Evaporation residue excitation function measurements for reactions forming Rn compound nuclei

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Quasifission [1] is a prominent reaction channel in heavy ion reactions and is a major hurdle in the formation of evaporation residues (ER). Its dependence on the entrance channel parameters is a key question in the field of nuclear physics research. For a proper choice of target and projectile in a reaction aiming at the synthesis of a superheavy element (SHE) [2], it is important to study the heavy ion reaction mechanism for different target-projectile combinations of varying entrance channel mass asymmetry that lead to the same fused system. We have previously studied the onset of quasifission process in reactions forming the compound system ^{210}Rn using the fission fragment mass ratio distribution studies [3] and the results hints the entrance channel dependence of quasifission despite the relatively lower values of $Z_P Z_T$ in these reactions.

In the present work, we analyze the importance of the entrance channel effect on the fusion-fission reaction dynamics by comparing the excitation functions of ERs measured for different reactions populating Rn compound nuclei (CN).

The ER excitation function measurements of ^{28,30}Si+^{180}Hf were performed using the pulsed beams from the 15UD Pelletron + LINAC accelerator facility at the Inter University Accelerator Centre (IUAC), New Delhi. The recoil mass spectrometer, HYRA (HYbrid Recoil mass Analyzer) [4] was used for the identification and separation of ERs from the intense beam background. Details of the experimental arrangement and analysis can be found in the reference [5].

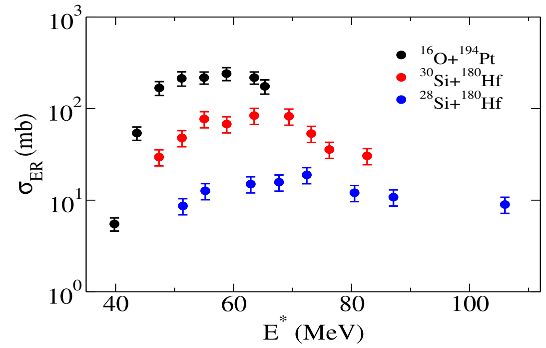

FIG. 1: The experimental ER cross section for ^{16}O+^{194}Pt and ^{28,30}Si+^{180}Hf reactions as a function excitation energy.

Fig. 1 shows ER cross section (σ_{ER}) as a function of excitation energy ($E^\star$) for the ^{28,30}Si+^{180}Hf reactions in comparison with ^{16}O+^{194}Pt [6] reaction. Reduction in ER cross section is observed for mass symmetric systems

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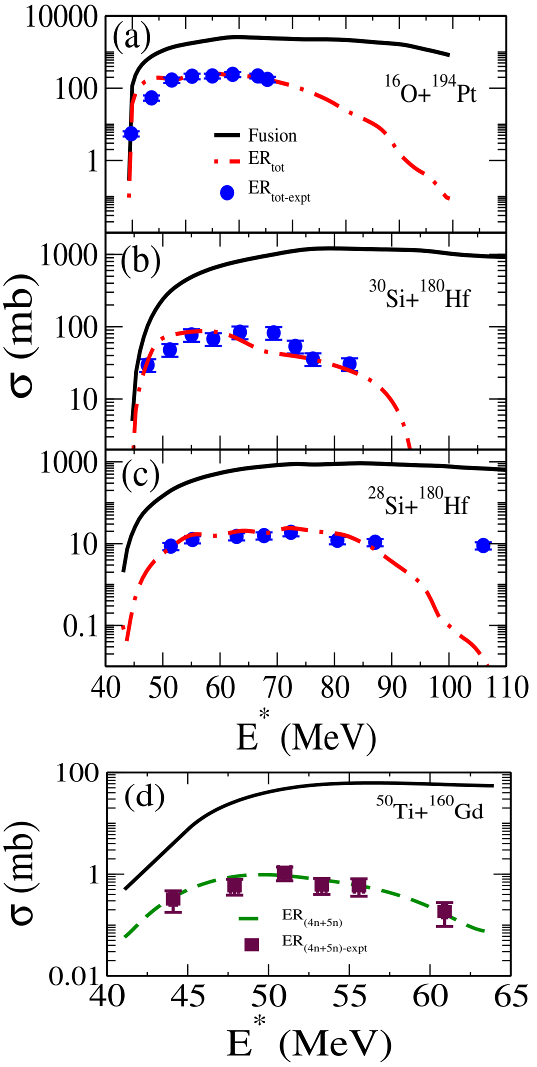

FIG. 2: The comparison of the theoretical excitation functions of fusion and ER cross sections with the experimental ER data of the reactions (a) ^{16}O+^{194}Pt, (b) ^{28}Si+^{180}Hf, (c) ^{30}Si+^{180}Hf and (d) ^{50}Ti+^{160}Gd.

^{28,30}Si+^{180}Hf compared to the mass asymmetric ^{16}O+^{194}Pt system. The hindrance to complete fusion is related to the increase in the competing quasifission events during the evolution of the di-nuclear system (DNS) formed after the capture of the projectile by the target. The entrance channel effects on the characteristics of the formed reaction products can be studied by comparing the experimental data with the theoretical DNS model [7] results obtained for the reactions.

The comparison of the theoretical excitation functions of fusion and ER cross sections with the experimental ER data for the reactions ^{16}O+^{194}Pt, ^{28}Si+^{180}Hf and ^{30}Si+^{180}Hf are presented in Fig 2 (a), (b) and (c). We also performed the model calculations for the ^{50}Ti+^{160}Gd [8] reaction for which 4n+5n channel cross section are known. This reaction also populate ^{210}Rn as the CN (Fig. 2 (d)). It is observed that quasifission is a dominant mechanism in all reactions except ^{16}O+^{194}Pt, clearly indicating the role of entrance channel in fusion. The P_{CN} values are observed to be much smaller than unity in these more symmetric reactions.

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References

[1] D. J. Hinde *et al.*, Phys. Rev. Lett. **74**, 1295 (1995).

[2] Yu. Ts. Oganessian *et al.*, Phys. Rev. Lett. **109**, 162501 (2012).

[3] A. Shamlath *et al.*, Nucl. Phys. A **945**, 67 (2016).

[4] N. Madhavan *et al.*, Pramana **75**, 317 (2010).

[5] A. Shamlath *et al.*, Proc. DAE Symp. Nucl.Phys. **60**, 384 (2015).

[6] E. Prasad *et al.*, Phys. Rev. C. **84**, 064606 (2011).

[7] A. K. Nasirov *et al.*, Eur. Phys. J. A **49**, 147 (2013).

[8] D. A. Mayorov *et al.*, Phys. Rev. C. **92**, 054601 (2015).