Reaction Mechanism of Multi-nucleon Transfer: Recent Studies with Spherical and Deformed Nuclei

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Significant advances have been achieved in the last years in the field of heavy ion induced multinucleon transfer reactions around the Coulomb barrier. Nice reviews on this subject can be found in Refs.[1, 2] and references therein. The nuclear structure effects eg., deformation is observed to have significant influence on heavy ion fusion cross section at energies near and below the Coulomb barrier[3,4], however, the target deformation dependence of multinucleon transfer cross section between complex nuclei needs a detailed study[5]. The multinucleon transfer reactions, beside studies of multi-particle correlations and nuclear structure, can be used for production of neutron rich unstable nuclei. Transfer reactions using radioactive beams also give access to a wide field of nuclear structure studies in the far-off stability region.

In spite of considerable progress in this field, the reaction mechanism is not so well understood especially when the number of nucleon transferred is large. For multinucleon transfer below or around the Coulomb barrier energies, the cross section in general is rather small and therefore one depends on detection systems having large acceptance and high resolution like magnetic spectrograph[1] etc. On the other hand the probability for transfer usually increases at higher projectile energies. But at high bombarding energies the price one pays is the difficulty in resolving transition to specific nuclear states due to the shift of Q-opt (optimum Q-value) to higher negative values. As a consequence, one deals with transfer cross sections which are result of integrations over wide Q-value window and any information on the reaction mechanism aspects can be probed by looking at the behavior of differential and total cross sections for excitation energy integrated data and total kinetic energy loss distributions of multineutron and multiproton transfer channels.

Recently we have performed[6,7] a series of measurements at the Pelletron-LINAC facility, Mumbai using various projectile (^{18,16}O) and target (^{206,208}Pb, ^{154}Sm, ^{27}Al) combinations. Reaction channels involving transfer of upto nine-nucleons have been detected. Total kinetic energy loss spectrum and angular distribution of cross sections have been measured. The θ- and Q- integrated cross sections are deduced. Fully microscopic Time Dependent Hartree-Fock (TDHF) model calculations[8], based on independent single nucleon transfer mode, have been carried out and are compared with the experimental data of multi-nucleon transfer reactions with an emphasis to understand multinucleon correlations. The TDHF calculations give a reasonably good agreement with the measurement for few nucleon transfer process, however, the theory becomes less accurate as the number of nucleons transferred increases. Effect of particle evaporation on the production cross sections has been studied. Inclusion of evaporation effects gives some improvements towards the measurement, however, the calculations still under predict the measured cross section by a significant amount especially for the cases where a large number of nucleons transferred are involved. Possible origin of these discrepancies and the importance of multi-particle correlations / pairing effects will be discussed.

The Samarium isotopes are known to span a wide range of deformation from the spherical ^{144}Sm to well deformed ^{154}Sm (prolate with quadrupole deformation β = 0.32). The present set of data will allow a detailed comparison between different systems (i)^{16}O+^{154}Sm (doubly magic nucleus ^{16}O and deformed target), (ii) ^{16}O+^{208}Pb (both projectile and target are doubly magic nuclei) and ^{18}O+^{206}Pb (deformed projectile and spherical target). In the present talk an overview will be given on aspects closely connected to the reaction mechanism aspects and the influence of nuclear structure, eg., deformation on multinucleon transfer processes.

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