Further evidence of the absence of shell effects in fission fragment mass distribution in ^{210}Po

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Introduction

Shell effect is one of the dominating factors in determining the stability of nuclei and formation of super heavy elements (SHE). The influence of shell effect on the dynamics of the fusion fission process and its evolution with excitation energy has been a matter of intense debate and research. One of the nuclei most extensively studied in recent years to elucidate this phenomenon is ^{210}Po [1, 2], which is neutron shell closed at N=126.In the experiment described in Ref. [2], the nucleus was populated through the channel ^{12}C + ^{198}Pt and fission fragment angular anisotropy was measured. A larger value of this anisotropy compared to ^{206}Po at similar excitation energies was interpreted as an effect of the N=126 shell closure in ^{210}Po [2]. In recent experiment [1] fission fragment mass distribution for the same compound nucleus was measured through the same reaction channel. However, it was found that there was no influence of the N=126 shell closure on the mass distribution of the ^{210}Po. The experimental results were also supported by Langevin calculations [1]. Recent theoretical calculations, like five dimensional potential model calculation of Moller et al [3], also simulates the mass distribution of ^{210}Po which is considered as a bench mark for newer advanced theories in the pre actinide region.

It is to be mentioned that, in our earlier experiment [1], the ^{210}Po was populated at an average angular momentum of ~30 ħ. As fission barrier and fragment mass distribution is dependent on both the temperature and the angular momentum, it would be interesting to look whether there is any influence of the angular momentum on the washing out of the shell effects in the mass distribution of ^{210}Po. This motivated us to measure the mass distribution of the same fissioning nucleus ^{210}Po populated through ^{4}He + ^{206}Pb reactions, at similar excitation energies as the earlier measurements, but at lower angular momentum.

Experimental details

The experiment was carried out at the K-130 cyclotron at VECC, Kolkata. ^{4}He ion beam with energies 37 to 60 MeV was bombarded on a target of enriched ^{206}Pb of thickness 250 μg/cm^2, which was evaporated on a carbon backing of 20 μg/cm^2. The target was mounted at an angle 45^0 to the beam axis and fission fragments were detected using two large area multi wire proportional counters (MWPC) of active area 20 X 6 cm^2. The photograph of the experimental set up is shown in Fig 1. The center of the forward detector was kept at an angle of 60^0 with respect to the beam direction with a total angular coverage of 60^0, while the backward detector was kept at an angle of 114^0 with respect to the beam axis with a total angular coverage of 72^0. The angles were selected corresponding to the folding angles of symmetric fission fragments following Viola's systematics [5]. The detectors were operated at a pressure of 3 Torr of isobutane gas. Operating the detectors at such low pressures makes them almost transparent to elastic and quasi elastic particles. The flight times, the coordinates (Θ, Φ) of the impact points, and the energy losses of the fission fragments in the gas detectors were measured and recorded on event by event basis using a VME based data acquisition system. From these measurements, the masses of the correlated fragments and transferred momenta were extracted.

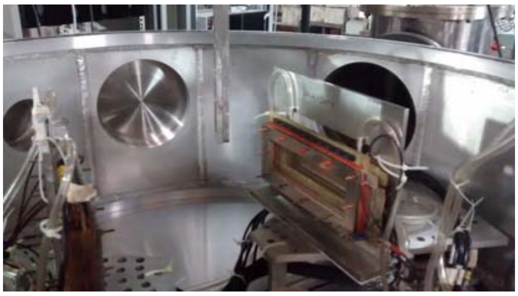

Fig 1: Photograph of the experimental setup

Results and discussion

Folding angle distributions were generated from the data and it was found to be consistent with the estimated values. This ensured that no transfer induced fission events were selected in calculation of the mass distributions. The masses were determined from the difference in their time of flight, azimuthal and polar angles, momenta and recoil velocities of each event. The procedure is described in detail in Ref. [4]. The fission fragment mass distribution for the representative excitation energy 40.8 MeV is shown in Fig 2.

It is found that the mass distribution could be well fitted with a single Gaussian distribution, which is consistent with the earlier measurement in $^{12}C+^{198}Pt$ reaction [1]. The shape of the fission fragment mass distribution is sensitive to the presence of shell effect in nuclei. It was shown that even a slight presence of shell effect in the dynamics would affect the mass distribution, thereby deviating from the single Gaussian structure [1]. Thus, it is evident from the data that shell effect do not survive at the excitation energy of 40.8 MeV for the nucleus ^{210}Po.

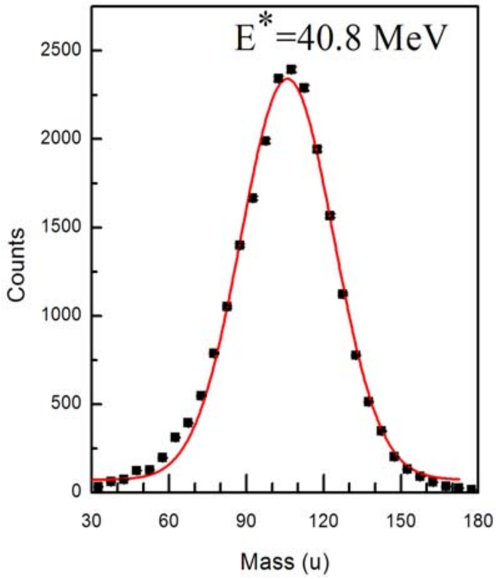

Fig 1: Fission fragment mass distribution for excitation energy of 40.8 MeV. The solid red line represents the single Gaussian fit.

Since the ^{210}Po nucleus was populated with much lower angular momentum in the present reaction as compared to the $^{12}C+^{198}Pt$ reaction and we find that still there is no influence of the N=126 shell closure on the mass distribution of the fission fragments, we could arrive at a conclusion that there was no influence of angular momentum on the observed absence of shell effect in the fragment mass distributions at excitation energy of 40 MeV.

References:

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