TOWARD A NEW INDIRECT APPROACH FOR NUCLEAR ASTROPHYSICS. A CASE STUDY

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Fusion reactions play a key role in astrophysics, as they are responsible of energy production and nucleosynthesis. The characteristic temperatures range from 10^9 K in hot explosive scenarios to 10^6-10^7 K in quiescent burning in low-mass stars. Therefore, the relevant cross sections have to be known at energies smaller than ~ 1 MeV. However, the Coulomb barrier and the electron screening effect make it very difficult to provide accurate cross sections. The presence of sub threshold resonances might radically alter the expected trend of the extrapolated cross section, leading to systematic errors. The $^{13}C(\alpha,n)^{16}O$ reaction is an example of reactions characterized by strong sub threshold resonances [1]. The $^{13}C(\alpha,n)^{16}O$ is the neutron source of the main component of the s-process, responsible of the production of most nuclei in the mass range 90 < A < 204 [2]. It is active inside the helium-burning shell in AGB stars, at temperatures ~ 10^8 K, corresponding to an energy interval of 140 - 230 keV. Though it plays a crucial role, no direct measurements exist inside the 140 - 230 keV range [1]. Extrapolations through the R-matrix and indirect techniques such as the ANC yield inconsistent results. The discrepancy amounts to a factor of 3 or more [3, 4]. Therefore, we have applied the THM to the $^{13}C(\alpha,n)^{16}O$ reaction. For the first time, the ANC for the 6.356 MeV level has been deduced through the THM, allowing to attain an unprecedented accuracy in the $^{13}C(\alpha,n)^{16}O$ study.This innovative approach, merging together two well establish indirect techniques, can find application in the study of a number of resonance reactions at deep sub Coulomb and even negative energies, where direct measurements are impossible.

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