Threshold anomaly study in ^{7}Li + ^{208}Pb system

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Introduction

For some time it has been known that reactions with heavy systems present a behavior so-called threshold anomaly (TA) [1-3]. It refers to the observation of a localized peak in the real part of the optical potential accompanying a sharp decrease of the imaginary part of the potential as the bombarding energy declines toward the Coulomb barrier. At higher energies, both the real and imaginary potentials are substantially energy independent. It has been shown that there is a connection between the real and imaginary parts of the optical potential, namely, a dispersion relation. This situation may change in the scattering of weakly bound nuclei [4]. These nuclei have lower breakup threshold energies and have a larger breakup (BU) probability. For weakly bound nuclei, the usual TA may still be observed or otherwise, an "anomalous behavior" will be observed. The new "anomaly" is the absence of the above TA. In such a situation one may say that the system presents the breakup threshold anomaly (BTA) [5]. The loss of flux from elastic channel goes to some of the reaction channels such as inelastic, breakup, transfer, and fusion, which changes the behavior of the real and imaginary parts of the optical potential by showing a BTA in the reactions involving weakly bound nuclei .

Many reports on the elastic scattering of ^{6}Li indicate the absence of the usual TA. Contradictory results have also been reported [6,7] where the BTA has been observed for both ^{6,7}Li projectiles. In the present work we have investigated the elastic scattering of the system ^{7}Li+^{208}Pb at lab energies ranging from below to above the coulomb barrier. ^{7}Li is a weakly bound nucleus having breakup threshold in (α+t) of 2.47 MeV, just 1 MeV above the breakup threshold of ^{6}Li (α+d). So it would be interesting to see how the BU of ^{7}Li will affect the elastic scattering compared to ^{6}Li case which has a larger breakup probability.

Experimental detail

The experiment was performed using a beam of ^{7}Li^{3+} delivered by the Laboratori Nazionali di Legnaro Tandem Van de Graaff accelerator with beam energies of 25, 31, 33,35 and 39MeV. An enriched, self- supporting ^{208}Pb target of thickness 200 μg/cm^{2} has been used in the experiment. Beam currents ranged between 5 and 10 nA. The elastically scattered ^{7}Li ions were detected with a 4π array (8πLP) of Si + CsI(Tl) telescopes, described in detail in [8].

Results and discussions

The analysis of the elastic scattering angular distribution was performed using phenomenological potentials in the code FRESCO [9]. The volume Woods-Saxon form was used for both the real and the imaginary part of the potential. In order to avoid a fit procedure with too many parameters, we used the fitting procedure described in [10]. Fig. 1 shows the elastic scattering data compared with calculation. We found several families of optical potential parameters that can describe all the angular distributions equally well. We determined the radii of sensitivity $R_{S_{real}}$ (R_{Sr}) and $R_{S_{imaginary}}$ (R_{Si}), which correspond to a point where the real and imaginary potential, calculated, respectively, with different strength, intersect.

An elastic scattering dispersion relation analysis has been carried out for ^{7}Li + ^{208}Pb in order to qualitatively understand the behavior of the real and imaginary potentials.

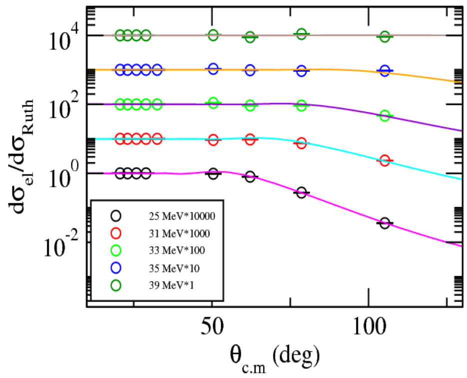

Fig.1: Elastic scattering angular distributions of ^{7}Li+^{208}Pb. The solid line represents prediction with the phenomenological potential using the code FRESCO.

The dispersion relation has been applied as a function of E_{lab} at the sensitive radius (R_{Sr} & R_{Si}) to the phenomenological optical potentials, determined at each energy between 25 to 39MeV. The linear segment model proposed in Ref. [11] was used in the imaginary part in order to get the real part. The energy dependence of the potential parameters for the systems ^{7}Li + ^{208}Pb is shown in Fig. 2. It can be seen clearly that the real potential is nearly constant at higher energies and are quite reproducible by the dispersion relation calculation. The imaginary part of the potential decreases below the barrier. This behavior is supported by the analysis of the dispersion relation that fits the data appreciably well. Thus it may be concluded that elastic scattering of the ^{7}Li + ^{208}Pb system has the usual threshold anomaly (i.e. absence of breakup threshold anomaly) as indicated by a characteristic localized peak in the real part and a corresponding decrease of the imaginary part of the optical potential as the bombarding energy decreases toward the Coulomb barrier.

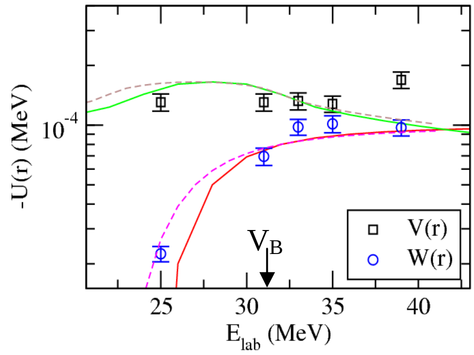

Fig.2: Energy dependence of the real and imaginary potentials at R_{Sr} = 8.05 fm for ^{7}Li + ^{208}Pb systems. The solid/dash red line represents the various fits of imaginary potential W(E); the corresponding curves for real potential V(E) were obtained from W(E) by using the dispersion relation. For the solid line E_0=24 MeV, Δ=4, W_0=0.0001 and for the dash line E_0=22MeV,Δ=5, W_0=0.0001 has been used.

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