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Recent experimental results on pre-compound emission reactions at low energies

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The recent experimental results on the excitation function measurements for light particle emission in several target nuclei of mass region A=159-185 with heavy ion (HI) beams (12C, 14N,16O, and 19F) at low energy below 5 MeV/nucleon are found in disagreement with the compound theory-based statistical models. This discrepancy between experimental data and statistical model predictions led to the identification of the pre-compound (PCN) emission process in such reactions. The PCN emission is well recognised as an intermediate mechanism bridging the compound and direct reactions in light ion (proton, deuteron and alpha) induced reactions at higher energies. The observation of direct reaction mechanism with 12C, 14N,16O and 19F beams is scarce due to the dominance of the breakup fusion (BUF) process at these energies.

Thus, the investigation of PCN emission in HI reactions is interesting at energies where the compound nucleus mechanism dominates [1]. It is because of the fact that the extensive measurements of the excitation functions for production residues carried out at the Variable Energy Cyclotron Centre (VECC), Kolkata, India with alpha-beam across a broad mass region A=59 and 187 [2-6] have attracted attention recently in establishing PCN emission as a premier reaction dynamics. The results of recent investigations with alpha particle beams have achieved three key milestones in PCN emission; (i) the development of mass-number dependence systematics for target nuclei (A=59–187) [7], (ii) exploration of the target deformation effects [8], and (iii) significance of the shell structure [8].

To achieve these milestones in HI reactions, the experiments have been conducted at the Inter-University Accelerator Centre, New Delhi, India, to measure the recoil range distributions (RRDs) and spin distributions (SDs) of a large number of residues produced in various target nuclei [9]. Analysis of the RRD and SD data revealed two distinct de-excitation patterns corresponding to the PCN and CN processes, providing valuable insights into the low-energy reaction dynamics of HI collisions. Nevertheless, the evidence of PCN emission at low energies (4–7 MeV/nucleon) highlights the crucial role of angular momentum, which is well explained by the measurements of isomeric cross-section ratio, establishing a huge PCN emission from the metastable state as compared to the ground state. Further details of these measurements will be presented.

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