Study of breakup and transfer breakup reactions in ^{7}Li+^{93}Nb system around the Coulomb barrier

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Understanding the mechanism of projectile break up is considered to be crucial while studying the reaction dynamics of weakly bound nuclei. Investigation of the two step reaction mechanism, namely, one nucleon transfer to a resonant state followed by breakup with these nuclei is of current interest. This complex process needs the simultaneous understanding of both the breakup and transfer reactions. Recent studies have revealed dominance of the two step mechanism with weakly bound ^{6,7}Li and ^{9}Be projectiles [1–3].

The present work reports the first measurement of the absolute differential cross-section for the transfer breakup reaction corresponding to both one proton and one neutron transfer. The measured cross-sections for direct breakup and transfer breakup have been analysed with continuum discretized coupled channels (CDCC) calculations and coupled reaction channels (CRC) calculations to get a deeper insight into the reaction mechanism that populate the states in continuum.

The experiment was carried out at 14UD BARC-TIFR Pelletron facility-Mumbai, using ^{7}Li beam of 24, 28 and 30 MeV. Self-supporting ^{93}Nb foils of thicknesses $\sim$1.75 mg/cm^2 were used as targets. Two segmented large area Si-telescopes of active area 5 x 5 cm^2 (thicknesses ΔE $\sim$50 μm, E $\sim$1500 μm) and five telescope consisting of Si-surface barrier detectors (thicknesses ΔE $\sim$ 20-50 μm, E $\sim$ 450-1000 μm) were used for coincidence measurement of the outgoing fragments. Two Si-surface barrier detectors (thicknesses 300 μm) kept at $\pm$20^{o} were used to monitor Rutherford scattering. The data were collected in an event by event mode, with the trigger generated from E detectors. Multiplicity threshold was kept at one to measure elastic scattering and at two for the measurement of breakup fragments in coincidence. The strips were calibrated using the known alpha energies from ^{7}Li+^{12}C reaction at 24 MeV. Particles were identified using energy loss information from ΔE and E.

The fragments' identity (A,Z), energy and relative angle were used to calculate their relative energy. The excitation energy of the ejectile prior to breakup were obtained by adding the breakup threshold to the measured relative energy. The efficiency of the detector for the detection of both the fragments depends on the velocity of the ejectile prior to breakup and the relative velocity of the fragments. Monte Carlo simulation technique was used to estimate the efficiency. The raw and efficiency corrected relative energy distributions are shown in Fig.1. The peaks in the relative energy spectra of α-α, α+d and α+t at 92 keV, 710 keV and 2.16 MeV correspond to the breakup of ^{8}Be (g.s.), ^{6}Li (2.18 MeV, 3^{+}) and ^{7}Li (4.63 MeV, $7/2^{-}$), respectively. The extracted differential cross-sections of these channels are shown in Fig.2.

CDCC and CRC calculations were performed using the code FRESCO. In the CDCC formalism ^{7}Li nucleus was considered as having α+t cluster structure. The optical potential for the entrance channel were generated by folding the α-target (V_α) and triton-target (V_t) potentials. The Wood-Saxon potential parameter for V_α and V_t were taken from global optical model potential [4, 5]. The results of the calculations (dotted lines) are compared with the measured angular distributions

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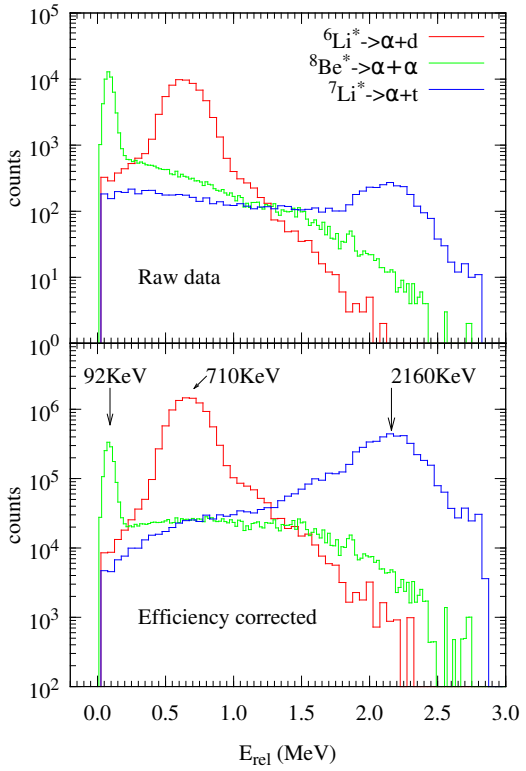

FIG. 1: Measured relative energy spectra between breakup fragments for reactions ^{7}Li on ^{93}Nb at beam energy E$_{beam}$=28 MeV.

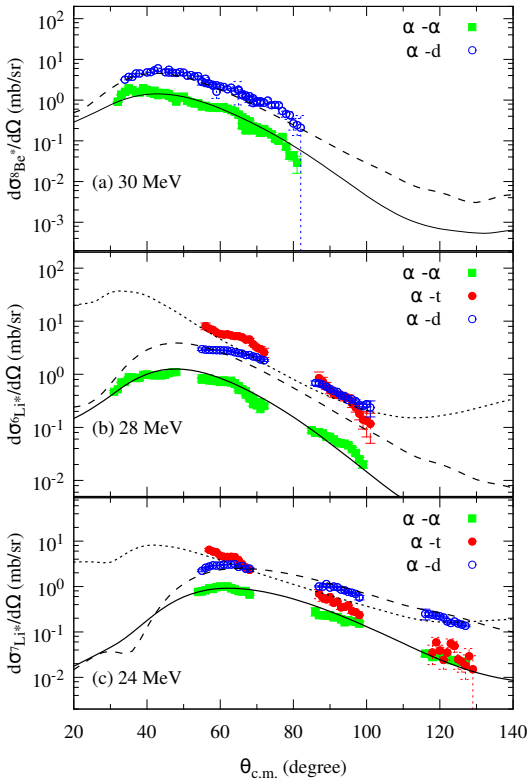

FIG. 2: Measured exclusive cross-sections for ^{93}Nb(^{7}Li,^{8}Be*), ^{93}Nb(^{7}Li,^{6}Li*) and ^{93}Nb(^{7}Li,^{7}Li*) reactions along with coupled channels calculations plotted as solid, dashed and dotted curve respectively.

for ^{7}Li* in Fig.2. In the CRC calculations excited states of ^{92}Zr up to 7 MeV were coupled for one-proton pickup from ^{93}Nb. Spectroscopic factor (SF) for all these states were assumed to be unity. As shown in Fig.2, the calculations (solid lines) are in good agreement with measured data. In case of calculations for 1-neutron stripping reaction, excited states of ^{94}Nb with excitation energy up to 2 MeV were coupled. SF values of all the states of ^{94}Nb were taken from the literature. Both ground state (1^+) and first excited state (3^+) of ^{6}Li were considered in the calculations. Calculations are in good agreement with measured data as shown by dashed lines in Fig.2.

In summary, measured direct and transfer breakup cross-sections for ^{7}Li+^{93}Nb reaction are presented. CDCC and CRC calculations are in a good agreement with the measured data.

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