Multi-nucleon Transfer Reactions with Deformed Target near Coulomb Barrier

B. J. Roy[1*], Y.Sawant[1], N.Dhingra[2], S.Santra[1], A.Pal[1], A.Kundu[1], D.Chattopadhyay[1], T.N.Nag[3], V.Jha[1], S.K. Pandit[1], V.V.Parkar[1], K.Ramachandran[1], K.Mahata[1], R.N.Sahoo[4], P.P.Singh[4] B.K.Nayak[1], A.Saxena[1] and K.Sekizawa[5]

1: Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400 085
2: Department of Physics, Amity University, Noida, Uttar Pradesh 201313
3: Radiochemistry Division, Bhabha Atomic Research Centre, Mumbai - 400 085
4: IIT- Ropar, Rupnagar, Punjab - 140001
5: Warsaw University of Technology, Koszykowa 75, 00-662 Warsaw, Poland

** Corresponding author, Email: bjroy@barc.gov.in*

In an experiment at the Pelletron- LINAC accelerator facility, Mumbai, we have measured multinucleon transfer cross sections with deformed target nucleus at energy around the Coulomb barrier. The system chosen was ^{16}O (spherical shape) + ^{154}Sm (prolate shape, β = 0.32). The primary motivation was to understand the deformation/ orientation dependence on the reaction mechanism of multinucleon transfer. For a comparison, we have also measured in the recent past transfer cross section for the systems ^{16}O+^{208}Pb(both projectile and target are of spherical shape) and ^{18}O+^{206}Pb (projectile prolate deformed) [1].

The experiment was carried out with ^{16}O beams of 85 MeV at the Pelletron-LINAC facility, Mumbai. An enriched ^{154}Sm target (on ^{27}Al backing) was used and projectile like fragments (PLF) were detected with silicon SSB detectors in ΔE-E configuration. A clear charge and mass separation for transfer products was achieved and reaction products were identified using particle identification algorithm. Data were also collected with ^{27}Al target for background subtraction. The elastic scattering angular distribution was also measured simultaneously. The optical model analysis of the measured elastic angular distributions was performed and the potential parameters were extracted.

Angular distributions for Q-integrated data for transfer reactions have been extracted and are plotted in Fig.1. The angular distributions in general are bell shaped indicating the grazing character of the reaction, peaking at an angle near the grazing angle. The total cross sections for different transfer processes have been obtained by integrating the angular distributions assuming Gaussian distribution as shown in the Fig.1.

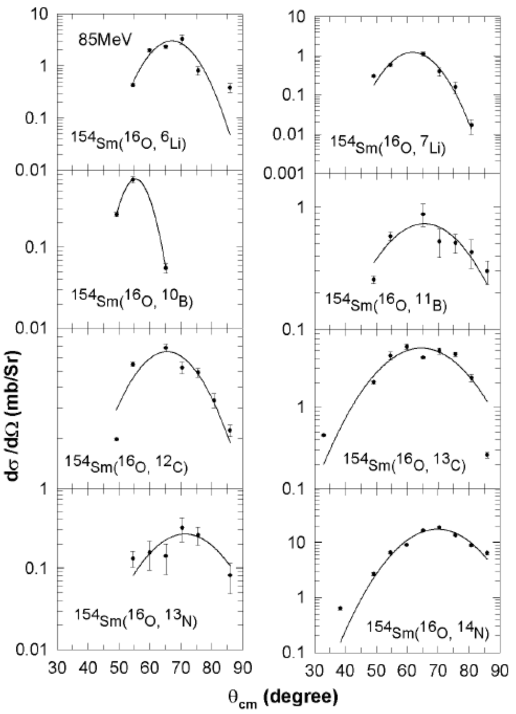

Fig.1 Preliminary results for angular distribution for some of the transfer reactions as representative cases.

Theoretical understanding of multinucleon transfer reactions is complicated and there is a lack of clear-cut theory for understanding the underlying mechanism, relative importance of various transfer paths[2] and effect of multinucleon correlations[3]. The present data are being analysed employing a microscopic framework of the TDHF theory developed by

Sekizawa and Yabana[4]. The detailed formalism has been described in our earlier work[1]. TDHF calculations (with Skyrme SLy5 parameter set) and present experimental data are shown in Fig.2&3. The calculations are performed for three different orientations of ^{154}Sm: the symmetry axis of ^{154}Sm is set parallel to the collision axis (x-direction), the impact parameter vector (y-direction), and perpendicular to the reaction plane (z-direction). A large discrepancy between calculation and measured data is observed when number of nucleons transferred is large probably indicating importance of effect of particle evaporation. Calculations incorporating these effects are being performed. GRAZING code calculations are also performed and are shown for comparison.

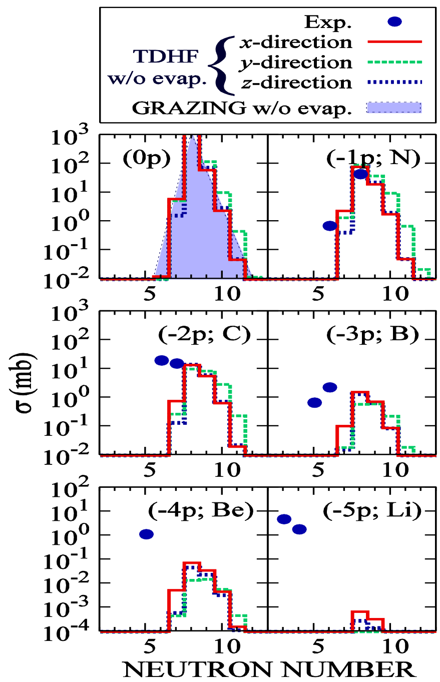

FIG. 2: TDHF calculations for various transfer reactions in ^{16}O+^{154}Sm reaction at 85 MeV. x-, y- and z- direction represents different orientation between projectile & target during collision. Experimental data are preliminary results.

In order to study orientation dependence of the transfer dynamics, we have also performed TDHF calculations for neutron rich ^{24}O + ^{154}Sm at the same C.M. energy. It is to mention that ^{24}O is spherical having magic proton number and neutron sub-shell closure with N=16. The results are compared between these systems and also with ^{16}O+^{208}Pb and ^{18}O+^{206}Pb. Interesting observations are made from these calculations (Fig.3&4): neutron pick up prefers y-direction for ^{16}O+^{154}Sm whereas for ^{24}O + ^{154}Sm system proton pickup prefers in y-direction and neutron stripping is preferentially in x- and z- direction. No neutron pickup is observed in the 2nd system. Such interesting deformation dependence needs to be further investigated. Results for other systems ^{16}O+^{208}Pb and ^{18}O+^{206}Pb will be presented.

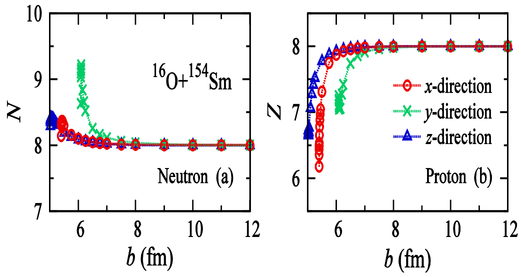

Fig.3 Average number of nucleons in the lighter fragments for system ^{16}O+^{154}Sm at E_{Lab} =85MeV.

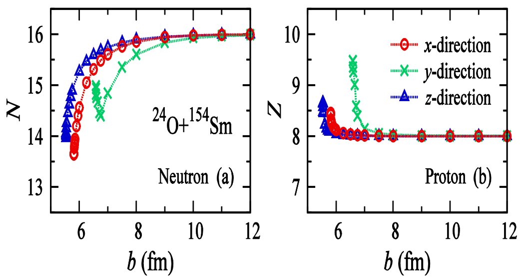

Fig.4. Same as Fig.3 but for ^{24}O+^{154}Sm at the same CM energy.

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