Elastic scattering of ^{7}Li + ^{27}Al system at near barrier energies

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Introduction

During the last decade, there has been considerable interest in study of nuclear reactions with weakly bound nuclei [1,2]. Several experiments with stable and unstable projectiles have been performed and a variety of theoretical approaches have been developed. It is observed that the interaction potential obtained from the optical model analysis of elastic scattering shows a particular nature in the vicinity of the top of the Coulomb barrier. It is seen that the magnitude of the imaginary potential begins to increase as the energy rises from Coulomb barrier at the same time real potential starts to decrease rapidly but at higher energies it appeared to saturate at a more or less constant value [3, 4]. This particular trend is named as a "threshold anomaly" (TA). This behavior may occur because of the coupling of elastic scattering to other reaction channels that produce an attractive polarization potential.

For the system of tightly bound nuclei it is well observed while for weakly bound nuclei still results are not very clear. Therefore, it is a subject of renewed interest both in theory and experiment, to investigate the presence of TA. With this objective, we have performed elastic scattering measurements for ^{7}Li + ^{27}Al system, around the coulomb barrier energies.

Experimental Details

The experiment was performed using ^{7}Li (3^+) beam at several bombarding energies from 8 MeV to 16 MeV using FOTIA facility, at BARC, Mumbai. A self supported ^{27}Al target of thickness ~220 μg/cm^2 was used. Using (ΔE-E) detection technique we have carried out measurements for elastic scattering angular distribution. We employed three telescopes (ΔE-E) of silicon surface barrier detectors of thicknesses 22 μm + 1.5 mm, 17 μm + 1 mm and 15 μm + 300 μm respectively with the separation of 10^0, to cover the wide angular range from 10^0-175^0. And for the purpose of normalization, as a monitor we set a single surface barrier detector of thickness ~300 μm on the other rotating arm at 20^0 with respect to the beam direction. At the entrance of the scattering chamber a collimator of ~5.0 mm was put to avoid intrinsic angular spread of the beam.

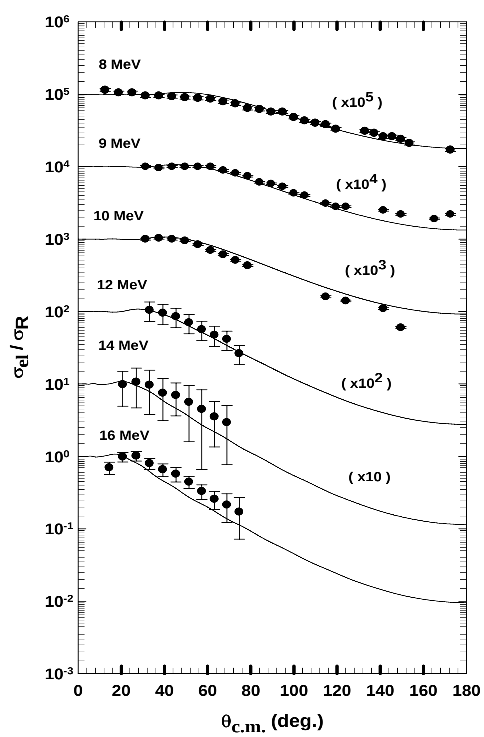

Fig. 1 Elastic scattering angular distribution at various bombarding energies with ECIS fit for ^{7}Li+^{27}Al system.

Results and Discussion

In order to explain the elastic scattering angular distributions, the Sao Paulo potential (SPP) was used. The calculations were performed using the ECIS code [ECIS] [5]. The imaginary part of the interaction is assumed to have the same shape as the real part, with one single adjustable parameter N_i related to its strength. The data fit procedure is performed with only two free parameters, the normalization factors for the real and imaginary parts, N_R and N_I. The SPP has been used for the analysis of near barrier elastic scattering of weakly bound nuclei of several systems [6, 7]. We have followed the least χ^2 approach to confirm the fitted results. The corresponding parameters and the resulting χ^2/N of the fits are presented in Table 1. The experimental elastic scattering angular distributions and the best fit obtained are shown in Fig. 1. The dependence of N_R and N_I on bombarding energies are shown in Fig.2. It can be seen that the strength of the real and imaginary potential follows the same trend at the barrier. For above barrier energies the real and imaginary potential strengths remain more or less constant. All these points suggest that particularly at the barrier energy no "threshold anomaly" is observed for ^{7}Li+^{27}Al system. However, it seems that more data points are required specially at below barrier energy in order to get complete understanding about the threshold anomaly for such a light mass system. Also, quantitative description is required through dispersion relation analysis in order to interpret the anomalous behavior (if any) in the present results.

Summary and Conclusions

We have carried out measurements for elastic scattering angular distribution for light mass system ^{7}Li+^{27}Al in the vicinity of the Coulomb barrier. The optical model analysis has been done using SPP to extract the strength for real and imaginary potentials. Below Coulomb barrier measurement is required to ascertain the presence or absence of threshold anomaly in the ^{7}Li+^{27}Al reaction.

Table 1: Energy dependent optical model parameters and total reaction cross section.

$E_{c.m.}$ (MeV)	N_R	N_I	χ^2/N	σ_R
6.35	5.10	1.16	4.44	427
7.15	1.50	0.443	0.546	443
7.94	0.808	0.457	4.60	503
9.53	0.866	0.833	0.105	822
11.12	0.802	0.543	0.219	1187
12.70	0.852	1.929	2.14	1277

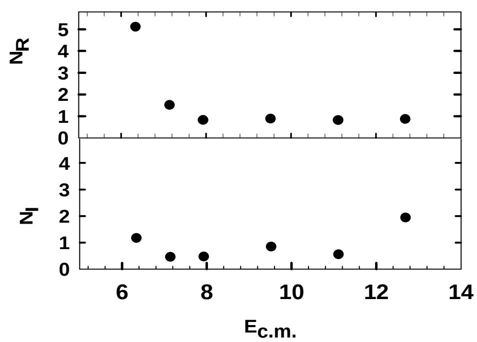

Fig. 2 Normalization factors of real and imaginary potential (N_R and N_I) as a function of bombarding energy.

Acknowledgments

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