Department of Physics, Florida State University, Tallahassee, Florida 32306, USA*

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 nuclei in the mass range $90 \leq A \leq 204$. It is active inside the helium-burning shell in asymptotic giant branch stars, at temperatures $\leq$ 108 K, corresponding to an energy interval where the $^{13}C\alpha,n)^{16}O$ is effective from 140 to 230 keV. In this region, the astrophysical S(E)-factor is dominated by the -3 keV subthreshold resonance due to the 6.356 MeV level in ^{17}O, giving rise to a steep increase of the S(E)-factor. Notwithstanding that it plays a crucial role in astrophysics, no direct measurements exist inside the s-process energy window. The magnitude of 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 3 or more right at astrophysical energies. Therefore, we have applied the Trojan horse method to the $^{13}C(^{6}Li,n$ $^{16}O)d$ 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 Trojan horse method as well as the n-partial width, allowing to attain an unprecedented accuracy in the $^{13}C\alpha,n)^{16}O$ study. 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. In the analysis a new theory of the resonant Trojan Horse reactions based in the surface integral formalism was used [1]. The paper was published in Phys. Rev. Lett. **109**, 232701 (2012). A.M. acknowledged the support by NSF, DOE and DOE-NNSA grants.

[1] A.M. Mukhamedzhanov, Phys. Rev. C **84**, 044616 (2011).