Elastic scattering angular distribution in the ^{7}Li + ^{232}Th reaction

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Introduction

Elastic scattering reactions are the simplest of all nuclear reactions. Precise measurements of the elastic angular distributions determine parameters of the real and imaginary parts of the nuclear interaction potential. From systematic analysis of elastic-scattering measurements involving tightly bound nuclei, the so called "threshold anomaly" (TA) has been observed in a number of systems [1]. A characteristic localized peak in the real part and the corresponding decrease of the imaginary part of the potential are observed as the bombarding energy decreases towards the Coulomb barrier. This has been understood in terms of couplings of elastic channel to the direct reaction channels that generate an additional attractive real dynamic polarization potential. In an earlier work, it has been observed that in heavy ion induced reactions, the projectile structure plays an important role [2]. Particularly, in case of scattering of loosely bound projectiles a different type energy dependence from that of TA is observed, which has been known as `breakup threshold anomaly' (BTA). In case of BTA, a repulsive real dynamical potential is generated due to couplings of breakup channels to the elastic scattering. There are some contradictory observations regarding BTA. For ^{7}Li + ^{208}Pb, TA has been observed, whereas for ^{6}Li + ^{209}Bi, the BTA has been observed [3]. Therefore, more measurements involving heavy targets and weakly bound projectile are required to understand the systematics of TA and BTA.

In the present work, the results on investigation of elastic scattering for ^{7}Li + ^{232}Th system have been reported through very precise and complete angular distribution measurements at energies from below the Coulomb barrier to approximately twice this value. The total reaction cross sections for this system have also been derived in order to investigate the role of breakup on the total reaction cross section.

Experimental details and results:

The experiment was performed using ^{7}Li beam from BARC-TIFR Pelletron facility, Mumbai, India. The beam was bombarded on self supporting ^{232}Th target of thickness 1.6mg/cm^{2}and the elastically scattered ^{7}Li ions were detected by four silicon surface barrier detectors in ΔE-E telescopic arrangements. The telescopes used had a thickness (T_1) with ΔE=25 μm and E=300 μm (T_2) with ΔE=15 μm and E=1.5 mm (T_3) with ΔE=15 μm and E=1.0 mm and (T_4) with ΔE=15 μm and E=1.0 mm. Two monitor detectors with thickness around 300 μm were used for absolute normalization and beam monitoring. The elastic scattering angular distribution measurements were carried out for different beam energies covering a wide range from 24 to 44 MeV.

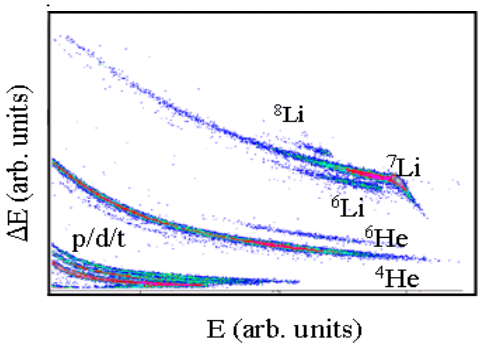

Fig.1: Typical ΔE Vs E spectrum for ^{7}Li + ^{232}Th system at $\theta_{lab=}$ 60°.

Fig.1 shows a typical two-dimensional ΔE vurses E spectrum for the present system ^{7}Li + ^{232}Th at a laboratary angle θ_{lab}=60^{o}. The elastic scattering angular distribution measurements have been carried out in a wide angular range from 25^{0} to 170^{0}. The ratios of elastic to the Rutherford scattering cross sections have been plotted as a function of scattering angle ($\theta_{c.m.}$) for various bombarding energies as shown in Fig.2.

The optical model analysis of the elastic scattering data were performed using the SNOOPY8Q code [4]. In the fitting procedure the real and imaginary diffuseness parameters (a_o and a_w) were kept fixed and only the strength of real and imaginary potential parameters (V_o and W_s) were varied to obtain the best-fit of the experimental data. Over all, very good fits to the experimental data were obtained at all energies as shown in. Fig.2. The values of the potential parameters for the best fit and the total reaction cross section are shown in Table-I. The best fitted optical model parameters show significant energy dependece as reflected from Table-I. This significant energy dependence is a characteristic feature of the elastic scattering. More detailed analysis with different form of the potential is being carried out and the results will be presented in the symposium.

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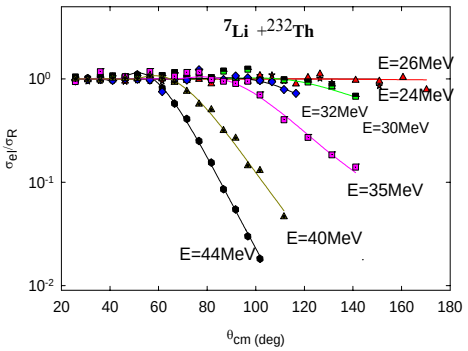

Fig.2: Elastic scattering angular distribution for the ^{7}Li + ^{232}Th system at different beam energies. The solid lines are optical–model fits to the data using the SNOOPY8Q code.

TABLE-I: Optical model parameters obtained by fitting to experiment elastic differential cross section data using the SNOOPY8Q code in ^{7}Li + ^{232}Th reaction.

Energy(MeV)	V_o	W_s	a_o	a_w	σ_{tot} (mb)
44	31.53	18.83	0.670	0.670	2110
40	35.28	33.61	0.670	0.670	1639
35	42.23	23.18	0.670	0.670	685.2
32	79.67	35.15	0.670	0.670	364.4
30	132.96	30.41	0.670	0.670	161.9
26	70.00	38.50	0.670	0.670	4.196
24	55.00	38.50	0.670	0.670	0.2499

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