Mass distribution of fission fragments of ^{200}Pb* at low energy

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Introduction

Heavy-ion (HI) nuclear reactions have been extensively studied over the last few decades. During the fusion process, the projectile combines with the target resulting formation of an excited compound nucleus (CN*), which takes a finite time to reach equilibrium across all degrees of freedom. The CN typically de-excites through particle evaporation or fission process [1]. The particles emitted during de-excitation contain valuable information about the reaction dynamics. These reactions, involving the interaction of multiple nucleons, provide an excellent opportunity to explore various nuclear reaction processes such as pre-compound (PEQ) emissions, complete fusion (CF), incomplete fusion (ICF), and fusion-fission [2].

The study of fission-like events, particularly within the context of HI-induced reactions, has gained significant interest, especially at incident energies below 7 MeV/nucleon [3]. When a heavier nucleus decays into two fragments during the fission process, a key question arises regarding the nature of the mass division - whether it is symmetric or asymmetric. The fission fragment mass distribution of fission fragments is a key characteristic used to describe the fission process. The variation in the width of this mass distribution with the excitation energy of the compound system serves as an important probe for investigating different types of fission processes, including statistical fission, fast fission, PCN fission, and quasi-fission [4].

In the present work, the measurements of fission fragments mass distribution of compound nucleus ^{200}Pb* have been carried out for ^{19}F+^{181}Ta reaction at nine varying energies from the Coulomb barrier to 115 MeV. These fragments are lying with mass numbers $66 \leq A \leq 140$ region.

Experimental details

The experiments have been carried out at the Inter-University Accelerator Centre (IUAC), New Delhi, India using the 15 UD pelletron accelerator facility. A beam of ^{19}F^{+7} has been bombarded on isotopically pure Tantalum targets and Aluminum catchers of sufficient thickness, both prepared using the rolling technique. In the present experiment, three stacks (each consisting of a different number of target-catcher foil assemblies) have been irradiated separately. The irradiation has been conducted in the General Purpose Scattering Chamber (GPSC) with in-vacuum transfer capability. After irradiation, off-line counting of induced activities in the samples was performed using a pre-calibrated HPGe detector (100 c.c. active volume) connected to a CAMAC-based data acquisition system with CANDLE software. Intensities of identified gamma rays of the radioactive residues are used to determine the cross-sections, em-

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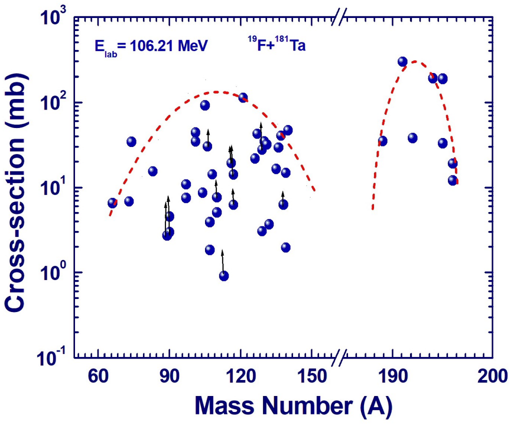

FIG. 1: Mass distribution of fission fragments of $^{200}Pb^{*}$ in reaction ^{19}F+^{181}Ta at $E_{lab} \approx 106$ MeV.

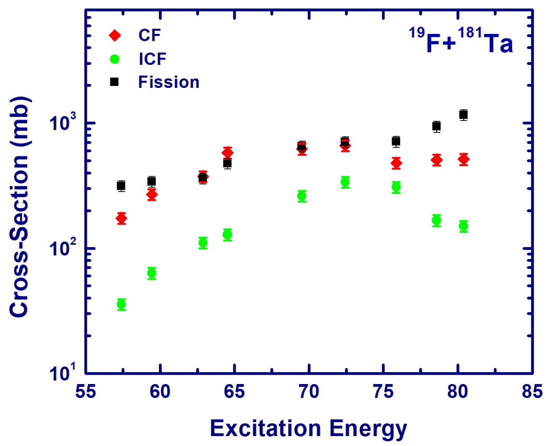

FIG. 2: Observed contribution of fission and fusion (CF and ICF) cross section as a function of Excitation energy in the ^{19}F+^{181}Ta reaction.

ploying standard formulations.

Mass Distribution of Fission Fragments

As a typical case, the measured fission mass distribution of ^{200}Pb* at 106.21 MeV is shown in Fig. 1. The mass distribution is found to be symmetric about half of the mass number ($A_{CN}/2$) of the CN. The distribution is broad and can be well fitted with a single gaussian peak, indicating that the identified fission products result from fully equilibrated CN processes. As such, the de-excitation of compound nuclei formed through CF and/or ICF, even at relatively low excitation energies. This behavior of the fission fragment mass distribution is a typical characteristic of the fusion-fission reaction.

Results

In the present work, the contribution of fission and fusion following CF and ICF for the $^{200}Pb^{*}$ compound nucleus formed in the collision of ^{19}F with ^{181}Ta at laboratory beam energies ranging from 84 to 115 MeV is also estimated and shown in Fig. 2. Evaporation residue cross-sections at various energies have been compared with statistical model calculations. The mass distribution has been accurately fitted with a single-peak Gaussian function, indicating that the fission fragments have been produced through the de-excitation of the equilibrated compound nucleus. At lower energies, notable components of asymmetric mass distributions are also observed, suggesting the presence of pre-equilibrium fission and fast fission processes. Further details will be presented.

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