Calculation of capture cross-section using 4D Langevin equations

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Introduction

In heavy ion induced nuclear reaction the first stage is the capture of the projectile to form a dinuclear shape. Dynamics plays a major role in the process of nuclear capture. In the present work 4-Dimensional Langevin dynamical model is employed for a systematic analysis of the capture process.

Model

To calculate the probability of capture process we follow the model described in Ref. [1]. The capture cross-section is given by

$$\sigma_c = \frac{\pi}{k^2}\sum_0^\infty (2l+1)T_l = \int_0^l \frac{d\sigma}{dl}dl \qquad (1)$$

where T_l can be estimated using Langevin dynamical model as

$$T_l = (\frac{N_{cap}}{N_{tot}})_l \qquad (2)$$

where N_{cap} is the no of captured events and N_{tot} is the total no of events considered for a particular l. To obtain N_{cap} we solved the 4-Dimensional langevin equation in the deformation space of $(r, \theta, \alpha_1, \alpha_2)$. Here r defines distance between the centre of mass of the target and projectile, θ is angle made by r on the reaction plane and α_1, α_2 defines the deformation of target and projectile, respectively. The driving force for the dynamics is calculated using LDM model is described Ref.[2], Ref.[3]. We have used the surface friction model to implement the fluctuation-dissipation forces within dynamical model in Ref.[1].

Results and discussion

We consider ^{16}O + ^{208}Pb reaction for the present study. For this system capture cross-section is equivalent to fusion cross-section as quasifission is absent. We calculated the capture cross-section at different beam energies.

In Fig.1 we show the calculated $d\sigma/dl$ corresponding to different energies. In Fig.2 we compare the calculated capture cross-section with experimental value. There is a good agreement between the experimental data and our model calculated result.

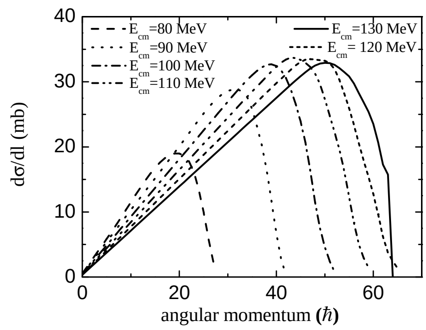

FIG. 1: Variation of calculated $d\sigma/dl$.

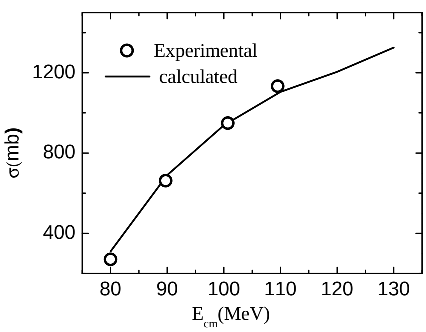

FIG. 2: Variation of capture cross-section with centre of mass energy.

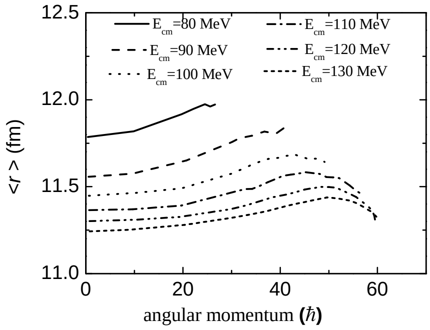

FIG. 3: Variation of $\langle\ r\rangle$ with angular momentum

In Fig.3 the variation of $\langle\ r\rangle$ is plotted with respect to angular momentum for different values of energy. The $\langle\ r\rangle$ for small angular momentum is less compared to high angular momentum for a particular energy as the kinetic energy decreases when angular momentum increases.In Fig.4 we plot the $\langle\ t\rangle$ with respect to angular momentum. Also the value $\langle\ t\rangle$ less for the small angular momentum at high energy. In Fig.5 we plot the $\langle\theta\rangle$ with respect to angular momentum. The nature of $\langle\theta\rangle$ is same as $\langle\ r\rangle$ as expected.

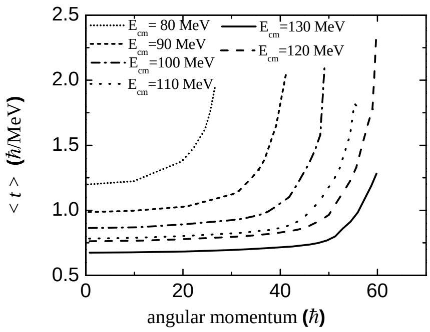

FIG. 4: Variation of $\langle\ t\rangle$ with angular momentum

In conclusion the capture cross-section of ^{16}O + ^{208}Pb is calculated. Experimental cross-section well produced. We have studied different dynamical quantity systematically.

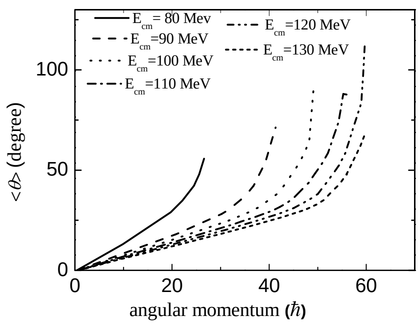

FIG. 5: Variation of $\langle\theta\rangle$ with angular momentum

References

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