Study of Threshold anomaly for ^{10,11}B + ^{232}Th systems

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Introduction:

The measurement of the elastic scattering angular distributions determines the parameters of the real and imaginary parts of the nuclear interaction potential. From systematic analysis of elastic-scattering measurements involving tightly bound nuclei, the "threshold anomaly" (TA) has been reported 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 the couplings of elastic channel to the direct reaction channels that generate an additional attractive real dynamic polarization potential. In case of scattering with loosely bound projectiles, a different type energy dependence from that of TA is observed, which has been known as `breakup threshold anomaly' (BTA) [2-4]. In this case, a repulsive real dynamical potential is generated due to couplings of breakup channels to the elastic scattering.

For heavy targets, due to the large Coulomb effects the TA/BTA can be more pronounced. More measurements involving heavy targets with various projectiles are required to understand the systematics of TA and BTA. In the present work, the results on the investigation of elastic scattering for ^{10,11}B + ^{232}Th systems have been reported through very precise and complete angular distribution measurements at energies from below to above the Coulomb barrier.

The total reaction cross sections for this system have also been derived in order to investigate the role of projectile structure on the total reaction cross section.

Experimental details and results:

The experiment was performed using ^{10,11}B beams from BARC-TIFR Pelletron facility, Mumbai, India. The beam was bombarded on self supporting ^{232}Th target of thickness 1.5 mg/cm^2 and the elastically scattered ^{10,11}B ion were detected by four silicon surface barrier detectors in ΔE-E telescopic arrangements. The telescopes used had thicknesses (i) ΔE = 25 μm and E = 300 μm (T_1), (ii) ΔE = 40 μm and E = 300 μm (T_2), (iii) ΔE = 25 μm and E = 300 μm (T_3) and (iv) ΔE = 25 μm and E = 300 μm (T_4). Two monitor detectors with thickness around 300 μm were mounted ± 18º for absolute normalization and beam monitoring. The elastic scattering angular distribution measurements were carried out for different beam energies covering a wide range from 49 to 65 MeV for ^{10}B + ^{232}Th system and 52 to 65 MeV for ^{11}B + ^{232}Th system. A typical bi-parametric ΔE versus E_{res} spectrum for ^{11}B + ^{232}Th system at E_{lab} = 65 MeV and θ_{lab}= 90° is plotted in Fig. 1.

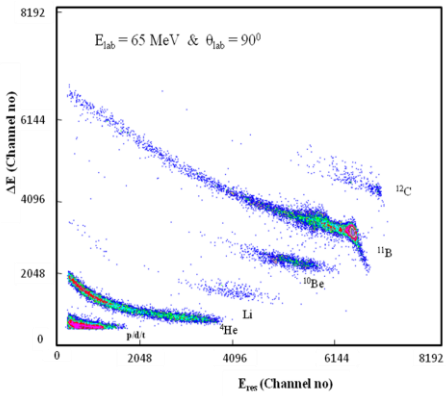

Fig.1. A typical bi-parametric ΔE versus E_{res} spectrum for ^{11}B + ^{232}Th system.

The elastic scattering angular distribution has been measured in a wide angular range from 35^0 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 for ^{11}B + ^{232}Th. The optical model analysis of the elastic scattering data were performed using the ECIS code [4,5]. In the fitting procedure, the real and imaginary diffuseness parameters (a_v and a_w) were kept fixed and only the strength of real and imaginary potential parameters (V_r and V_i) 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.

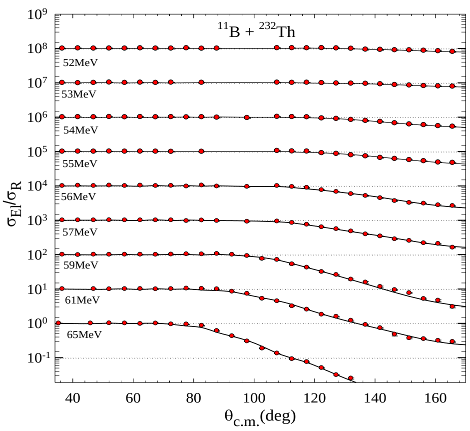

Fig.2. Experimental elastic scattering cross section normalized to the Rutherford cross section as a function of $\theta_{c.m.}$ for ^{11}B + ^{232}Th system.

The mathematical relation between the energy dependent real and imaginary parts of the optical potential in the dispersion relation given in Ref. [1] is

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

Here, P denotes the principal value and Equation (1) is used in evaluating ΔV, the dispersive contribution to the real part from 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 49 to 65 MeV for both the $^{10,11}B$ + ^{232}Th systems as shown in Fig.3. The linear segment model proposed in Ref. [1-4] was used in the imaginary part in order to get the real part. 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 both systems $^{10,11}B$ + ^{232}Th, thereby indicating the presence of threshold anomaly (TA).

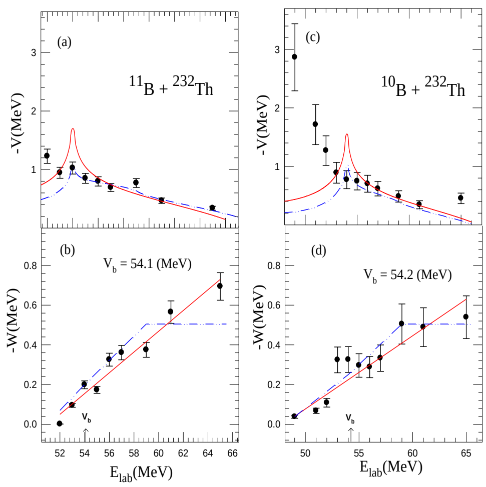

Fig. 3: Energy dependence of the real and imaginary potentials at r = 12.14 fm and 12.45 fm of ^{10}B + ^{232}Th and ^{11}B + ^{232}Th systems, respectively. The straight line segments represent various fits of imaginary potential W (E) and the corresponding curves for real potential V (E).

More detailed analysis with different form of the potential is being carried out and the results will be presented in the symposium.

Acknowledgments:

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