Fission fragments mass distributions of nuclei populated by multinucleon transfer channels in ^{6,7}Li+^{238}U reaction

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Introduction

Measurements on fission fragment angular distributions (FFAD) and mass distributions (FFMD) have been meagrely carried out for fission following transfer or breakup reactions. Anisotropy of FFAD for transfer induced fission for ^{6}Li+^{232}Th systems have been recently studied [1] and the role of the transfer induced fission on angular anisotropy of inclusive fission has been investigated. The study of the effect of transfer or projectile breakup on FF mass distribution is equally interesting. Preliminary results reported in Ref. [2] on FFMD of α-gated fission in ^{6,7}Li+^{238}U reactions indicate that transfer induced fission channel is responsible in modifying the width of the folding angle distributions and the peak to valley ratio (P/V) of mass distributions.

In the present work, the detailed analysis of the FFMD for all breakup or transfer induced fission channels in ^{6,7}Li+^{238}U systems have been completed and the effect of these channels on inclusive FFMD have been investigated. The mass-distributions of several exotic neutron rich fissioning nuclei namely, ^{242,243,244}Pu and ^{240,241}Np populated in multinucleon transfer/ ICF reactions have been studied. Interestingly, the mass-distributions of the composite nuclei ^{244}Pu and ^{241}Np cannot be measured using the fusion reaction of any stable target/projectile combination. These nuclei have been populated by the capture of ^{6}He and triton respectively by ^{238}U target by transfer reactions, and have been studied for the first time.

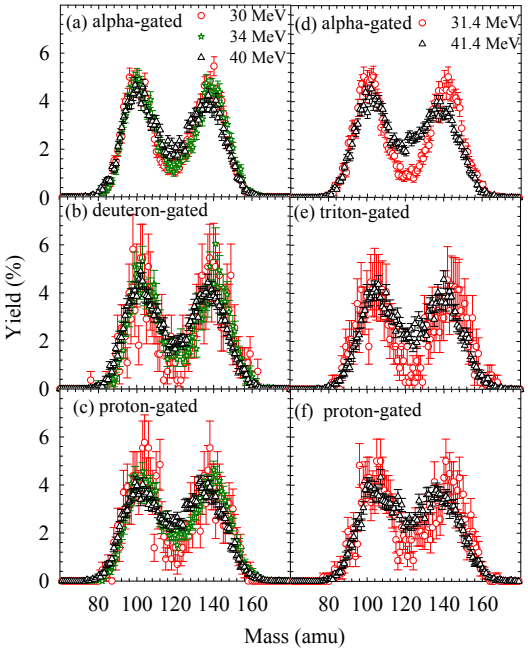

FIG. 1: Transfer induced FFMD obtained from ^{6}Li(a,b,c) and ^{7}Li (d,e,f) +^{238}U reaction.

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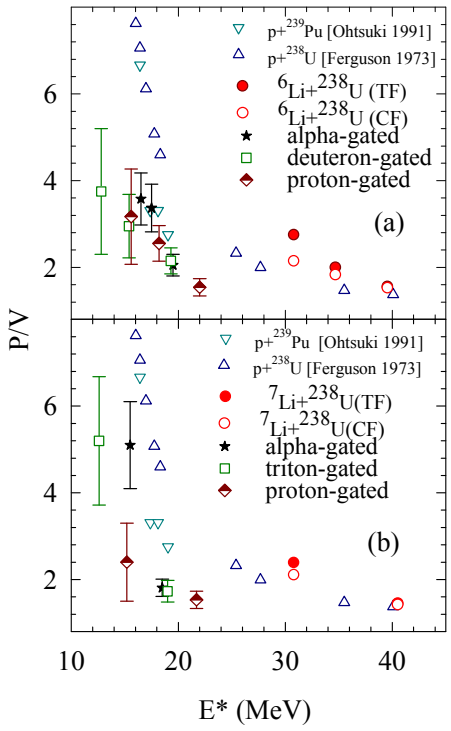

FIG. 2: P/V ratio of transfer induced FFMD obtained from ^{6}Li(a) and ^{7}Li (b) +^{238}U reaction.

Measurements and Results

Exclusive measurements of fission fragments in coincidence with light charged particles in ^{6,7}Li + ^{238}U reactions were carried out at 15-UD Pelletron facility at IUAC, New Delhi using 30, 34 and 40 MeV ^{6}Li beam and 31.4 and 41.4 MeV ^{7}Li beam. The details of the experimental set up were described in Ref. [2]. Here, the identification of fissioning nuclei and measurement of excitation energy have been performed through the measurement of outgoing projectile like fragments detected in coincidence with the two fission fragments.

Applying momentum conservation along the beam direction, mass distributions for transfer induced fission have been obtained. Mass distributions thus obtained in coincidence with alpha (dominant transfer channel), deuteron/triton and proton have been shown respectively in Fig. 1 (a),(b) and (c) for ^{6}Li + ^{238}U reaction and in Fig. 1 (d), (e) and (f) for ^{7}Li + ^{238}U reaction. It can be observed that the mass distribution for these transfer induced fission events produce higher P/V ratio than the ones for inclusive fission (reported in Ref. [2]) at respective beam energies. Smaller excitation energies associated with the composite fissioning nuclei actually lead to higher P/V ratio in case of these transfer-fission channels.

In ^{6}Li+^{238}U reaction, the α, d and p-gated fission events correspond to the composite fissioning nuclei ^{240}Np, ^{242}Pu and ^{243}Pu (formed by the capture of deuteron, α and ^{5}He respectively), Whereas in ^{7}Li+^{238}U reaction, the α, t and p-gated fission events correspond to the composite fissioning nuclei ^{241}Np, ^{243}Pu and ^{244}Pu (formed by the capture of triton, α and ^{6}He respectively). It may be emphasized that mass distributions of fissioning nuclei ^{244}Pu and ^{241}Np, formed by capture of ^{6}He and triton respectively by ^{238}U target, have been studied for the first time.

The P/V ratio for all transfer induced fission channels (α, d/t and p-gated), CF-fission (CF) and inclusive fission (TF) have been shown in Fig. 2(a,b) for both the reactions. The P/V ratio for transfer channels are more compared to CF-fission at respective projectile energies and hence responsible for the enhancement in the P/V ratio of CF-fission compared to inclusive fission.

Thus, in the present exclusive measurements the mass distributions of a few exotic neutron rich nuclei populated by multinucleon transfer reaction have been obtained and these transfer induced fission channels have been found to be responsible for enhancing P/V ratio of inclusive mass distribution compared to the ones in CF-fission.

References

[1] A. Pal *et al.*, Phys. Rev. C **96**, 024603 (2017).

[2] A. Pal *et al.*, Proceedings of the DAE-BRNS Symp. on Nucl. Phys. 61, 376 (2016) and references therein.