Study on effect of pre-equilirium mechanism on the proton induced fission of ^{238}U

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Introduction

The mass distribution of nuclear fission products has importance in accelerator driven sub critical systems in the energy production domain. The ADS is utilizing an effective neutron spectrum, thermal to 50MeV, with a huge neutron flux in the range of 10^{16} cm^2 s^{-1} [1]. This holds a significant fraction of high energy neutrons capable of initiating significant pre-equilibrium components in nuclear reactions. Further, it is well accepted that pre-equilibrium mechanism significantly effects the breakage of clustering in the nuclei due to the formation of exciton.

Recent studies show that, as the excitation energy goes higher than the shell binding energy, the shell effect is getting meltdown. This produces a higher population in the symmetric fission modes [2,3]. Which alters the original fission mass distribution. Altering of this mass distribution will cause the integral bench marked characteristics of the reactor to deviate from its original behavior. The isotopic yields calculated from the spectrum averaged mass distribution are significantly affected by neutron multiplicity as well as the neutron capture cross section of isotopes. Hence, the evaluation of such situations requires accurate theoretical models. Studies show that there is an effect of pre-equilibrium mechanism on the population of fission modes. In the pre-equilibrium region, the isotope production is different from the design curve of a reactor as expected. It has to be taken into account for an accelerator driven systems (ADS) to reduce the risk of supercriticality.

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The liquid drop model predicted a symmetric mass split in fission [4]. The experimental observation is the asymmetric mass split. This experimental observation of asymmetric mass split is primarily due to stabilization by shell effect, and symmetric fission is suppressed by shell closure [5,6]. The factors on which fission modes depend are not yet completely explored. The pre-equilibrium contribution to the fission reaction mechanism has to be taken into account so as to improve the existing theoretical models. So, it is interesting to explore the pre-equilibrium correlation to the strength of shell closures to decide modes of fission. In this work we have studied the effect of pre-equilirium mechanism on the proton induced fission of ^{238}U .The correlation coefficient, for the pre-equilibrium contribution and contribution from symmetric fission, are evaluated over the incident proton energies 3-20 MeV.

Theoretical Calculation

The mass distribution data for ^{238}U(p,f) available in the experimental nuclear reaction database-EXFOR is used for the study [7]. The mass distribution data in the incident proton energies 3-20 MeV are taken for the analysis. The modes of fission are fitted using gaussians and the contribution of symmetric fission has been extracted.

Theoretical model calculation is done using the nuclear reaction code TALYS 1.95 [8]. Calculations have been performed using various fission models and preequilibrium models available in TALYS 1.95, out of which mamdouh table model of fission barrier along with exciton with analitical transition preequilibrium model is found to better reproduce the experimental data, and the pre-equilibrium contribution in the proton induced fission of 238U was calculated.

Results and Discussion

As a typical case the mass distribution curve for 10 and 20MeV proton energies are shown in Fig. 1 (a) and (b) respectively. The contribution of symmetric fission are calculated for each incident proton energy for both pre-neutrons and post-neutrons. The pre-neutron

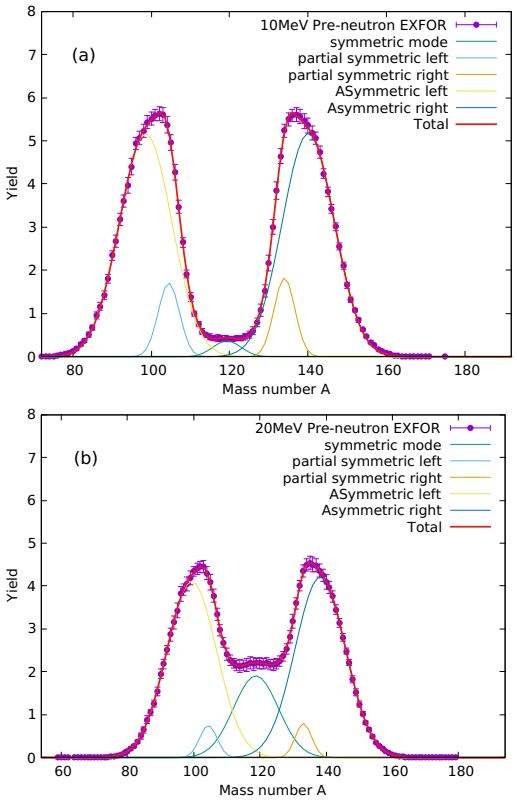

FIG. 1: *Mass distribution curve of excitation energy 10MeV (a) and 20MeV (b).*

and post-neutron symmetric fission yields expressed as a function of pre-equilibrium is shown in Fig. 2. The correlation coefficient obtained is about 0.91, which implies that there is a strong linear correlation between pre-equilibrium and symmetric fission.

We obtained a strong correlation between pre-equilibrium and symmetric fission. Which indicates that the pre-equilibrium suppresses the shell effect and thereby enhancing the symmetric fission. So the deviation in mass

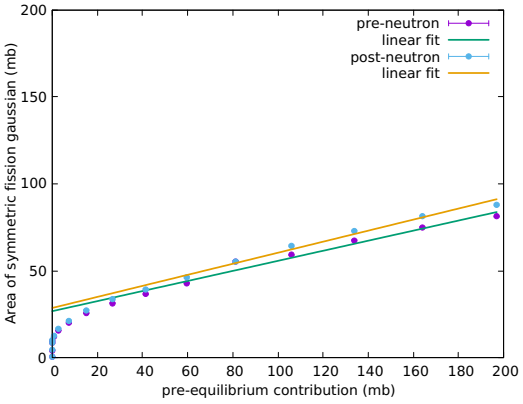

FIG. 2: *The pre-neutron (violet circles with error bars) and post-neutron (blue circles with error bars) symmetric fission yields expressed as a function of pre-equilibrium. The linear dependence of these parameters are shown as solid lines.*

distribution due to pre-equilibrium contribution must be accounted very well. So that the theoretical models can be improved to reproduce the data more accurately. This study is important for analyzing the criticality of accelerator driven systems (ADS) to reduce the risk of diverging reactor behaviour.

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