An imaginary-time study of carbon burning in stellar conditions

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The carbon burning reaction is a fundamental step of stellar evolution and involves the depletion and production of chemical elements important for the formation of life. In this work [1], we use the molecular dynamics Hybrid α-Cluster (HαC) [2] approach, as well as an analytical theory, to study the $^{12}C+^{12}C$ fusion towards zero energy. The calculation of the sub-barrier cross section is performed in the framework of the imaginary time method (ITM) [3], which is based on the Feynman Path Integrals.

We obtain the values of the cross sections and astrophysical S*-factors, which we correlate to collective motion of the monopole and dipole type. We additionally include a calculation for the reaction with a carbon in its 2^+ state above the threshold and discuss a possible experimental investigation. Our results confirm direct experimental and theoretical results close to the barrier and suggest possible 2^+ mixtures in the indirect experimental data [4]. Our study offers an accurate view of the burning process in the somewhat unexplored low energy region.

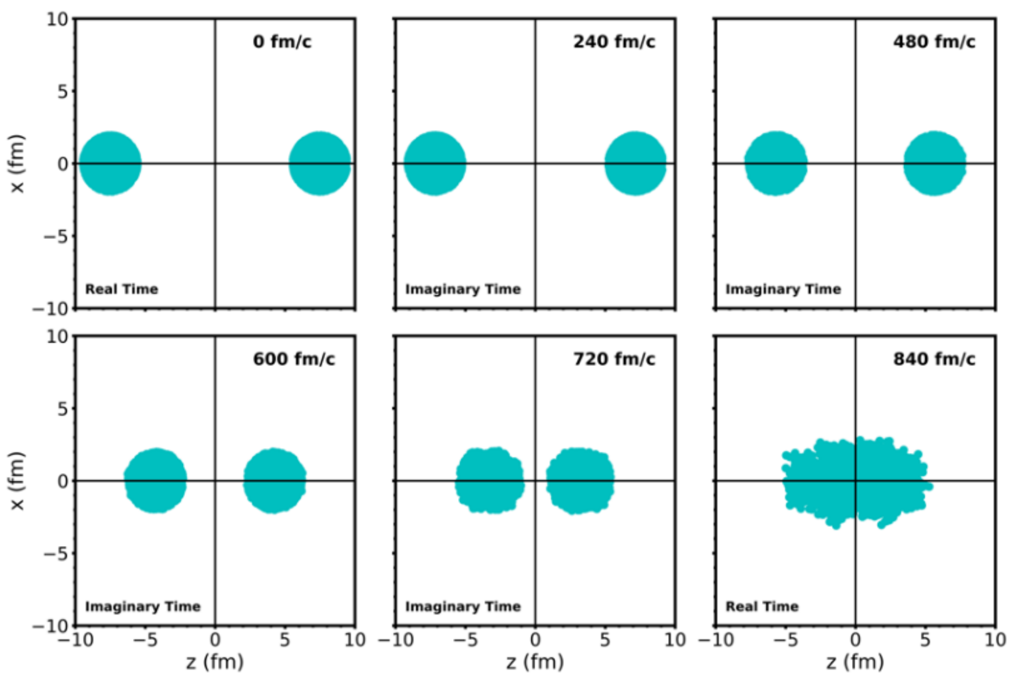

FIG. 1. (Color online) Evolution of the 12C+12C fusion in the xz plane with EC.M. = 3.5 MeV. The cyan points are the densities of the alpha particles from 300 event calculations with the HαC model, while the reaction axis is defined to be the z-axis.

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[3] A. Bonasera and V. Kondratyev, Phys. Lett. B **339**, 207 (1994).

[4] A. Tumino *et al.*, Nature (London) **557**, 687 (2018).