De-excitation of the compound nucleus (CN) $^{210}$Po, formed in heavy ion-induced fission 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 ($\sigma_{\text{fiss}}$) and pre-scission neutron multiplicities ($\nu_{\text{pre}}$) 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 (Bi), the orientation degree of freedom of the CN spin ($K_{\text{or}}$) and the collective enhancement in level density (CELD) are considered in the model. The effect of dissipation ($\beta$) in fission dynamics is also included in the calculation.

We consider here population of $^{210}$Po via four different entrance channels, viz., (a) $^{2}H$+$^{209}$Bi [5–8], (b) $^{4}$He+$^{208}$Pb [9–11], (c) $^{12}$C+$^{188}$Pt [1, 12, 13], and (d) $^{18}$O+$^{192}$Os [13–15]. Measured evaporation residue (ER) cross sections ($\sigma_{\text{ER}}$), $\sigma_{\text{fiss}}$ and $\nu_{\text{pre}}$ 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] ($\Gamma_{\text{BW}}$) as:

$$\Gamma\left(E^*, J\right) = \Gamma_{\text{BW}}\left(E^*, J, K = 0\right) \frac{K_{\text{rot}}}{2\pi\gamma_{\text{eff}}} \operatorname{erf}\left(\frac{\beta\sqrt{\omega_{\text{vib}}}}{2\pi\gamma_{\text{eff}}^2}\right) \tag{1}$$

with $K_{\text{rot}}^2 = \frac{\tau_{\text{eff}}}{\beta^2} T_{\text{sad}}$, where $\gamma_{\text{eff}}$ is the effective moment of inertia, $\frac{1}{\gamma_{\text{eff}}} = \frac{1}{\gamma_\parallel} + \frac{1}{\gamma_\perp}$, $\tau_\parallel$ and $\tau_\perp$ are the moments of inertia of the nucleus perpendicular to and about the nuclear symmetry axis, at the saddle. $\operatorname{erf}(x)$ is the error function. The effects of CELD is included following the work of Zagrebaev et al. [20] where the enhancement changes from vibrational ($K_{\text{vib}}$) to rotational ($K_{\text{rot}}$) type with increasing quadrupole deformation of a nucleus. The level density would then be $\rho(E^*) = K_{\text{coll}}(E^*) \rho_{\text{intr}}(E^*)$ where $K_{\text{coll}}$ is the enhancement factor and $\rho_{\text{intr}}(E^*)$ 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 $\sigma_{\text{ER}}$ and $\sigma_{\text{fiss}}$. Hindrance in fission is introduced using the Kramers-modified fission width [21]:

$$\Gamma_{\text{K}} = \Gamma_{\text{f}} \left\{ 1 + \left(\frac{\beta}{\omega_{\text{s}}}ight)^2 - \frac{\beta}{\omega_{\text{s}}} \right\} \tag{2}$$

where, $\beta$ is the reduced dissipation coefficient and $\omega_{\text{s}}$ is the local frequency of a harmonic oscillator potential. $\Gamma_{\text{f}}$ is the Bohr-Wheeler fission width obtained with shell corrected level densities, CELD and $K$-orientation. A value of $\beta = 3 \times 10^{23}$ s$^{-1}$ is required here to reproduce $\sigma_{\text{fiss}}$ and $\sigma_{\text{ER}}$ for all the reactions (dashed magenta lines). Measured $\nu_{\text{pre}}$, though, is not reproduced except for the most symmetric reaction.

The calculated values of $\nu_{\text{pre}}$ include the neutrons during saddle-to-scission evolution ($\nu_{\text{ss}}$) 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, $\nu_{\text{ss}}$ is a small fraction of $\nu_{\text{pre}}$ and $\nu_{\text{pre}}$ 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 $\nu_{\text{ss}}$ and hence $\nu_{\text{pre}}$.  

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De-excitation of $^{210}$Po

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The present results indicate that a stronger dissipation in the saddle-to-scission region is required in order to reproduce the experimental \( \nu_{\text{pre}} \). 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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