Quasi-elastic Scattering Measurements for ^{28}Si+^{154}Sm System

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Introduction

In heavy ion reactions, couplings to different channels affect the fusion cross section. This gives information about the nuclear properties through fusion excitation function and barrier distribution (BD). It has been suggested that channel couplings also affect the scattering process and same information can also be obtained from quasi elastic (QE) scattering (a sum of elastic, inelastic, transfer and other peripheral processes) cross sections at large backward angles [1]. Expermimental advantages of measuring the QE cross section over fusion cross section measurements are reported in Ref. [2]. Eventhough, a simple energy detector is sufficient to obtain QE events, employing hybrid detector has an advantage of Z identification which inturn gives the transfer channels information. The effect of various transfer channels in nuclear process may be probed from the detail angular distribution studies. Total reaction cross section can also be calculated from QE angular distribution.

In the present work, we have measured the QE scattering cross section at large backward angle and the QE angular distribution for the system ^{28}Si+^{154}Sm using hybrid telescope detectors. Experimental BD has been extracted from the measured QE cross section using the method proposed by Timmers et al. [3] and results are compared with the coupled channel calculations.

Experimental Setup

Measurements were performed in the General Purpose Scattering Chamber (GPSC) facility using ^{28}Si beam from 15UD Pelletron at IUAC, New Delhi. Sandwiched ^{154}Sm target of typical thickness $\sim 200\ \mu g/cm^2$ with carbon capping and backing of thickness $\sim$ 20 and 40 $\mu g/cm^2$, respectively, was used. The experimental measurements have been performed employing thirteen hybrid telescope detectors with gas ionisation detector as dE detector and PIPS detector as E detector. The active length of dE detector was 18 mm which is equivalent to 2 μm of SBD and the thickness of E detector was 300 μm which was sufficient to fully stop the heavy projectile like particles. Four telescopes, two in plane and two out of plane, each at angle of 170^0 were placed in the ring for the QE measurements at backward angle. For angular distribution and elastic cross section at forward angles, six telescopes were placed at the angle from 140^0 to 40^0 with angular separation of 20^0. Other three telescopes were at angle of 33^0, 45^0 and 57^0. The spectra were recorded in the bombarding energy range from 90.0 to 135.0 MeV in steps of 2.0 MeV. Two silicon surface barrier detectors, to monitor the beam and to determine the absolute values of the cross sections, were positioned at $\pm 10^0$ w.r.t. beam direction.

Results and Discussion

A two-dimensional spectrum of the differential energy loss in dE versus residual energy in E detector gave the Z identification of the incoming particle, allowing the distinction of projectile like particles from background particles. Typical particle identification spectrum obtained in the ^{28}Si+^{154}Sm reaction at θ_{lab}= 170^0 for E_{lab}=118 MeV has been shown in FIG. 1. As QE is sum of all peripheral pro-

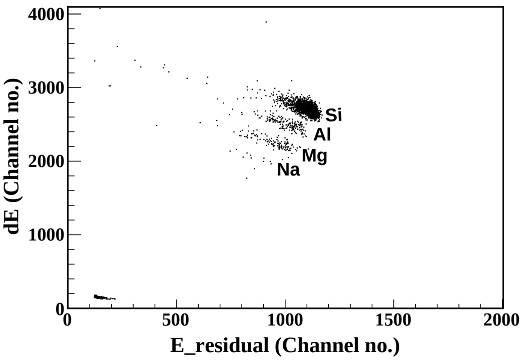

FIG. 1: Online 2D spectrum for E_{lab}=118 MeV obtained with one of the dE-E hybrid telescope detector placed at 170^0 w.r.t. beam direction.

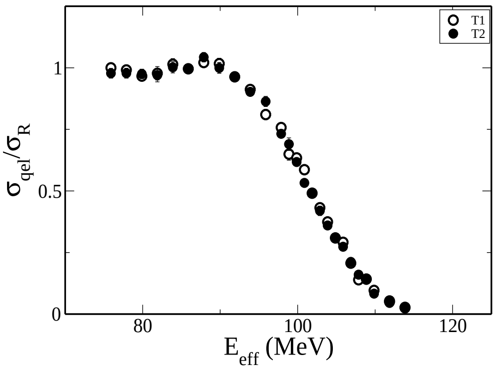

FIG. 2: Quasi elastic excitation function for the reaction ^{28}Si+^{154}Sm.

cesses, so sum of all the measured counts has been considered in calculating the QE cross section. FIG. 2 shows the excitation function, obtained from two telescopes T1 and T2 placed at θ_{lab}= 170^0, as a function of E_{eff} where E_{eff}=$2E_{cm}/(1+\mathrm{cosec}(\theta_{cm}/2))$, introduced to correct for centrifugal effects. Experimental BD has been extracted from measured QE events and is shown in FIG. 3. For understanding the BD structure, theoretical calculations have been performed using CCFULL program [3]. Notation [n_1;(n_2,n_3)] has been used to describe a state of the interacting nuclei. Here, n_1 denotes the number of quadrupole vibrational excitations of ^{28}Si projectile, whereas n_2 and n_3 represent the number of rotational states and octupole vibrational phonon of ^{154}Sm nuclei, respectively, included in the coupled channel calculation.

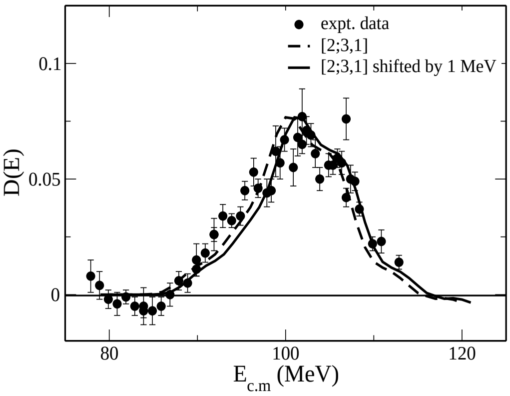

FIG. 3: Experimental barrier distribution (dots) for ^{28}Si+^{154}Sm. Lines represent the coupled channel calculations (see text for detail).

Conclusions

Consistency between the theoretically calculated fusion BD and that obtained from measured QE cross sections at large backward angle indicates that the QE method gives a good representation of the fusion barrier, though it is shifted in energy by 1 MeV. This shift is due to the distortion of the Rutherford trajectories by the nuclear field. The octupole vibration of ^{154}Sm seems to play a vital role in addition to its rotational excitation.

Measured QE angular distribution will be studied in further analysis.

References

[1] M. V. Andres et al., Phys. Lett. B **202**, 292 (1988).

[2] K. Hagino et al., Phys. Rev. C **69**, 054610 (2004).

[3] H. Timmers et al., Nucl. Phys. A **584**, 190 (1995).