Study of fission fragment mass distributions for the reactions ^{16,18}O + ^{197}Au

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Introduction

Nuclear fission is a process in which a heavy nucleus divides into two fragments. Nuclear fission process involves the complex shape changes and the drastic rearrangement of the interacting nucleons within the nucleus, as the system evolves from mono-nuclear to di-nuclear configuration. Recently there is much more interest in the study of fusion-fission dynamics in less fissile systems due to the observation of asymmetric fission in several compound nuclei [1]. It is well known that the entrance channel properties of the interacting system appear to play a major role in the nuclear reaction dynamics of nucleus fission, in particular the entrance channel mass-asymmetry, target/projectile deformation, their spins and the product of Z_pZ_t. The observation of the unexpected presence of quasi-fission in reactions forming compound systems as light as ^{216}Ra has become a matter of intense investigation with less asymmetric systems like ^{19}F + ^{197}Au [2]. At the same time there were few reports mentioning no evidence for non compound nucleus fission in the same reaction through fission fragment angular distribution studies, as the experimental results are matching with theoretical predictions for compound nucleus fission [3]. Further fission fragment angular and mass distribution results for the reaction ^{18}O + ^{197}Au didn't show any evidence of non compound nucleus fission, even though the studied reaction is having similar entrance channel mass asymmetry as that of ^{19}F + ^{197}Au [3, 4]. It appears that in these less fissile systems, the relaxation of mass is slower than the relaxation in K-degrees of freedom, which is in contradiction to heavier and highly fissile systems. Thus, it becomes imperative to understand the relaxation mechanism of various degrees of freedom in detail, in less fissile systems. In this context, we have studied fission fragment mass distributions for the reactions ^{16,18}O + ^{197}Au populating the compound nucleus ^{213,215}Fr through GEF calculations [5].

Theoretical calculations

We have re-analyzed the mass distribution data for the reaction ^{18}O + ^{197}Au, and extracted the mass widths at different excitation energies. The mass distributions for the reaction ^{16}O + ^{197}Au were taken from the Ref [6]. The GEF (GEneral discription of Fission observables) model is the most efficient and reliable statistical code in describing the compound nucleus fission phenomena from the fission observables such as fission fragment mass and charge yields, kinetic energy distribution, prompt neutron yields and prompt gamma yields. In order to perform the GEF code calculations one has to enter the mass, charge, excitation energy and average angular momentum $< l >$ of the fissioning compound nucleus as input parameters. The $< l >$ values were obtained from coupled channel calculations by using CCFULL code. By using GEF code one can extract the mass distributions before emission of prompt neutrons (ν_{pre}) and after emission of prompt neutrons (ν_{post}). The fission fragment mass widths were calculated from obtained mass yields before emission of prompt neutrons by using the following formula:

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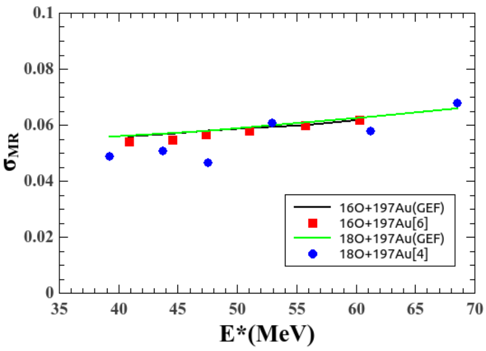

FIG. 1: Experimental and calculated mass ratio distributions for the reactions ^{16,18}O + ^{197}Au at different excitation energies .

$M_R = \dfrac{M_1}{M_{CN}}$, where M_1 is the mass of the first fragment and M_{CN} is mass of the compound nucleus $= M_1 + M_2$.

Results

In Fig.1, we have plotted the GEF calculations along with the experimental mass widths for the reactions ^{16,18}O + ^{197}Au as a function of excitation energy. It is well known that, GEF code predicts only compound nucleus fission, for instance if there is a component of non compound nucleus fission in the studied mass distributions, one can expect the width of experimental mass distributions would be higher than the liquid drop model predictions (GEF calculations). One can observe from Fig.1, that there is no significant difference in the mass widths for the two reactions ^{16}O + ^{197}Au from the GEF calculations indicating that fission is taking place after complete equilibration of the projectile with the target. It appears that in less fissile systems, the relaxation of mass is slower than the relaxation in K - degrees of freedom.

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