Mass distribution for ^{210}Po at E*~30 MeV

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Introduction

One of the interesting experiments in recent years was that of the beta delayed fission of ^{180}Tl, resulting in the fission of the nucleus ^{180}Hg [1]. It was expected that the mass distribution of the fission fragments would be symmetric around the ^{90}Zr nucleus (Z=40, proton semi magic, N=50, neutron magic). However, it was found that the mass distribution of the fission fragments was asymmetric. This result opened up new questions in our understanding of the fission process and a huge amount of theoretical effort has been put since, to delve into the dynamics of fission in the pre-actinide region of A~180-200. Several models were developed to understand the influence of shell effect on the dynamics of the fusion fission process and its evolution with excitation energy in the pre-actinide Hg-Pb region.

One of the most advanced theoretical models developed by Peter Moller, *et al.*, [2] is Brownian shape-motion model that claimed to reproduced the asymmetric mass distributions of ^{180}Hg. Using this macroscopic-microscopic model, they also have calculated the fission fragment mass distributions for multiple nuclei in the above mentioned mass region and requires experimental validation to test the universality of the model. Figure 1 shows the fission fragment mass distribution calculated by Moller *et al.*, for ^{210}Po at an excitation energy of ~31 MeV.

The fission of the N=126 shell closed nuclei ^{210}Po is indeed a topic of intense debate, on the question whether shell effects play any role on the fission dynamics in fusion reaction ^{12}C+^{198}Pt at an excitation energy of 40 MeV and above. Measurement of the fission fragment mass distribution of the system [3, 4] showed no influence of the N=126 shell closure in the fusion-fission dynamics. This has been corroborated by the theoretical calculations of Moller et al [2], who have, however, predicted that at a lower excitation energy of 31.43 MeV, the shell effects may still play some role in the fusion fission dynamics.

Here, we report the results of our measurement of the fission fragment mass distributions of ^{210}Po at the excitation energy of 30 MeV to look for the predicted asymmetric fission pathway in ^{210}Po.

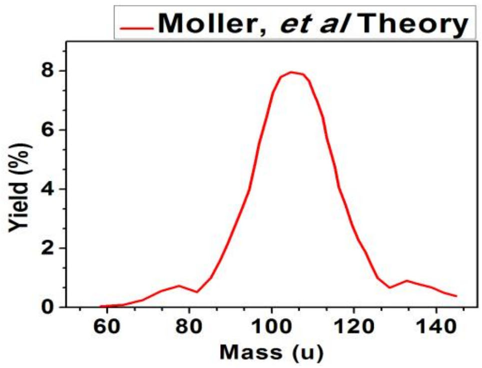

Fig 1: The mass distribution for ^{210}Po at E*=31.43 MeV as calculated in ref [2].

Experiment

Alpha beam of energy 37 MeV from the K-130 Room Temperature Cyclotron at VECC, Kolkata, was bombarded on an enriched target of

^{206}Pb to produce the nuclei of ^{210}Po. The target of ^{206}Pb was of thickness 250 µgm/cm^2 on a backing of 20 µgm/cm^2 of carbon. The fission fragments were detected using two indigenously developed MWPC of active area 20 X 6 cm^2. The target was set at an angle of 45^0 to the beam axis and the detectors were mounted at 60^0 and 114^0, to the beam axis respectively. The forward detector had an angular coverage of 60^0, while the backward detector had an angular coverage 72^0. The detectors were placed so that complementary fission fragments could be detected, on the basis of symmetric fission fragments following Viola's systematics. The MWPCs were operated with isobutane gas at 3 torr pressure which ensured that the detectors remained transparent to the elastic and quasi elastic particles. The time of flights, the position (X,Y) of striking the detectors, and the energy losses in the gas volume for each of the fission fragments were recorded event-by-event in a VME based DAQ system. Using the principle of conservation of momentum and kinetic energy, the mass of the fission fragment was calculated from the difference in the time of flights, the polar and azimuthal angles, the transferred momenta and the recoil velocities.

Results and discussions

As alpha beam was used in this experiment, minimum contribution from any transfer induced fission type events was expected. To ensure that the data was free from any incomplete fusion type events, a gate over the folding angle distribution was used, which corroborated with that calculated for complete transfer of momentum of the projectile to the target. Lower panel of figure 2 shows the fission fragment mass distribution as obtained in the experiment. The solid red line shows the single Gaussian fit to the data. The deviation from the Gaussian in the tail regions is clearly seen. At the upper panel of the figure 2, we show the difference of the data and the fitted Gaussian which appears like a combination of two small Gaussians, both at 1 % peak yield level, one on low mass side (peaking around 70 ± 4) and the other on the high mass side (peaking around 130 ± 4). This is qualitatively consistent with theoretical predictions of Moller et al. [2] at the excitation energy of 31.43 MeV, where weak asymmetric component (at 1 % yield level) were shown to coexist along with the strong symmetric mass distribution.

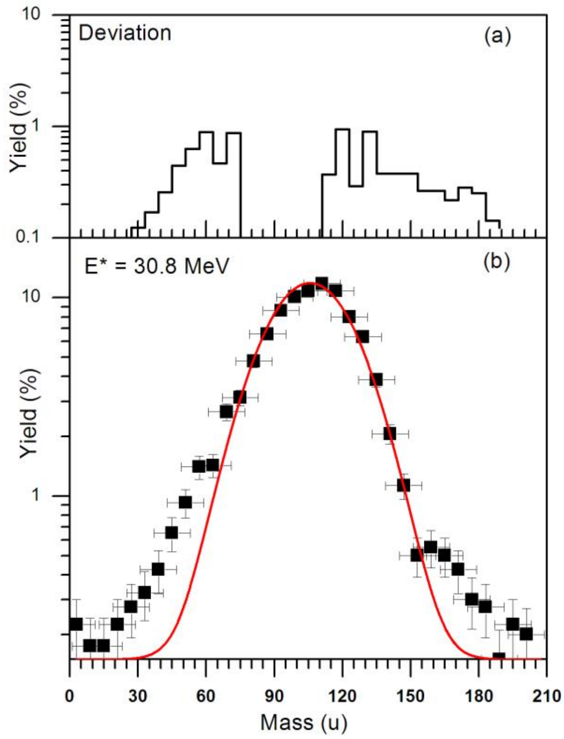

Fig 2: The fission fragment mass distribution at E*=30.8 MeV along with the deviation from the single Gaussian fit.

In summary, we report the fission fragment mass distribution for ^{210}Po at 30 MeV excitation energy. Persistence of shell effect in fission fragment mass distribution of ^{210}Po was observed at this excitation energy as predicted by a recent macroscopic microscopic theory.

References

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