Deciphering pre-compound emission in low energy heavy ion interactions from recoil range and spin distributions

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Emission of light fast particles (LFP), particularly in heavy ion reactions at low energies, has regenerated interest in pre-compound (PCN) processes. Generally, the relative strength of compound (CN) and PCN components in such reactions is estimated from the enhancement in the flux of emitted LFPs in forward direction over the backward direction. Another method often employed is to analyze the measured excitation functions (EFs) for deviations from the statistical predictions and to attribute them to the PCN processes.

However, the underlying reaction mechanism is still not well understood particularly for those reactions which are associated with the loss of particles in primary stage in a very short reaction time (10^{-21} sec.) prior to the establishment of equilibrated CN. The loss of these particles termed as "pre-equilibrium (PE) particles" reduces the momentum of the product residues. As such, the measurement of the momentum transferred during the interaction may provide a promising tool for the characterization of the reaction mechanism. Information about the momentum transfer may be obtained from the measurement of the recoil range distributions (RRDs) and the spin distributions (SDs) of the product residues. It is because of the fact that loss of particles via PE emission takes away a significant part of angular momentum, the driving input angular momentum associated with PCN products is relatively lower than that associated with CN process. Therefore, in such reaction residues high spin states are hindered which in turn results in lesser feeding to the states of lower spins.

In order to investigate the role of PCN emission following three consistent measurements i.e., the EFs, RRDs and SDs of product nuclei produced in the ^{16}O+^{169}Tm system have been carried out by using GPSC and GDA facilities of the IUAC, New Delhi. Measurement of the EFs and RRDs are based on the recoil catcher off-line spectroscopy. However, measurements of the SDs is based on the detection of prompt γ-rays of product residues in forward and backward directions. The details of these experiments are reported in our earlier publications[1–4].

Experimentally measured EFs has been analyzed within the frame work of statistical model code PACE for the reaction ^{169}Tm(^{16}O, 2n)^{183}Ir and is shown in Fig. 1(a). It has been found that measured EFs are significantly enhanced at higher energies. This observed enhancement of the experimental EFs for this reaction is attributed to the emission of the LFP (i.e., 2n) via PCN process during the equilibration of the compound nucleus.

Based on linear momentum transfer the

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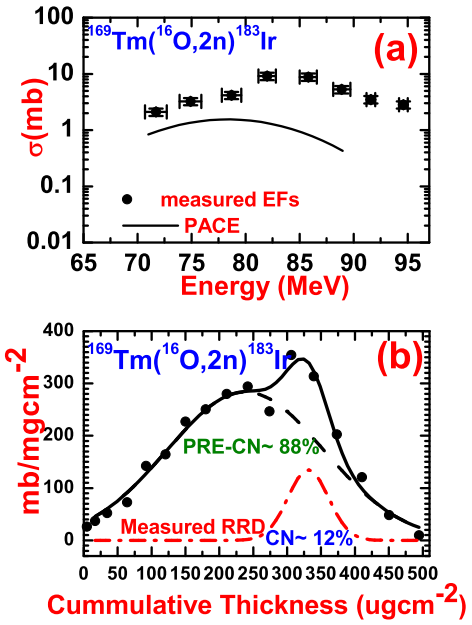

FIG. 1: The experimentally measured EFs and RRDs for reaction ^{169}Tm(^{16}O,2n)^{183}Ir

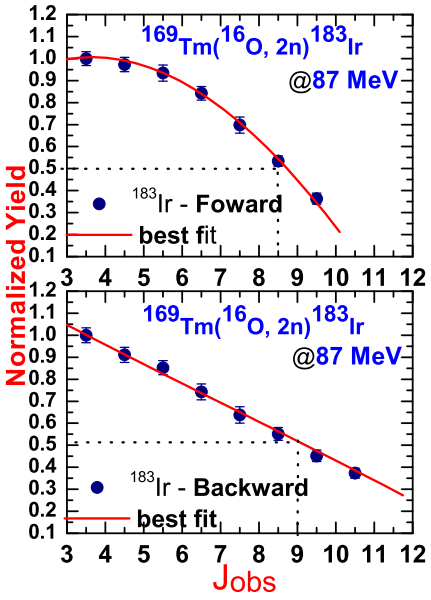

FIG. 2: The experimentally measured SDs for reaction ^{169}Tm(^{16}O,2n)^{183}Ir

relative contributions of the CN and the PCN processes have been measured for the same reaction ^{169}Tm(^{16}O, 2n)^{183}Ir by the measurements of forward RRDs at energy 87 MeV and is shown in Fig 1 (b). The Fig 1(b) shows a distribution corresponding to two distinctly different linear momentum transfer components. The higher value of RRD corresponds to full momentum transfer in CN process while lower value of RRD corresponds to reduced momentum transfer for PCN process. The relative contribution of CN and PCN processes obtained from EFs and RRDs measurements are found to match each other with an uncertainty of ≈5%.

The analysis of SDs of same reaction ^{169}Tm(^{16}O, 2n)^{183}Ir at 87 MeV as shown in Fig 2. indicates a relatively lower value for the driving input angular momentum associated with PCN process than that for the CN process. Feeding intensity profiles generated from the experimental SDs suggest less feeding during the de-excitation of pre-compound residues. The population of high spin states during the de-excitation of fully equilibrated CN as compared to those populated via PCN processes reveals that a significant fraction of angular momentum is taken away by the emission of light fast particles. Further details will be presented.

References

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