2018-19 3.3.3(2)

Sensitivity on potential parameters of fusion reaction cross section around Coulomb barrier

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Introduction

During last few decades, the fusion dynamics of weakly bound nuclei has been investigated comprehensively with the advancement in radioactive ion beam facilities [1]. The fusion reactions involving these nuclei dominantly affected by, the diffused density distribution and low breakup threshold. The key ingredient required in fusion reactions is the interaction potential and understanding of which remains one of the major subject in nuclear physics research. However, the phenomenological Woods-Saxon potential has been used frequently to interpret the experimental results obtained through fusion reactions induced by weakly and tightly bound projectiles. Nevertheless, it is not free from the ambiguities of magnitude of potential parameters which needs proper tuning.

Therefore it is worth to investigate the sensitivity of geometrical parameters like radii and diffuseness of considered potential form while analyzing the fusion reaction data. Here, in this conference contribution we focused on the analysis of $^{6}He+^{209}Bi$ fusion reaction in the vicinity of Coulomb barrier, through Kemble version of WKB approximation and Hill-Wheeler formula, with a particular emphasis to understand the sensitivity of fusion cross section on radius diffuseness, curvature as well as on the number of partial waves.

Theoretical formalism

The total interaction potential between the colliding pair may be written as,

$$V_l(r) = V_N + V_C + V_{Ce}$$

here V_N, V_C and V_{Ce} represent nuclear, Coulomb and centrifugal parts of potential respectively. The Woods-Saxon form is used to represent the nuclear part of total interaction potential and expressed as

$$V_N(r) = \frac{V_0^N}{1+\exp\left[\frac{(r-R)}{a}\right]}$$

V_0^N, R and a gives potential depth, range and diffuseness parameters respectively. Further the depth (V_0^N) and range (R) are parameterized as

$$V_0^N = -40 \times \frac{R_P R_T}{R_P+R_T} \quad (1)$$

with $$R_{P(T)} = r_0(A_{P(T)})^{1/3} - 0.77(A_{P(T)})^{-1/3} \quad (2)$$

and $$R = r_0(A_P^{1/3} + A_T^{1/3}) \quad (3)$$

here R_P, R_T and A_P, A_T denote the size and mass numbers of projectile and target respectively. Now the fusion reaction cross section summed over partial waves can be evaluated through following expression [2]

$$\sigma_f = \frac{\Pi}{k^2}\sum_{l=0}^{\infty}(2l+1)T_l^f \quad (4)$$

For projectiles with energy less than barrier height the transmission coefficient (T_l^f) for l-th partial wave is estimated through Kemble version of WKB approximation [3] which is written as

$$T_l^f = \frac{1}{1+\exp\left(2\,\mathrm{Im}\left(\int_{r_{in}}^{r_{out}} K_l(r)dr\right)\right)}$$

here r_{in} and r_{out} gives the inner and outer classical turning points of the potential $V_l(r)$ and are calculated with condition $V_l(r_{(in/out)}) = E$. The wave number ($K_l(r)$) is given by

$$K_l(r) = \frac{1}{\hbar}\sqrt{2\mu(E - V_l(r))}$$

While for projectile having energies above the barrier the analytical form of transmission coefficient for l-th partial wave has been expressed by Hill-Wheeler formula as [4]

$$T_l^f(E_{c.m.}) = \left(1 + \exp\left(\frac{2\Pi}{\hbar\omega}(V_{Bl} - E_{c.m.})\right)\right)^{-1}$$

here V_{Bl} represents barrier height for l-th partial wave while $\hbar\omega$ gives the corresponding curvature of the inverted parabola.

Results and Conclusions

In present contribution we have analyzed the degree of sensitivity of different geometrical components of total interaction potential on potential barrier and fusion reaction cross section for $^{6}He+^{209}Bi$ system in the