Multi-nucleon Transfer Study at above the Coulomb Barrier ($E_{c.m.}/V_C \sim 1.6$)

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Nuclear reactions involving a large number of nucleons transferred from projectile to target and vise-versa have been often observed to occur with a probability comparable to that of single nucleon and account for a large fraction of the total reaction cross section. The multi-nucleon transfer plays a very important role for the definition of the reaction mechanism that describes the evolution of the reaction from the quasi-elastic regime to the more complex deep-inelastic reactions and could provide a detailed insight into the underlying reaction mechanisms and its effect on the other reaction processes. The cross section for such multi-nucleon transfer reactions is usually small below and around the Coulomb barrier, the probability of transfer increases with increasing beam energy. Thereby, study of nuclear reactions in which a very large number of nucleons transferred is feasible at higher energy. However, the understanding of reaction mechanism at higher energy becomes difficult and complicacy increases with increasing bombarding energy. The Q-opt, optimum Q-value, for such reactions shifts to higher negative value, thereby, preferentially populating the higher excited states /continuum in the final nuclei which is difficult to resolve experimentally. Therefore one talks of Q-integrated cross section and any theoretical understanding of the reaction mechanism and extraction of structure information from the energy integrated data is not that straightforward as in the case of transfer to specific levels.

With a motivation to understand the multi-nucleon transfer reaction mechanism, we have studied the reaction $^{18}O+^{206}Pb$ at $E_{cm} \sim 1.6 \times V_C$. The reaction $^{18}O+^{206}Pb$ has the advantage of having a +ve Q-value for the two-neutron stripping channel, cross section for the 2n- and 2n- correlated transfer are expected to be large. The experiment was carried out with ^{18}O beams at the Pelletron-LINAC facility, Mumbai. An enriched ^{206}Pb target evaporated on carbon backing was used and projectile like fragments (PLF) were detected with SSB detectors of appropriate thickness. We could achieve a clear mass separation up to oxygen isotopes in ΔE-E configuration (see Fig.1.).

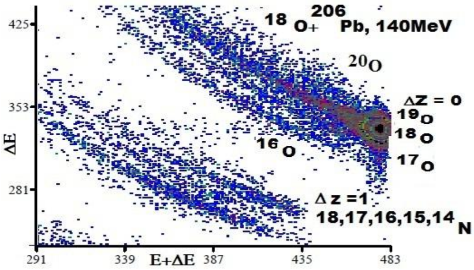

Fig.1 (colour online) A ΔE-E plot showing the mass separation for oxygen and nitrogen isotopes

Angular distribution @139 MeV for all transfer channels up to ^{7}Be (ΔN=11) are measured (see Figs.2-5). The elastic scattering angular distribution was also measured simultaneously and the transfer probability (P_{tr}) was extracted. The optical model analysis of the measured $(d\sigma/d\Omega)_{el}$ was performed and the potential parameters were extracted and compared with that of our measured data at 79 MeV.

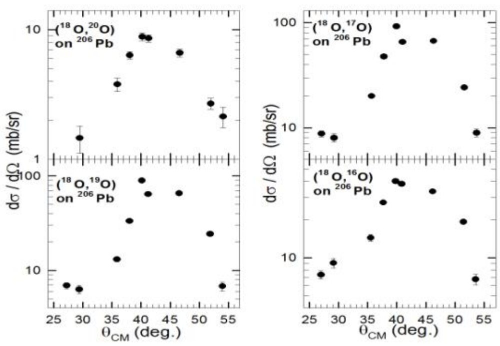

Fig.2 Angular distribution for oxygen isotopes

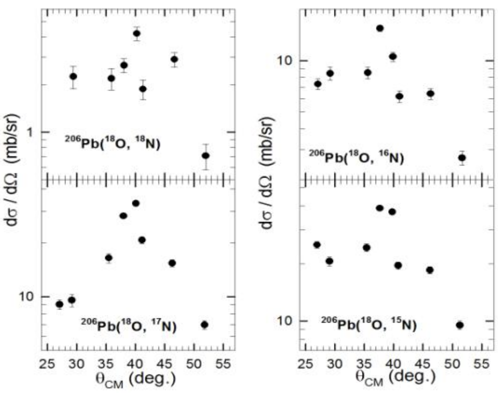

Fig.3 Angular distributions of nitrogen group

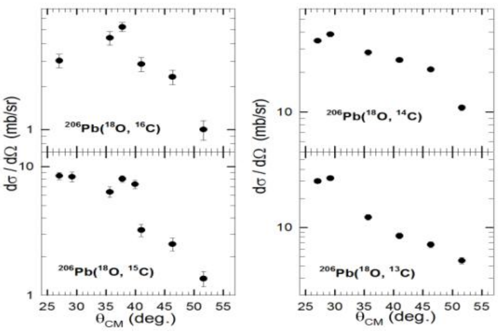

Fig.4 Angular distributions for carbon group

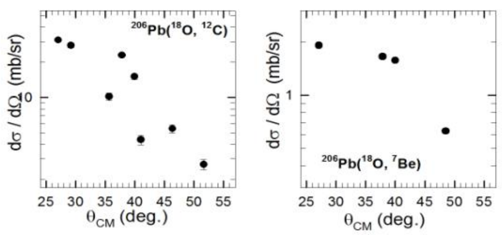

Fig.5 Angular distributions for the ^{12}C and ^{7}Be

The measured angular distributions for one- and two-nucleon transfer are typical bell shaped nature, while it is forward peaked when the number of nucleons transferred increases and is due to the increasing effect of the attractive nuclear potential. The P_{tr} values (plotted in Figs.6-8) for the present two-nucleon pick up and stripping reactions have been compared with the corresponding probabilities of successive transfer of two independent nucleons. The observed large difference between P_{2N} and the uncorrelated transfer of two nucleons $(P_{1N})^2$ is an indicative of the dominance of a correlated pair transfer of neutrons (protons) in the respective cases.

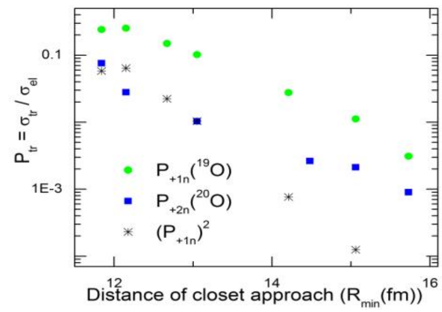

Fig.6 Transfer probabilities for the 1n and 2n pick up reactions compared with $(P_{+1n})^2$

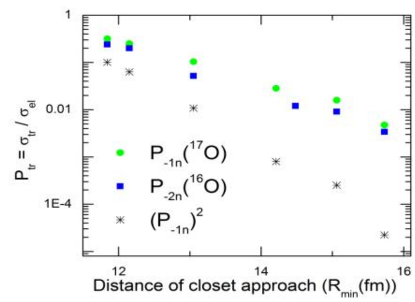

Fig.7 Same as Fig.6 but for 1n and 2n stripping

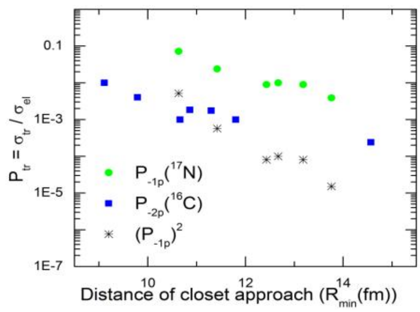

Fig.8 Same as Fig.6 but for 1p and 2p stripping

Theoretical understanding of heavy ion transfer reaction is complicated and there is lack of clear-cut theory for understanding the underlying mechanism & relative importance of various transfer paths. One such calculation would be to use the coupled reaction channel formalism and the inclusive cross section can be obtained by simply, though cumbersome, summing up all the specific transitions. Such calculations are being performed for understanding the present data.

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