Threshold anomaly in the ^{6,7}Li + ^{232}Th reactions

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Introduction

The measurements of the elastic scattering angular distributions determine parameters of the real and imaginary parts of the optical model potential parameters. 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, 2]. 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 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 + ^{80}Se, TA has been observed, whereas for ^{6}Li + ^{80}Se, the BTA has been reported [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, we have investigated the elastic scattering for ^{6,7}Li + ^{232}Th systems through very precise and complete angular distribution measurements at energies around the Coulomb barrier. The main objective was to observe the TA/BTA in those weakly bound projectiles in terms of dispersion relation.

Experimental details and results:

The experiment was performed using ^{6,7}Li beams to bombard a self supporting ^{232}Th target of thickness 1.6 mg/cm^2. Four ΔE-E silicon surface barrier detector telescopes and two monitor detectors were mounted inside the general purpose scattering chamber for measuring the elastically scattered ^{6,7}Li particles in the angular range 20-150 deg.

The optical model analysis of the elastic scattering angular distribution data were performed using the ECIS code [4]. In the fitting procedure the real and imaginary diffuseness parameters (a_v & a_w = 0.71 fm) and radius parameter (r_o = 1.06 fm) 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 for both systems, as shown in Fig.1 and 2.

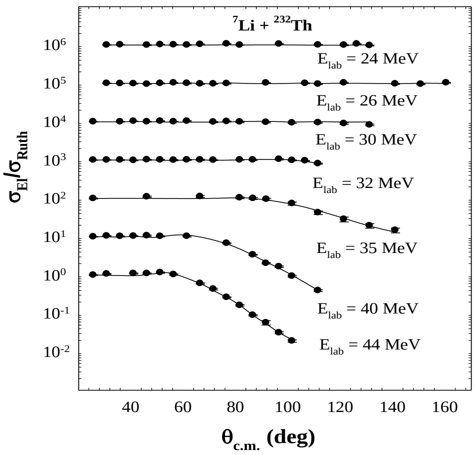

Fig.1: Elastic scattering angular distribution for the ^{7}Li + ^{232}Th system at different beam energies. The solid lines are optical–model fits to the data using the ECIS code.

The mathematical relation between the energy dependent real and imaginary parts of the optical potential in the dispersion relation given in Ref. [2] is

$$\Delta V(E) = \frac{P}{\pi} \int_{-\infty}^{+\infty} \frac{W(E')}{E'-E} dE' \qquad (1)$$

Here, P denotes the principal value. Eq. (1) allows to evaluate ΔV, the dispersive contribution to the real part form the knowledge of empirical values of the optical model absorption term W (E) at sensitive radius.

In this work, the dispersion relation has been applied as a function of E at sensitive radius (R_s) to the phenomenological optical model potentials, determined in the energy range 24 to 44 MeV for both ^{6,7}Li + ^{232}Th systems. The linear segment model proposed in Ref. [1] was used in the

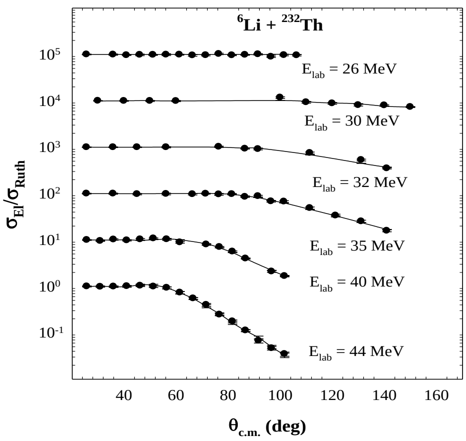

Fig.2: Elastic scattering angular distribution for the ^{6}Li + ^{232}Th system at different beam energies. The solid lines are optical–model fits to the data using the ECIS code.

imaginary part in order to get the real part. In both the systems, three sets of the real potential V(E) were obtained by numerical integration of Eq. (1) using three sets of different line segment fits of imaginary potential W(E) [5]. This analysis indicated the characteristic localized peak in the real part and the corresponding decrease of the imaginary part of the potential as the bombarding energy decreases towards the Coulomb barrier for ^{7}Li + ^{232}Th, thereby indicating the presence of usual threshold anomaly (TA). The fits of ^{6}Li + ^{232}Th system show that the imaginary part of optical potential parameters increases and there is a decrease in the real part of the potential parameters, which is an indication of break up threshold anomaly (BTA). The results on TA/BTA are presented in Fig. 3(a) and 3(b) and the present work clearly brings out the projectile structure effects on elastic scattering for weakly bound projectiles.

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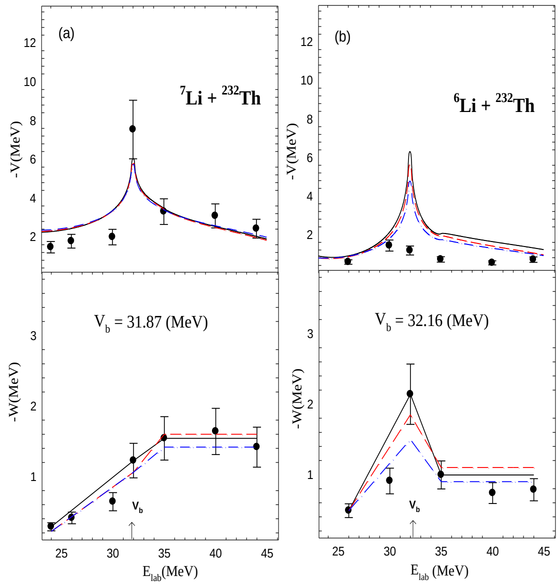

Fig. 3: Energy dependence of the real and imaginary potentials at r = 12.14 fm and 11.27 fm of ^{6}Li + ^{232}Th and ^{7}Li + ^{232}Th systems, respectively. The straight line segments represent various fits of imaginary potential W (E) and the corresponding curves for real potential V (E).

This work is partially supported by a research project being financed by UGC-DAE-CSR, Kolkata.

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