Prediction of quasifission reaction for the production of ^{188}Pt* through the system with Z_PZ_T ~1000

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INTRODUCTION

A nuclear reaction is a process whereby a nucleus is transformed from one species into another. There are five basic types of nuclear reactions: elastic scattering, inelastic scattering, radiative capture, particle ejection and fission. Elastic scattering reactions involve no kinetic energy transferred into nuclear excitation. Inelastic scattering, on the other hand, results in the nucleus being raised to an excited state.

In the case of radiative capture, the incident particle is absorbed into the nucleus, thus raising the energy level of the nucleus. The compound nucleus then emits a photon to rid itself of the excess energy. In a particle ejection reaction, the compound nucleus releases excess energy by emitting a particle. The fission reaction results in the nucleus breaking apart into two fission fragments and releases a large amount of energy. Fission reactions produce additional neutrons which may be available to initiate further fission reactions.

The quasi-fission - or fast-fission – reaction is intermediate between deep-inelastic scattering and fission of the fully equilibrated compound nucleus. Suppression in the evaporation residue cross section, anomalous fission fragment angular distribution and broadening in the fission fragment mass distribution are considered as signatures of fusion hindrance or quasifission. Asymmetric fission due to the contribution from NCN fission has also been reported.

PRESENT STUDY

Earlier it was predicted that the quasifission occurs only when $Z_PZ_T \geq 1600$[1]. However, recently it has been established that the onset of quasifission starts as early as Z_PZ_T ~1000 [2], where Z_P is the atomic number of projectile and Z_T is the atomic number of target. With this finding as motivation, we have proposed two systems ^{50}Ti + ^{138}Ba and ^{16}O + ^{172}Yb , both forming the same compound nucleus ^{188}Pt*. The Z_PZ_T value of first system is 1232 and that of the second system is 560.

Many studies have already established [3-6] the suppression of fusion cross section as an indicator of quasifission. For example, in a reaction [7] that involves three systems, ^{50}Ti + ^{170}Er (Z_PZ_T = 1496) , ^{34}S + ^{186}W (Z_PZ_T = 1184) and ^{16}O + ^{204}Pb (Z_PZ_T = 656) , all of them form same compound nucleus ^{220}Th, it is found that the fusion cross section is suppressed for ^{50}Ti + ^{170}Er and ^{34}S + ^{186}W. A plot showing the width of the mass distribution against excitation energy is shown in Fig1.

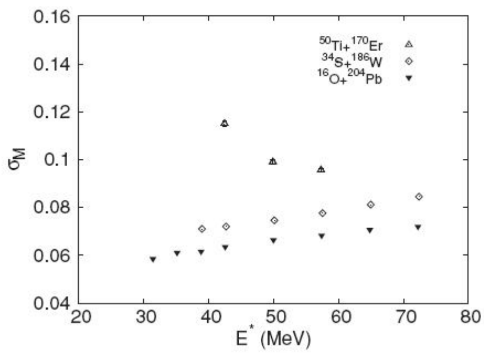

Fig. 1 The standard deviations (σ_M) of the Gaussian fit to the mass ratio distributions are plotted as a function of the compound nucleus excitation energy.

If we plot a graph between excitation energy and fusion cross section for the same excitation energies of two different systems, forming same compound nucleus, then the system with quasifission will show a suppressed evaporation residue cross section. For the systems ^{48}Ca + ^{154}Sm and ^{16}O + ^{186}W forming same compound nucleus $^{202}Pb^*$[8], the excitation energy versus fusion cross section graph is shown in Fig.2. Quasifission reaction has been reported for ^{48}Ca + ^{154}Sm system.

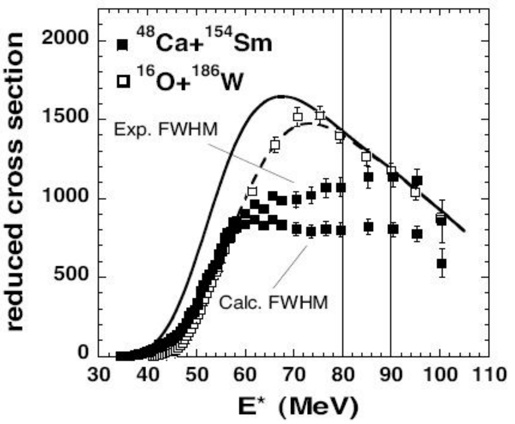

Fig.2 Reduced ER excitation functions. A fusion hindrance effect is anyway present in the excitation energy range 80-90MeV

The experimental probes for the study of quasifission are generally fission fragment angular distribution and evaporation residue cross section measurement. In the case of fragment angular distribution, a higher level of anisotropy indicates the presence of quasifission. The evaporation residue cross section will be a much lower for a quasifission reaction. But there are many instances [9-10] where the two probes are giving diametrically opposite results.

The theoretical predictions, using coupled channel code CCFULL and statistical code PACE, for the proposed systems are as shown in Fig.3. It can be seen that ^{50}Ti + ^{138}Ba show a suppressed fusion cross section.

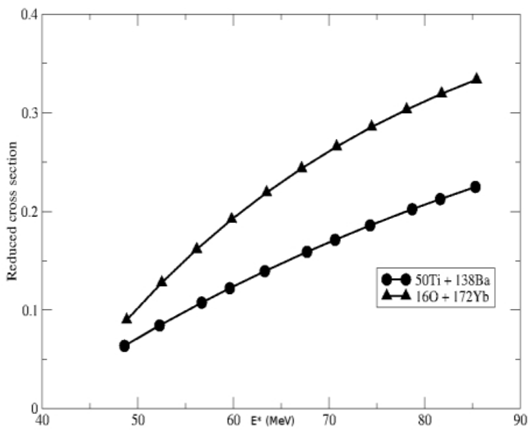

Fig.3 Suppression in the ER cross section of ^{50}Ti + ^{138}Ba is predicted.

This indicates that, there is a significant contribution due to quasifission in the case of ^{50}Ti + ^{138}Ba. It is expected that the predicted quasifission reaction may be experimentally verified during the upcoming beam time at 15UD Pelletron accelerator facility of the Inter University Accelerator Centre (IUAC), New Delhi.

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