De-excitation of ^{210}Po

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De-excitation of the compound nucleus (CN) ^{210}Po, formed in heavy ion-induced fusion reactions, has received considerable attention in the recent years [1–4]. The roles of shell effects and fission dynamics in reproducing the experimental fission cross sections ($\sigma_{\rm fiss}$) and pre-scission neutron multiplicities ($\nu_{\rm pre}$) have been examined in these works. Simultaneous reproduction of different observables though remains a challenge.

In this contribution, we present results of a statistical model (SM) calculation for decay of the CN ^{210}Po. Shell effects in both the level density (LD) and the fission barrier ($B_{\rm f}$), the orientation degree of freedom of the CN spin ($K_{\rm or}$) and the collective enhancement in level density (CELD) are considered in the model. The effect of dissipation (β) in fission dynamics is also included in the calculation.

We consider here population of ^{210}Po via four different entrance channels, *viz.*, (a) ^{1}H+^{209}Bi [5–8], (b) ^{4}He+^{206}Pb [9–11], (c) ^{12}C+^{198}Pt [1, 12, 13], and (d) ^{18}O+^{192}Os [13–15]. Measured evaporation residue (ER) cross sections ($\sigma_{\rm ER}$), $\sigma_{\rm fiss}$ and $\nu_{\rm pre}$ are compared with our SM [16] predictions.

The fission barrier is obtained by including shell correction in the liquid-drop nuclear mass [3, 17]. The effect of K-degree (component of CN spin along the nuclear symmetry axis) of freedom [19], is added to the Bohr-Wheeler fission width [18] ($\Gamma_{\rm BW}$) as:

$$\Gamma_{\rm f}(E^*, J) = \Gamma_{\rm BW}(E^*, J, K=0)\frac{(K_0\sqrt{2\pi})}{2J+1}\ \mathrm{erf}\left(\frac{J+1/2}{K_0\sqrt{2}}\right) \quad (1)$$

with $K_0^2 = \frac{\tau_{\rm eff}}{\hbar^2}T_{\rm sad}$, where $\tau_{\rm eff}$ is the effective moment of inertia. $\frac{1}{\tau_{\rm eff}}=\frac{1}{\tau_\parallel}-\frac{1}{\tau_\perp}$, $\tau_\perp$ and $\tau_\parallel$ are the moments of inertia of the nucleus perpendicular to and about the nuclear symmetry axis, at the saddle. erf(x) is the error function. The effects of CELD is included following the work of Zagrebaev *et al.* [20] where the enhancement changes from vibrational ($K_{\rm vib}$) to rotational ($K_{\rm rot}$) type with increasing quadrupole deformation of a nucleus. The level density would then be $\rho(E^*) = K_{\rm coll}(E^*)\rho_{\rm intr}(E^*)$ where $K_{\rm coll}$ is the enhancement factor and $\rho_{\rm intr}(E^*)$ is the intrinsic level density.

Results of our calculation (continuous black lines) are presented in Fig. 1. It is clear that, a suitable value of the dissipation coefficient has to be taken into consideration to reproduce $\sigma_{\rm ER}$ and $\sigma_{\rm fiss}$. Hindrance in fission is introduced using the Kramers-modified fission width [21]:

$$\Gamma_{\rm K} = \Gamma_{\rm f}\left\{\sqrt{1+\left(\frac{\beta}{2\omega_s}\right)^2} - \frac{\beta}{2\omega_s}\right\} \quad (2)$$

where, β is the reduced dissipation coefficient and $\omega_{\rm s}$ is the local frequency of a harmonic oscillator potential. $\Gamma_{\rm f}$ is the Bohr-Wheeler fission width obtained with shell corrected level densities, CELD and K-orientation. A value of $\beta = 3\times 10^{21}$ s^{-1} is required here to reproduce $\sigma_{\rm fiss}$ and $\sigma_{\rm ER}$ for all the reactions (dashed magenta lines). Measured $\nu_{\rm pre}$, though, is not reproduced except for the most symmetric reaction.

The calculated values of $\nu_{\rm pre}$ include the neutrons during saddle-to-scission evolution ($\nu_{\rm ss}$) of the CN [22]. For a reaction induced by a very light projectile (*e.g.* ^{1}H+^{209}Bi), the CN spin is small and the saddle is close to the scission. Consequently, $\nu_{\rm ss}$ is a small fraction of $\nu_{\rm pre}$ and $\nu_{\rm pre}$ is reproduced well by the SM. In case of heavier projectiles, CN spin becomes larger and hence saddle-to-scission evolution takes place over a longer duration. This makes emission of more neutrons possible causing enhancement of $\nu_{\rm ss}$ and hence $\nu_{\rm pre}$.

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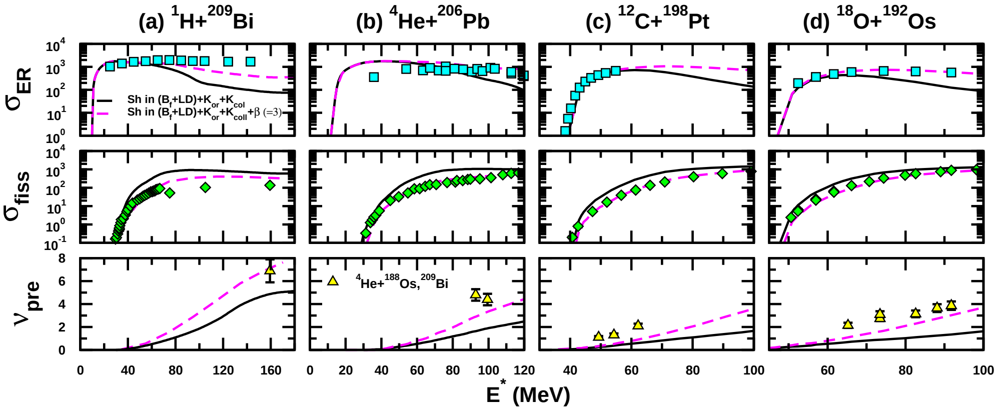

FIG. 1: Measured and calculated $\sigma_{\rm ER}$, $\sigma_{\rm fiss}$ and $\nu_{\rm pre}$ for (a) ^{1}H+^{209}Bi, (b) ^{4}He+^{206}Pb, (c) ^{12}C+^{198}Pt and (d) ^{18}O+^{192}Os. Continuous lines indicate predictions of SM without including dissipation ($\beta = 0$). Dashed lines indicate SM predictions with a suitable value of β.

The present results indicate that a stronger dissipation in the saddle-to-scission region is required in order to reproduce the experimental $\nu_{\rm pre}$. Such a shape-dependent dissipation has been reported earlier from both phenomenological studies [23] and also from theoretical considerations [24].

It has also been pointed out that neutrons can be emitted during the comparatively longer formation stage of the CN [25] for reactions induced by heavier projectiles. A suitable model for decay of the CN in which fission is treated dynamically appears to be more appropriate to describe such reactions.

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