Elastic scattering of $^{6}Li + ^{112}Sn$ system near barrier energies

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Introduction

In nuclear reactions the simplest experiment contemplated is the elastic scattering experiment between a projectile and a target that can be induced by a hadronic interaction. In spite of that it plays the vital role to provide the information of nuclear properties. Up till now the study of interacting potentials of the tightly bound nuclei as a function of energy, in the elastic scattering experiments near Coulomb barrier energies has been popularly named as Threshold Anomaly (TA) [1, 2]. In this the real and imaginary parts of the potential show a rapid variation and are consistent with the dispersion relation [3, 4]. But nowadays the direction have been changed by the replacement of tightly bound with weakly ones, and many aspects differing from the former ones have been developed in the recent past few years. One of the chief aspect is the possibility of the opening of other channels especially breakup using the weakly bound projectiles such as ^{6}Li, ^{7}Li & ^{9}Be in the elastic scattering experiments in the vicinity of the Coulomb barrier has attained a great attention. Here the projectile being weakly bound, couples to the breakup channel and the probability of breakup cross section stays alive. Furthermore it has been also observed that the breakup cross section becomes larger than the fusion cross section at the sub barrier energies [5] and contradicts to the usual Threshold Anomaly and this effect is named as Breakup Threshold Anomaly (BTA) [4]. In the former a localized peak in the real part of the potential and a sharp decrease in the imaginary part is observed as the bombarding energy decreases to the Coulomb barrier and in the later one the case seems to be vice a versa i.e., the imaginary part shows the increasing trend with a small reduction in the real part of the potential near the barrier. In usual TA it is considered that an attractive polarization potential has been developed due to the coupling of elastic channel to the other reaction channel and then decrease of the imaginary part of the potential near and below the Coulomb barrier is considered as the closing of non elastic channels, whereas in BTA a repulsive real polarization potential [6] has been developed and the reason assumed for the increase of imaginary part of the potential is the opening of the breakup channel near and below the Coulomb barrier. The purpose of the present work is to provide accurate elastic scattering data for the ^{6}Li + ^{112}Sn system and to extract the influence of breakup on these channels.

Experimental Details

In the present work we have also tried to investigate the BTA by performing elastic scattering experiment in the near, below and higher energies to the Coulomb barrier using the weakly bound projectile ^{6}Li and the medium mass range target ^{112}Sn. The experiment was performed using the $^{6}Li^{+3}$ beam delivered by the 14UD Pelletron accelerator of the TIFR/BARC facility in Mumbai, India. To study the energy dependence of the interaction potential, the bombarding energies were selected from below to much above the Coulomb barrier viz., 21, 23, 25 and 35 MeV. The nominal Coulomb barrier for this system is around 23.8 MeV (all the energies mentioned are in the laboratory frame). Beam currents were typically in the range of 2.5–30 nA. The beam energies were corrected for the half target thickness in the analysis process that amounts to a maximum of 110 keV for 21 MeV and a minimum of 79 keV for 35 MeV. The beam was bombarded on a 540 μg/cm^{2}, self supported enriched ^{112}Sn (≥ 99.5%) target and the elastically scattered ^{6}Li ions were detected by three solid state silicon surface barrier detectors in a ΔE + E telescopic arrangements. The telescopes used were of different thickness viz., T_1 with ΔE = 30 micron and E = 300 micron thick, T_2 with ΔE = 25 micron and E = 1 mm thick, and T_3 with ΔE = 50 micron and E = 2 mm thick. Two monitor detectors M_1 = 200 micron and M_2 = 600 micron were used for the absolute normalization. The telescopes were placed on a rotatable arm inside a 1 meter scattering chamber at angular separation of 10° between consecutive telescopes and both monitors were placed at ± 20°. The angular distributions were measured in steps of 2.5° to 5° at angles $\theta_{lab} \leq 173°$ for lower energies and $\theta_{lab} \leq 105°$ for higher energies. The data were recorded using the Linux based data acquisition system LAMPS.

Results and Discussion

Optical model analysis of elastic scattering angular distribution data has been carried out to extract the optical potential parameters and reaction cross sections at the energies at which data were obtained. The elastic scattering angular distribution data for the systems under consideration were analyzed with the optical model (OM) using a phenomenological Woods-Saxon potential (WSP). The calculations were performed by using the ECIS code (7). With an average sensitive radius R_{Sr} = 8.92 fm (average between R_{Sr} and R_{Si}) and the mean diffuseness a=0.67 fm, we have calculated the energy dependence of the real and imaginary potentials at this radius. Fig. 1 shows the experimental elastic scattering angular distribution and best fit obtained using the potential parameters in the table. The corresponding values of the energy dependence of the real and imaginary potentials for the $^{6}Li + ^{112}Sn$ system are shown in Fig. 2.

Energy	V_r (MeV)	V_i (MeV)	χ^2 /n	σ_R (mb)
21	17	25	5.00	235
23	16	24.7	5.33	480
25	18	26	4.92	736
35	20.4	41	9.46	1660

In conclusion the presence of BTA / TA is not clearly seen in the present result. This is probably due to insufficient amount of energy point data.

References

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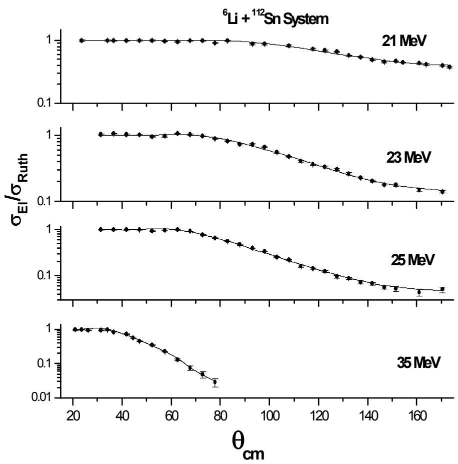

Fig. 1. For details see in text.

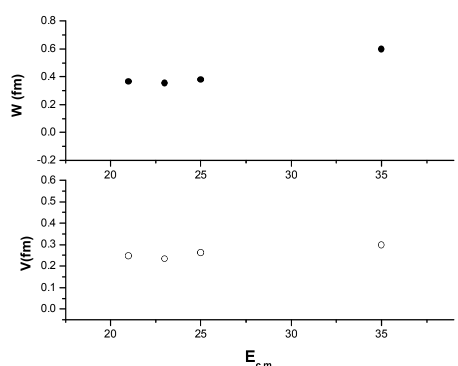

Fig. 2. For details see in text.