Large back-angle quasielastic scattering of $^{7}Li+^{159}Tb$: coupled channel calculations

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Introduction

To investigate the role of different channel couplings on the fusion cross sections, extraction of barrier distribution from measured fusion excitation function is a relevant approach proposed by Rowley *et al* [1]. But to obtain a meaningful barrier distribution very precise measurement of fusion cross sections is necessary. Similar barrier distribution can also be obtained from large back angle quasielastic (QEL) scattering measurements, as QEL backscattering process can be considered to be complementary to the fusion process. QEL scattering is defined as the sum of elastic and inelastic scattering and all other direct reaction processes. For reactions induced by weakly bound projectiles, like $^{6,7}Li$, along with elastic scattering, inelastic scattering and n-transfer events, there can be strong contribution of α-particles, arising from breakup/transfer processes. For such cases, whether QEL scattering definition should include α-particle contribution or not remains a question. Therefore, for such systems, several authors have defined partial QEL scattering cross sections as a sum of elastic and inelastic scattering cross sections [2]. The present work deals with the partial QEL scattering contribution from the $^{7}Li+^{159}Tb$ reaction.

Quasielastic Excitation function

QEL scattering measurements were performed for the $^{7}Li+^{159}Tb$ system, at backward angles of 170° and 160° w.r.t. the beam direction, using beams from the 14MV BARC-TIFR Pelletron at Mumbai. The QEL excitation function and barrier distribution (b.d.) have been obtained from the data. The partial QEL excitation function corresponding to 170° has already been presented [3]. Subsequently, the data corresponding to 160° have been analyzed, and the partial QEL excitation function have been obtained and is found to agree very well with the excitation function obtained from the 170° data, as seen in Fig. 1.

Coupled Channel calculation

To analyze the QEL scattering cross sections, we have performed the CRC calculations using the code FRESCO [4]. As suitable optical model potential was not available for $^{7}Li+^{159}Tb$ system, to start with a global optical model potential [5] was used. The results of the CRC calculations are shown in Fig. 1. The black dashed curve shows the calculated elastic scattering cross sections. The ^{159}Tb is a well deformed nucleus with g.s. deformation parameter β_2=0.271. The sum of elastic and inelastic scattering cross sections were obtained including excitation of target rotational states up to $9/2^+$ state. The result is shown in the figure by the black solid curve. It can be observed that the calculated results using global potential for $^{7}Li+^{159}Tb$ falls way below the experimental data.

Next we used the energy dependent optical model potentials given in Ref [6] for the CRC calculation. The red dashed line represents the elastic scattering cross sections and the green solid line shows the results after including target inelastic excitation up to the same $9/2^+$ state and it shows slight enhancement in the above barrier region with the experimental data. But unfortunately this doesn't cover our entire energy range of measurement. Thus interpretation of QEL scattering data for ^{7}Li+^{159}Tb over our entire energy region of measurement requires an appropriate set of optical potential for the system.

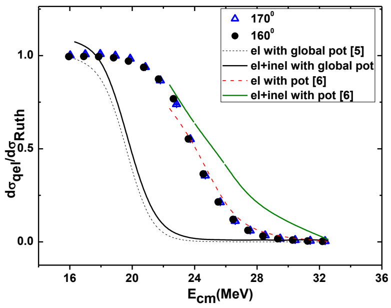

FIG. 1 Partial QEL excitation function for ^{7}Li+^{159}Tb at 170^{o} (blue triangles) and at 160^{o} (black circles) w.r.t beam direction. The different lines represent the CRC calculations with two different optical potentials. See text for details.

However, we have calculated the QEL excitation function using a scattering version of CCFULL program [7]. In this program, the nuclear potential has real and imaginary components, both of which are assumed to be Woods-Saxon. For the real part, we have used the potential parameters of Mukherjee *et al* [8]. For the real part of nuclear potential the parameters used were depth V_0=132MeV, radius parameter r_0=0.98fm and diffuseness parameter a=0.85fm. The imaginary part simulates compound nucleus processes, and a depth parameter of 30 MeV, radius parameter of 1.0 fm, and surface diffuseness parameter of 0.3 fm were used for the calculation. This choice of parameters confines the imaginary potential inside the Coulomb barrier with a negligible strength in the surface region. Target inelastic states were included by coupling to the ground state rotational band of ^{159}Tb nucleus. The low-lying rotational states can be considered to be built up through coupling of last valence proton to the 0+,2+,4+… rotational states present in neighboring even-even rotational nucleus ^{158}Gd or ^{160}Dy. So, the excitation energy and deformation parameters for ^{159}Tb nucleus were taken as the averages of corresponding values for neighboring even-even rotational nucleus ^{158}Gd and ^{160}Dy. The ground state rotational band of the corresponding average spectrum, up to 12^+ , were included in the calculation and deformation parameters used were β_2=0.344 and β_4=+0.062. The coupled channels calculations for QEL excitation function and b.d. are shown in Fig.2. The red solid line shows the uncoupled calculations and the blue dashed line shows the calculated results including coupling to the target excited states. The results of the CCFULL calculation agree fairly well with the experimental excitation function and barrier distribution. Details of the calculations will be presented at the conference.

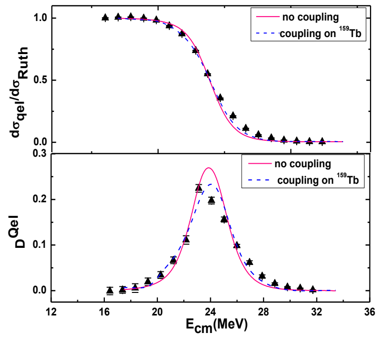

FIG. 2 CCFULL calculations compared with the experimental data. Upper: QEL excitation function excitation function, lower: QEL barrier distribution

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