Large Back-angle Quasi-elastic Scattering for ^{6}Li+^{159}Tb

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Introduction

Quasi-elastic scattering is defined as the sum of all direct processes such as elastic and inelastic scattering and transfer reactions. Fusion corresponds to transmission through a barrier and large back angle quasi-elastic scattering corresponds to reflection at that barrier and so because of conservation of the reaction flux these two processes may be considered to be complementary to each other. The measurement of the quasi-elastic scattering (QES) cross section is much easier compared to that of the fusion cross section. In the past few years, the investigation of reactions involving unstable nuclei, far from the valley of stability, has generated a great interest [1,2] due to the recent availability of radioactive ion beams. Reactions with beams of high intensity stable weakly bound nuclei (such as ^{9}Be, ^{6,7}Li) which have significant break-up probability are good references for testing the effect of weak binding of nuclei on the reaction mechanism. In this work, the measurement of large back angle quasi-elastic scattering excitation function of ^{6}Li+^{159}Tb is reported.

Experiment

The experiment has been performed using ^{6}Li beam at the 14UD BARC-TIFR Pelletron facility in Mumbai, India. A self-supported ^{159}Tb target of thickness ~560 µg/cm2 was used. Two Si detectors located at θ_{lab} =±20° with respect to the beam direction were used to monitor the beam and to normalize the cross sections. To detect and identify the charged particles produced in the reaction a set of four ΔE-E telescopes of Si-surface barrier detectors were placed at ±170° and ±160° relative to the beam direction inside a big scattering chamber of diameter 1m. The measurements were taken at bombarding energies from 17 to 33 MeV respectively, corresponding to energies well below to above the Coulomb barrier (25.5 MeV).

Results

A typical two-dimensional ΔE-E scatter plot from the detector telescope taken at a scattering angle of 160° showing (elastic + target inelastic scattering) and various transfer or breakup products at E_{lab}=24 MeV is shown in Fig.1. The energy calibration of x-axis of two-dimensional ΔE-(ΔE+Eres) spectrum was done using the elastic peaks of ^{6}Li beam scattered from ^{197}Au target (thickness~200 μg/cm^2) at different bombarding energies below Coulomb barrier.

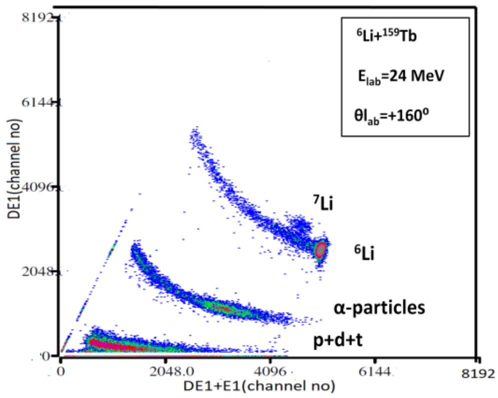

Fig.1 A typical two-dimensional ΔE-E spectrum at angle 160° and energy 24 MeV

The detected charged particles were identified from the ΔE-E spectrum and using the well-known Bethe formula $E.\Delta E \sim MZ^2$ where M and Z are the mass and atomic number of the particle. The peak in the Z=3 band arises from contributions due to elastic scattering of ^{6}Li and inelastic scattering from the excited states of ^{159}Tb. The ^{7}Li events resulting from 1-neutron transfer to ^{6}Li, appear above the ^{6}Li band. The Z=1 band shows a fall back feature because the stop detectors were not thick enough to stop the Z=1 particles. The present work being an inclusive measurement, the α-particles coming from all possible reaction processes are recorded. The contribution of the α-particles, emitted mostly at energies corresponding to beam velocity mainly originate from breakup related processes like NCBU (^{6}Li breaks into α+d) and ICF (where deuteron is captured by ^{159}Tb target, following the breakup of ^{6}Li into α+d). It may also have contributions from single nucleon transfer from ^{6}Li and consequently resulting in α-particles. The experimental results of QES excitation functions for ^{6}Li and ^{6}Li+α outgoing channels are shown in Fig.2. The centre-of-mass energies were obtained after the centrifugal correction. From Fig.2 it can be observed that the contribution of 1n-transfer channel (^{7}Li) is very small but there is a significant contribution of α-channel (transfer/breakup) at higher energies in the QES excitation function.

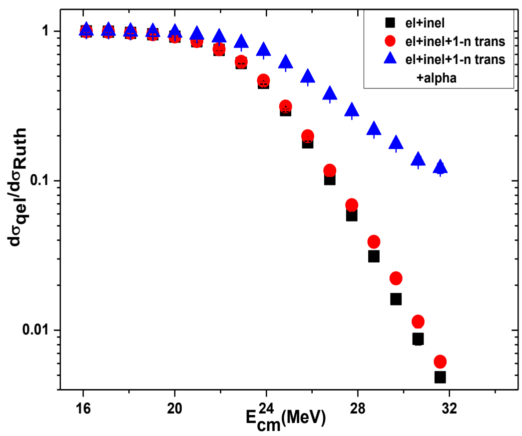

Fig.2. Quasi-elastic scattering excitation function

Coupled Channel Calculation

The experimental data for QEL excitation functions were analyzed within the coupled-channel (CC) method. A preliminary calculation was carried out using the code FRESCO [3]. To calculate elastic scattering cross sections a global optical model potential [4] was used. The Coulomb term is taken as that for a uniformly charged sphere of radius R_c = $1.3A_T^{1/3}$ fm where A_T is the target mass. The prediction from calculations with this optical model potential is shown in Fig. 3.

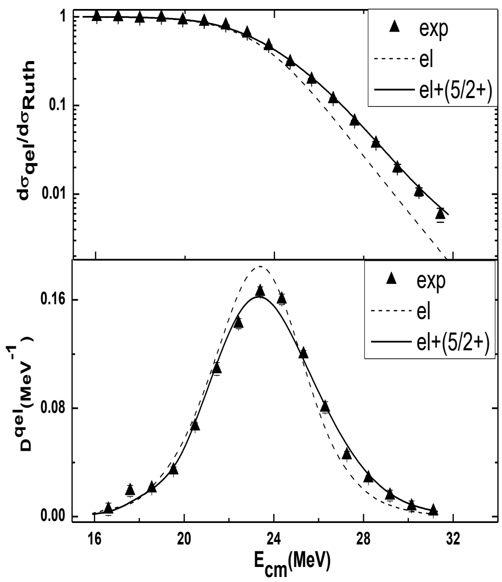

Fig.3 FRESCO calculations compared with the experimental data

The dashed curve is the result of the calculations without any coupling. The no coupling calculation for the excitation function is far from the experimental data. The ^{159}Tb is a well deformed nucleus with g.s. deformation parameter β_2=0.271. The solid curve is the result of a coupled channel (CC) calculations when inelastic excitation of the first excited state (5/2+) of ^{159}Tb target was included in the coupling scheme. Further calculations are in progress details of which will be presented at the conference.

References

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