FUSION OF ^{12}C WITH ^{144,154}Sm AT SUB-BARRIER ENERGIES

Vijay, **Dr. Rishi Pal**, Department of Physics, Chaudhary Bansi Lal university, Bhiwani and
Dr. Manjeet Singh, Government College Alewa, Jind

DAE-HEP 2022

IN PURSUIT OF KNOWLEDGE

Abstract:

- The fusion cross-sections for ^{12}C + ^{144,154}Sm systems are examined by using the symmetric-asymmetric Gaussian barrier distribution (SAGBD) model and coupled channel model at sub-barrier energies.
- The fusion dynamics of chosen reactions are strongly influenced by internal structure of participating nuclei and such results in SAGBD model are inferred in terms of channel coupling parameter and V_{CBRED}.

Research Methodology:

In order to take into account of multi-dimensional character of the realistic barrier, the total fusion cross-section is obtained by weight average of one-dimensional Wong formula.

$$\sigma_{Fus}^{SAGBD}(E_{c.m.}, V_B) = \int_0^\infty D_f\,(V_B)\sigma^{Wong}(E_{c.m.}, V_B)\,dV_B$$

Where, σ^{Wong} is the Wong formula and $D_f\,(V_B)$ represents the effective barrier distribution

$$D_f\,(V_B) = \frac{1}{N} exp\left[-\frac{(V_B - V_{B0})^2}{2\Delta^2}\right]$$

with , $N = \Delta\sqrt{2\pi}$

where, V_{B0} and Δ represents the mean barrier height and standard deviation for the chosen case.

Channel coupling parameter: $\lambda = V_{CB} - V_{eff}$ and

$$V_{CBRED} = \left[\frac{V_{CB} - V_{eff}}{V_{CB}}\right] x100\%$$

Results and discussion:

- The no coupling predictions, which treats striking couples as inert events, are much smaller than the experimental excitation functions in the ^{12}C + ^{141,154}Sm system.
- Owing to the spherical shape of the fusing partners, the influences of low-lying vibrational states seem to be dominant, and the coupling to such states result in a significantly larger fusion enhancement at sub-barrier energies than predicted by the simple BPM in the ^{12}C + ^{144}Sm reaction.

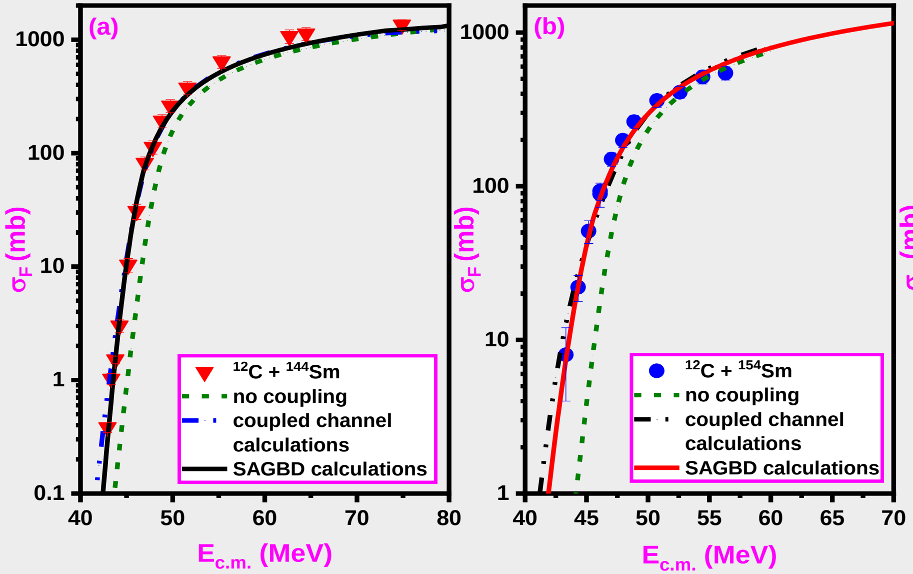

Fig. 1: The extracted fusion cross-sections for ^{12}C + ^{144,154}Sm reactions systems as a function of center of mass energy. The SAGBD and coupled channel predictions are also compared with experimental data.

- The presence of substantial anharmonicities in the energy spectrum has a big impact on the reported fusion enhancement of the ^{144}Sm-target with ^{12}C.
- The couplings to rotational degrees of freedom of ^{154}Sm-isotopes greatly improve the size of the fusion cross-sections beyond the one-dimensional BPM predictions in the ^{12}C + ^{154}Sm reaction.
- The domination of static deformation of ^{154}Sm-isotope over low-lying excitation states of the ^{144}Sm-isotope can be connected with the larger fusion enhancement of ^{12}C + ^{154}Sm compared to the ^{12}C + ^{144}Sm system at sub-barrier energies.
- The non-zero and larger values of channel coupling parameter and V_{CBRED} for ^{12}C + ^{154}Sm (2.81 and 5.88% of V_{CB}) over ^{12}C + ^{144}Sm reaction (2.68 and 5.49% of V_{CB}) suggests that former system has larger sub-barrier fusion enhancement with respect to later system.
- The SAGBD based results and the coupled channel based results properly explain the fusion dynamics of chosen reactions around the Coulomb barrier.
- This in turn reflects that SAGBD model intrinsically incorporates the influences of dominant channel couplings.

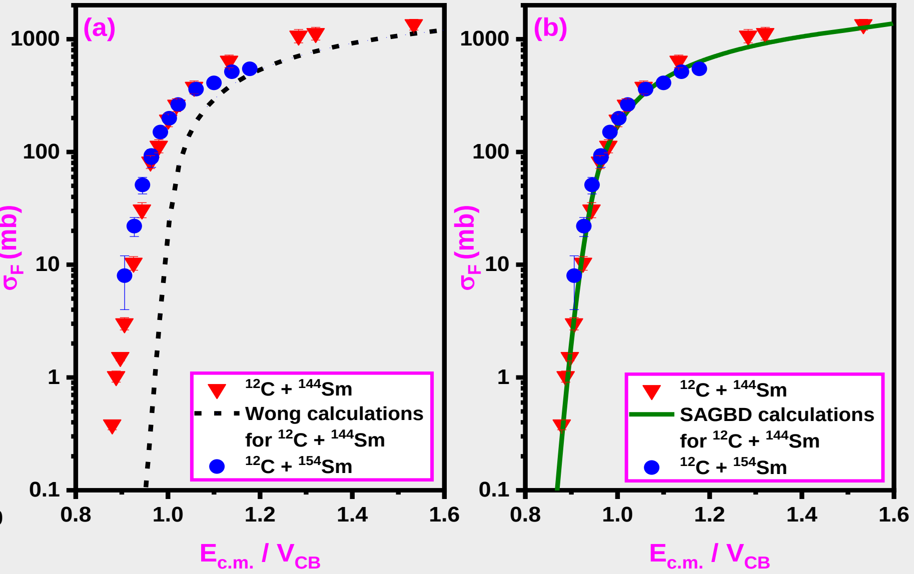

Fig. 2: The fusion cross-sections in reduced scale for ^{12}C + ^{144,154}Sm reactions. The SAGBD and simple Wong predictions are also compared with experimental data.

Summary:

In brief, the SAGBD and coupled channel calculations are done for the investigated reactions which clearly show that the couplings of intrinsic degrees of freedom of collision partners with their relative motion are necessary for the proper addressal of the sub-barrier fusion enhancement of ^{12}C + ^{154}Sm over ^{12}C + ^{144}Sm reactions. The SAGBD computations fairly addressed the fusion cross-sections of the chosen systems and hence indicates that the shortcomings of one-dimensional barrier penetration can be overcome by choosing the Gaussian type of weight function.

References.

1. Vijay et al., Phys. Rev. C **103**, 024607 (2021).
2. C. Y. Wong, Phys. Rev. Lett. **31**, 766 (1973).
3. K. Hagino, N. Rowley and A.T. Kruppa, Comput. Phys. Commun. **123**, 143 (1999).
4. S. Gil *et al.*, Phys. Rev. C **31**, 1752 (1985).
5. Vijay et al., Phys. Scr. **97**, 045305 (2022).