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Influence of entrance channel shell closure on dissipative nature of nuclear fission

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Despite extensive efforts, comprehending the bulk rearrangement of nuclear matter during fission of a compound nucleus (CN) remains elusive. The main challenge is to unravel and subsequently model the role of various collective and intrinsic variables governing the process. Neutrons emitted from the CN as it goes through multiple shape deformations between the equilibrium state and the scission state prove to be an imperative observable to understand the fission dynamics. Neutron multiplicity measurements have illuminated various aspects of the phenomenon including the role of entrance channel dynamics on the fission timescale, the significance of shell-effects in fission barrier calculations and most importantly the dissipative nature of fission [1]. Dissipation transiently drives the collective fission degree of freedom and delays the journey of CN across the barrier, thus manifesting a reduced fission flux [2], an increased saddle to scission time [3] and an enhanced particle emission [4, 5]. A profound description of fission dynamics based on neutron multiplicities thus requires accurate estimation of dissipation strength within the existing macroscopic-microscopic models. Present work explores the role of entrance channel closure on fission dynamics, through pre-scission neutron multiplicity (ν_{pre}) of three different even-even isotopes of Th:
^{220,222,224}Th. The reaction channels populating Th isotopes include doubly magic projectile ^{16}O with the magic ^{204,206}Pb and doubly magic ^{208}Pb as targets. A new parameter (δ_{sh}) is defined to denote the deviation of neutron and proton numbers in the target and projectile from the respective nearest magic numbers. Further, a systematic analysis of the ^{220,222,224}Th νpre data (δ_{sh} = -4, -2, 0) along with ν_{pre} data of 28 other complete fusion reactions is performed (Details have already been given in [6]). Theoretical analysis is performed within the standard statistical model framework, where reduced dissipation strength (β) is used as a tuneable parameter. A strong correlation is observed between the extracted β values and δ_{sh}: a maximum at δ_{sh} = 0 with a symmetric decrease on either side. This implicates a more hindered fission pathway for reactions with shell closed nuclei in the entrance channel. Absolute β values are also extracted by fitting the experimental ER cross-section for 12 reactions (Details have already been given in [6]). An inverse systematic dependence of β on δ_{sh} is observed by fitting the ER cross-section data : minimum β is required for δ_{sh} = 0 and then it gradually increases as δsh deviates from zero. The persistence of the same behavior of β over a wide range of excitation energy confirms that such dependence on the entrance channel magicity is independent of the compound nuclear shell structure and other finer details of the modeling.
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