Isotopic and Isobaric Yield Distribution of Fission-Like Events in the $^{12}C+^{208}Pb$ System at E_{lab}=75.8, 82 MeV

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Introduction

Nuclear fission has been the subject of rigorous investigations over the past few decades. In recent years, a growing focus has been on analyzing fission-like events within heavy-ion (HI) induced reactions, specifically at incident energies < 10 MeV/A. It has been observed that the compound nucleus splits into fission-like intermediate mass fragments depending on the available excitation energy and angular momentum. According to the liquid drop model [1], the mechanism of fission has been suggested to manifest only when the fissioning nucleus surmounts the fission barrier, which emerges from the interplay between coulomb and surface energy factors within the semi-empirical formula. For Z≥104; no fission barrier exists; therefore, a symmetric, single-humped distribution of masses of fission fragments is most probable. However, an asymmetrical mass distribution was subsequently observed in the context of low-energy fission of actinides. This asymmetry in mass distribution may be explained on the basis of nuclear shell effects.

Furthermore, studies indicate that an increase in excitation energy reduces asymmetry in the mass distribution of fission fragments, ultimately leading to symmetric fission. This may be explained based on the gradual washing of shell effects of the composite system at higher excitation energies [2]. It may be pointed out that the charge and mass distributions are two essential post-fission observables that are broadly studied at intermediate energies to understand the disappearance of shell effects with excitation energy. These observables are valuable tools for gaining insights into diverse reaction mechanisms and contribute significantly to advancing our understanding of fission dynamics.

Experimental Details

Experiments have been performed at the Inter-University Accelerator Centre (IUAC), New Delhi, using ^{12}C beam bombarded on ^{208}Pb targets to study different aspects of HI-induced fusion-fission reaction. The ^{12}C beam was bombarded on the ^{208}Pb target foils of (thickness $\sim$ 0.169-0.237 mg/cm^2) which were prepared on Al-backing (thickness $\sim$ 1.0-1.5 mg/cm^2) by using high-vacuum evaporation techniques. The target foil was covered from both sides with pure Al-catcher foils (thickness $\sim$ 3.0-4.5 mg/cm^2) to collect the recoiling fission products in the forward and backward cone. The recoil catcher activation technique, followed by the offline γ-spectroscopy method, was used to measure the production cross-section of fission-like events [3].

Resutls and discussion

In the present work, 30 fission-like events have been identified. The preliminary identification of residues was made on the basis of their characteristic γ-rays, which was further confirmed by the decay-curve analysis. As a representative case, the decay curve of ^{116}Te isotope achieved by following the 93.7keV γ-line is shown in Fig.1, indicating good agreement with the literature value of its half-live [4]. The mass distribution of the fission-like

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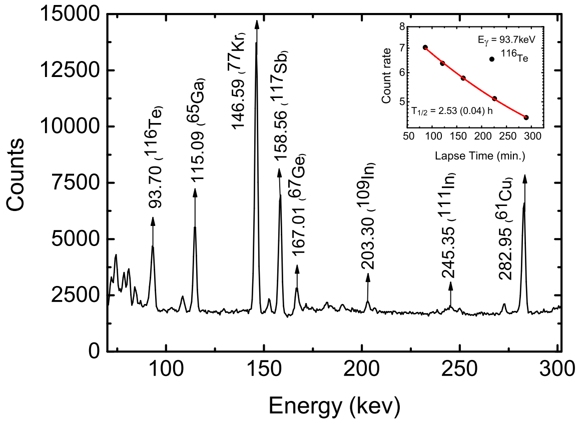

FIG. 1: A Typical γ-ray spectrum of ^{12}C+^{208}Pb at E_{lab} = 82 MeV. The γ lines are assigned to different fission-like events. A typical decay curve of Tellurium isotope (^{116}Te) is obtained by following 93.7 keV γ-line at E_{lab} = 82MeV.

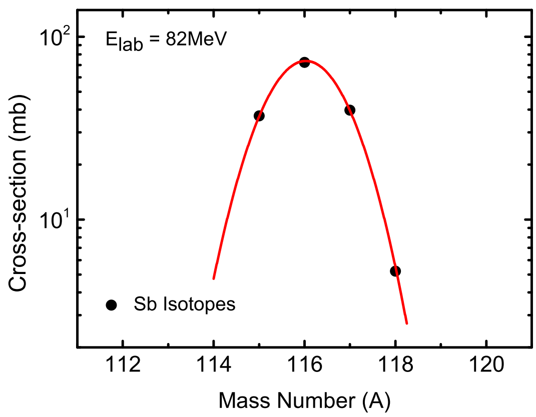

FIG. 2: Isotopic yield distribution for (^{115,116m,117,118m}Sb) Antimony isotopes at E_{lab}= 82MeV. The solid line shows the Gaussian fit to the data.

events and the isotopic and isobaric yield distribution of the identified isotopes produced as a result of fission have been studied in the present work. Isotopic yield distribution of fission fragments has been used to extract the charge distribution parameters. Four isotopes of Antimony, ^{115,116m,117,118m}Sb, have been observed at E_{lab} = 82 MeV. The parameters of isotopic yield distribution, viz., A_p and $\sigma^2{}_A$, i.e., the most probable mass and variance for Antimony isotopes, respectively, are obtained by fitting a Gaussian distribution, refer to Fig.2. The value of most probable mass, A_p, for antimony isotopes at excitation energy $E^\star \approx 45.5$ MeV is found to be 116.03±0.01. The width parameter for isotopic yield distribution is estimated to be 1.74±0.03. The uncertainties presented in the estimated parameters are the fitting errors. The value of the variance ($\sigma^2{}_A$) for Antimony isotopes shows a good agreement with the values reported in the literature for different fissioning systems. The value of the width parameter (σ_z) of the isobaric distribution obtained from the experiment and by converting the width parameter of isotopic yield (σ_A) to (σ_z) = (σ_A).Z/A_p are also found to be in good agreement. This shows the self-consistency of the present analysis. Further details regarding measurement and analysis will be presented during the symposium.

Acknowledgments

The authors acknowledge the Inter-University Accelerator Centre for providing all the facilities to carry out these measurements and the Pelletron crew for continuous delivery of ^{12}C throughout the experiments. One of the authors, R.K., thanks the University Grant Commission for a doctoral fellowship.

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