Dissipation in fusion-fission dynamics

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Heavy-ion-induced fusion-fission reaction is a complex process. Significant developments have been achieved in this field in the past two decades but are not yet fully understood. A fully equilibrated compound nucleus decays following two different routes - either fully deexcites to a single nucleus (evaporation residue) or may separate into two fragments (fission), both accompanied by the emission of light particles and photons. The residue nucleus, light particles, and the photons emitted during this decay provide valuable insight into understanding the complex dynamics of nuclear fission.

Previous studies have revealed that fusion-fission is a slower process than that predicted by the statistical model of Bohr and Wheeler [1]. This suggested that the fission dynamics is dissipative in nature. Kramers first proposed the dynamical model for nuclear fission, using the analogy between the nuclear fission dynamics and the Brownian particle motion in a heat bath. The Focker-Plank or the equivalent Langevin equation has been extensively used to describe the fission dynamics. One of the important parameters for such calculations is the dissipative property of the nucleus since it accounts for both the dissipative and random forces acting on the fission degrees of freedom.

In the present work, we solve the one dimensional Langevin equation using the elongation parameter c (Funny Hill parametrization) [2] as a relevant coordinate,

$$\frac{dp}{dt} = -\frac{p^2}{2}\frac{\partial}{\partial c}\left(\frac{1}{\mathcal{M}}\right) - \frac{\partial F}{\partial c} - \frac{\eta(c)}{\mathcal{M}}p + g\Gamma(t)$$
$$\frac{dc}{dt} = \frac{p}{\mathcal{M}} \qquad (1)$$

where, η is dissipation coeffecient and product $g\Gamma(t)$ is the random force.

We attempt to study the evaporation residue (ER) cross-section and the pre-scission neutron multiplicity (ν_{Pre}) for the system ^{16}O+^{208}Pb [3–5] and ^{16}O+^{194}Pt [6, 7]. These reactions are well studied, and no contribution of non-compound events has been reported. We use one body dissipation: wall and window friction (WWF) with reduction factor $k_s = 0.25$ and chaos weighted wall friction (CWWF) [4]. Fig. 1 and 2 show that the

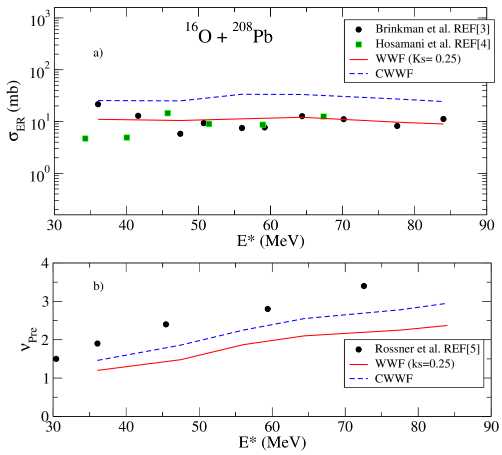

FIG. 1: a) ER cross section calculated with WWF ($k_s = 0.25$) and CWWF represented by solid line and dashed line respectively. b) Prescission neutron multiplicity calculated with WWF ($k_s = 0.25$) and CWWF represented by a solid line and dashed line, respectively.

strength of WWF with the reduction coefficient $k_s = 0.25$ is weaker than the CWWF. We observe that for the reaction ^{16}O+^{208}Pb, experimental data are well reproduced by WWF. Calculations using both friction models underestimate experimental prescission neutron multiplicity for this reaction. Furthermore CWWF overestimates for ^{16}O+^{208}Pb while it

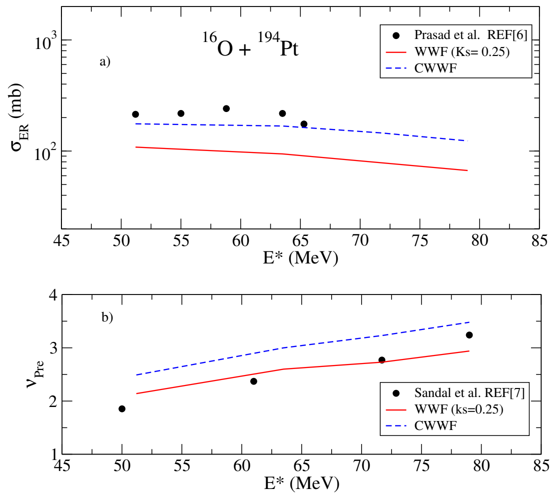

FIG. 2: a) ER cross section calculated with WWF (ks=0.25) and CWWF represented by solid line and dashed line respectively. b) Pre-scission neutron multiplicity calculated with WWF (ks=0.25) and CWWF represented by a solid line and dashed line, respectively.

provides quite a good fit for ^{16}O+^{194}Pt. Pre-scission neutron multiplicity for ^{16}O+^{194}Pt is well reproduced by the WWF.

The decay of a fully equilibrated hot compound nucleus to the evaporation residue and the fission are complementary events. It is natural to expect that the same strength of dissipation should reproduce the ER cross-section and the pre-scission neutron multiplicity simultaneously. However, our analysis shows inconsistent results. It is possible that a new form of dissipation can address this inconsistency. Further studies have been initiated to obtain a clear picture of this aspect.

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