Analysis of Quasi fission mechanism in Heavy ion reactions around mass A~200.

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Introduction

The study of fusion-fission dynamics in heavy-ion-induced collisions is a topic of intense research today. When two heavy ions scatter off each other many new reaction channels become possible since they impart large amount of energy and angular momentum. In the fusion of two nuclei near Coulomb barrier energy, the dominant reaction channels possible are the formation of a composite di-nuclear system, which gradually evolves to form a compact mono-nuclear configuration (compound nucleus) after equilibration in all (energy, mass and shape) degrees of freedom. The excited compound nucleus (CN) may then end up as an evaporation residue (ER) after emitting neutrons, light charged particles and gamma rays. If the compound nucleus is of higher fisility and produced at higher excitation energy, it reaches the unconditional mass-symmetric saddle through shape oscillations and subsequently undergoes binary fission or fusion-fission (FF) (1-4). However, in some of the cases, it is found that the composite system breaks up in fission like events before achieving complete equilibration in shape and mass degrees of freedom. This is known as quasi-fission (QF)(5).

Quasi-fission is a serious competitor for the formation of a compound nucleus and subsequently, the formation of an ER. Since quasi-fission occurs before the target and the projectile fuse to form a compound nucleus, it hinders the formation of the ER. It is a prominent reaction channel at low excitation energies, just above the fusion threshold, where the ER formation is also dominant. Hence, for a proper choice of target-projectile combination it is important to understand the reaction dynamics of fusion-fission and quasi-fission at beam energies close to the Coulomb barrier.

It has been suggested that for the onset of quasi-fission the Z_pZ_t should be greater than 1600[1]. Recent studies predict that quasi-fission exist for the systems with Z_pZ_t is less than 1000. Mass asymmetry α should be less than α_{BG} (Buisinaro Gallon Mass asymmetry)[5]. Effect of deformation of any of the reacting partners also effect the reaction mechanism[6]. Since ER production is the true signature of compound nucleus formation the reduction in the ER cross section is a true indication of fusion suppression and quasi fission.

Present Study

The measured ER cross section data taken from the literature for some reactions with varying entrance channel parameters are plotted as a function of excitation energy. The data is then compared using the statistical model code PACE4. The measured ER cross section data of the following systems are compared.

16O+188Os...>204Po
28Si+176Yb...>204Po
40Ar+164Dy...>204Po
16O+194Pt...>210Rn
18O+192Os...>210Po
48Ca+162Dy...>210Rn

All the system considered above have different entrance channel properties: like ZpZt, mass asymmetry, deformation of the projectile and the target and the magicity of the incident nuclei and that of compound nucleus. For all the systems with compound nucleus mass A=210, all the projectiles are magic nuclei and only the targets are deformed. The compound nucleus 210Po is also a magic nucleus in its neutron number.

Table 1. The reaction parameters of the system.

CN	System	ZpZt	α	β_{target}
204Po	16O+188Os	608	0.843	0.198
204Po	28Si+176Yb	980	0.725	0.289
204Po	40Ar+164Dy	1188	0.608	0.296
210Rn	16O+194Pt	624	0.848	0.130
210Po	18O+192Os	608	0.829	0.164
210Rn	48Ca+162Dy	1320	0.543	0.283

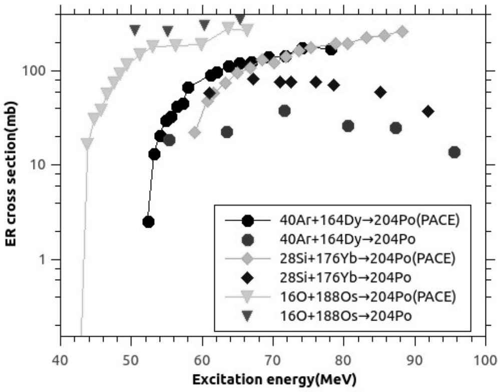

Fig 1. The ER cross section of 204Po formed through different entrance channel.

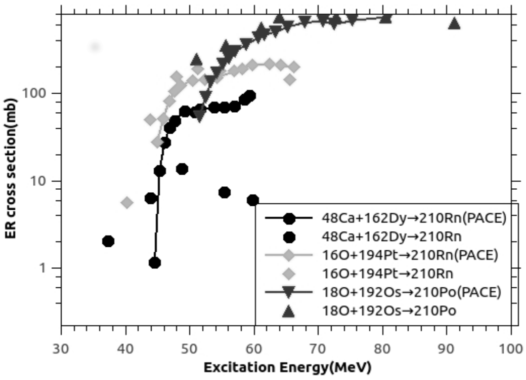

Fig. 2. The ER cross section of 210Po and 210Rn formed through different channels.

In fig.1 for the system 16O+188Os the theory and the experiment are in good agreement. But for the Si and Ar induced systems there is a large discrepancy between the theoretical and the experimental values. As the value of ZpZt increases and the mass asymmetry decreases the discrepancy between the theory and experiment increases. As the deformation of the target increases the deviation from the theory also increases.

From the fig.2 it is clear that for 16O and 18O induced reactions both theory and experiment are in good agreement. But for 48Ca induced reaction the discrepancy between the theory and experiment is large. This system is more symmetric and has large ZpZt compared to the other two. The deformation of the target is more for this system than the other two.

Coclusion

As the Coulomb repulsion (ZpZt) increases and as the mass asymmetry decreases the quasi fission probability increases due to the strong inhibition to fusion. As the deformation of the target increases the probability for the quasifission increases because of the unmature breaking of the composite system before achieving the complete equilibrium.

References

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