Study of non-dissipative dynamical evolution of heavy ion induced reaction

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Introduction

In heavy ion induced fusion reaction the first stage is the capture of the projectile in the entrance channel. Apart from the classical Newtonian evaluation, fluctuation-dissipation plays an important role in the process of capture. Before embarking into the full stochastic dynamics here we tested the deterministic part of the dynamics using Langevin equations.

Model

To calculate the probability of capture process we follow the model described in Ref. [1]. The relative coordinate between the target and projectile is defined in terms of spherical polar coordinates (r, θ, ϕ). Presently r and θ are used as dynamical coordinates keeping ϕ fixed at zero. In addition the deformation of target (α_1)and projectile (α_2) are used as dynamical coordinates in the Langevin equations. The corresponding 4 D collective potential Ref.[3] is calculated by following prescription given in Ref.[2]. The 4 dimentional langevin equations without fluctuation-dissipation are

$$r_{n+1} = r_n + \frac{p_{r(n)} + p_{r(n+1)}}{2\mu}\tau \quad (1)$$

$$\theta_{n+1} = \theta_n + \frac{L_n + L_{n+1}}{2\mu r_n^2}\tau \quad (2)$$

$$\alpha_{i(n+1)} = \alpha_{i(n)} + \frac{\pi_{i(n+1)} + \pi_{i(n)}}{2B_i}\tau \quad (3)$$

$$p_{r(n+1)} = p_{r(n)} - \left(\frac{\partial V}{\partial r} - \frac{L^2}{\mu r^3}\right)_n \tau \quad (4)$$

$$L_{n+1} = L_n - \left(\frac{\partial V}{\partial \theta}\right)_n \tau \quad (5)$$

$$\pi_{n+1} = \pi_n - \left(\frac{\partial V}{\partial \alpha_i} + C_l \alpha_i\right)_n \tau \quad (6)$$

p_r and π_i represents momentum conjugate to r, α respectively. L is the angular momentum and V is the potential energy.

Results and discussion

We consider ^{208}Pb + ^{48}Ca as target-projectile combination. At first deformation α are fixed at zero and calculation are performed with r and θ. We study the variation of coordinates with time and simultaneously check the conservation of total energy, angular momentum. Here angular momentum is expected to be conserved as deformation zero. Subsequently, the deformation degrees of freedom are switched on and we studied the effect of deformation in all the dynamical coordinates and in energetics.

In Fig.1 we show the variation of r without and with target projectile deformation. At first, the distance between target and projectile decreases and then the trajectory deflected outward because of strong Coulomb repulsion. In Fig.2 we plot the variation of deformation of target and projectile respectively. The change in deformation of projectile ^{48}Ca is prominent in comparison to the the change in deformation of heavier target ^{208}Pb.

In Fig.3 the variation of angular momentum is plotted with respect to time. The angular momentum without considering deformation of target, projectile is constant with respect to time variation. Whereas the value of angular momentum is not conserved when we switched

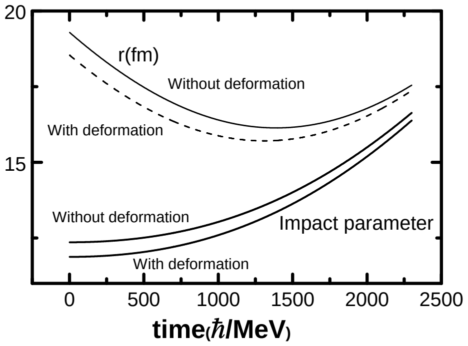

FIG. 1: Variation of r and impact parameter with time

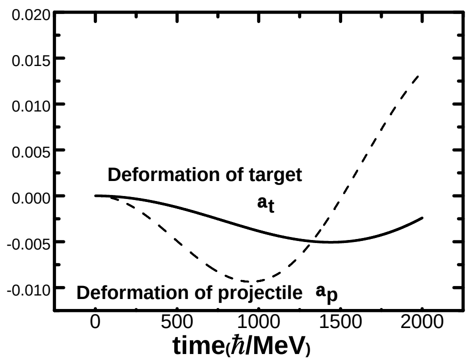

FIG. 2: Variation of deformation of target and projectile with time

on the deformation of target and projectile as the potential changes along θ direction.

In Fig.4 we plot the time evolution of total energy and potential energy. The total energy consists of kinetic energy, rotational energy, deformation energy and potential energy, is always conserved. The potential energy is first increasing as r decreases and reaches its maximum value at the closest approach. Then the projectile deviates from the trajectory to minimise the potential energy.

In conclusion the Newtonian dynamics is tested. We are working in inclusion of dissipation-fluctuation in the model. Eventually we will calculate the capture cross section.

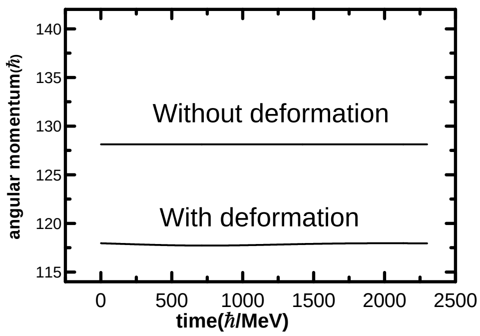

FIG. 3: Variation of angular momentum with time

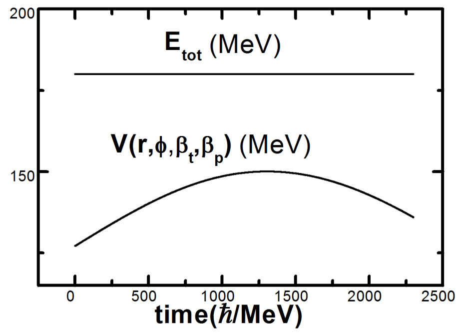

FIG. 4: Variation of total energy (MeV) and potential energy(MeV) with time

References

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[3] Int. Symp. on Nucl. Phys. 61 (2016).