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Fusion dynamics of $^{12}C+^{12}C$ reaction: An astrophysical interest within the relativistic mean-field approach

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ABSTRACT

The ^{12}C + ^{12}C fusion reaction holds a great significance in the later phases of stellar evolution. To get involved in this evolution, one must understand the corresponding fusion-fission dynamics and reaction characteristics. In the present analysis, we have studied the fusion cross-section along with the S-factor for this reaction using the well-known M3Y and recently developed R3Y nucleon-nucleon (NN) potential along with the relativistic mean-field densities in double folding approach [1]. The density distributions and the microscopic R3Y NN potential are calculated using the NL3* parameter set. The ℓ-summed Wong formula is employed to investigate the fusion cross-section, with ℓ_{max}- values from the sharp cut-off model. The calculated results are also then compared with experimental data [2, 3]. It is found that the R3Y interaction gives a nice fit to the data. So it would be of interest to study the details of this fusion reaction in a microscopic approach.

Reference:

1. M. Bhuyan, Raj Kumar, Shilpa Rana, D. Jain, S. K. Patra, B. V. Carlson, Phys. Rev. C **101**, 044603 (2020); and references therein.
2. J. R. Patterson, H. Winkler, and C. S. Zaidins, Ast. Jour. **157**, 367 (1969).
3. E. F. Aguilera et al., Phys. Rev. C **73**, 064601 (2006).

MOTIVATIONS/ OBJECTIVE:

- ^{12}C and ^{16}O are the main nucleosynthesis products of stellar helium burning.

- In later phases of stellar evolution the fusion reactions $^{12}C + ^{12}C$, $^{12}C + ^{16}O$, $^{16}O + ^{16}O$ holds a paramount significance.

- The fusion dynamics and S- factor of these reactions are of great astrophysical interest.

- Recently microscopic R3Y nucleon-nucleon (NN) potential analogous to well known M3Y potential have been derived from the relativistic mean field (RMF) formalism.

- Here, the reaction $^{12}C+ ^{12}C$ is investigated using both M3Y and R3Y NN interactions and the results are then compared with the experimental data.

Fusion Cross Section and Astrophysical S-factor

$$V_{eff}^{M3Y}(r) = 7999\frac{e^{-4r}}{4r} - 2140\frac{e^{-2.5r}}{2.5r} + J_{00}(E)\delta(r)$$

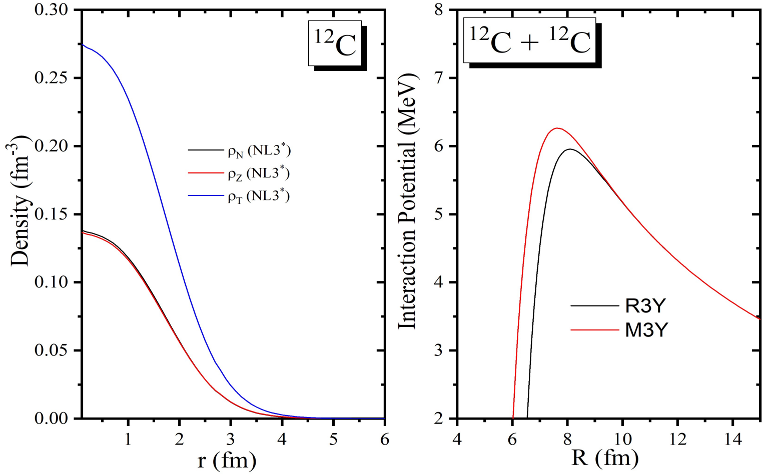
$$V_{eff}^{R3Y}(r) = \frac{g_\omega^2}{4\pi}\frac{e^{-m_\omega r}}{r} + \frac{g_\rho^2}{4\pi}\frac{e^{-m_\rho r}}{r} - \frac{g_\sigma^2}{4\pi}\frac{e^{-m_\sigma r}}{r} + \frac{g_2^2}{4\pi} r e^{-2m_\sigma r} + \frac{g_3^2}{4\pi}\frac{e^{-3m_\sigma r}}{r} + J_{00}(E)\delta(r)$$

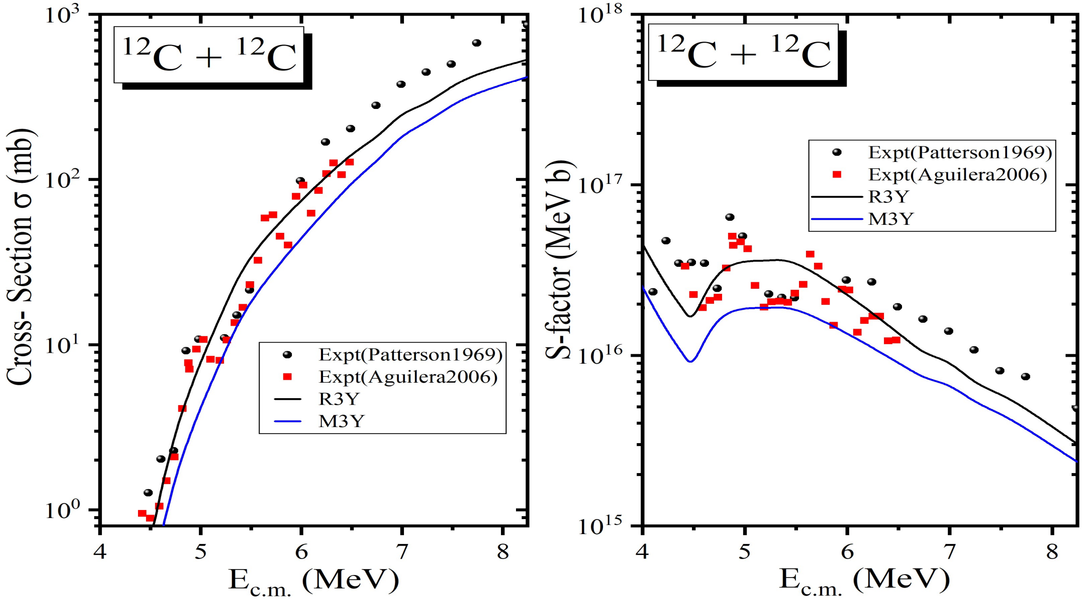
$$\sigma(E_{c.m.}) = \frac{\pi}{k^2}\sum_{\ell=o}^{\ell_{max}}(2\ell+1)P_\ell(E_{c.m})$$

$$S = \sigma \cdot E_{c.m.} exp(87.21E^{-1/2} + 0.46E)$$

Thanks for your kind attention & welcome for discussions

The RMF ($NL3^*$) Density Distributions and Interaction Potential





Fusion cross-section and S-factor as function of center of mass energy