Exploration of Threshold Anomaly—"Threshold Resonance" (manifestation of doorway state) in Nuclear Reactions with Weakly Bound Projectiles : Elastic scattering angular distributions in ^{6}Li + ^{74}Se System

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Introduction

Heavy-ion induced reactions are **very distinct** from light-ion (p,α) induced reactions because it bring in **large** angular momentum (***J***). In light-ion induced reactions with beam energies ≤ **5 MeV/nucleon,** the reactions are found to be **always compound nuclear**. So, one may assume that the above prescription of compound nucleus (CN) formation should hold good for heavy-ion induced reactions also. And, one can populate CN at moderately higher excitation energies (say, upto ~ 50 MeV or so) in heavy-ion reactions—unlike, in light-ion reactions where such excitation energies [$\boldsymbol{Ex^{tot} = Ex^{int} + Ex^{rot}}$, Ex^{int} being higher in CN at the same Ex^{tot} produced with light-ion] correspond to beam energies which lead to significant contributions from non-compound nuclear processes. However, **because of large *J* involvement**, **the above conventional wisdom does not hold good for heavy-ion reactions**. A significant amount of flux always proceeds through non-compound nuclear processes**— often** with the **formation** of an **"intermediate structure"— "door-way" state**[1, 2] **—a "general feature" in heavy-ion reactions,** even at **lower** bombarding energies (below the Coulomb barrier), which makes the study of heavy-ion reactions very interesting at extreme sub-barrier to around barrier energies.

The effect of large ***J*** which drives a **significant** incoming flux through non-compound processes can be studied through various **exit channels** and, also through different exit channels from reactions forming a nucleus at the **same excitation energy** with **different entrance channels**. For example: (i) by measuring **inclusively** or **exclusively** (angular momentum-gated) evaporated light particle (like p, n, α etc.) spectra and its angular distributions, (ii) gamma-ray spectra and its angular distributions, (iii) fusion excitation functions, (iv) evaporation residue(ER) excitation functions, (v) excitation functions for evaporated particles feeding to discrete states of a residual nucleus, and its angular distributions, (vi) fission excitation functions and fission fragment angular distributions, (vii) elastic scattering excitation functions and angular distributions etc.

^{6}Li is a stable nucleus. And it has a break-up(BU) threshold of **only 1.48** MeV in the $\alpha + d$ BU channel. While ^{7}Li has **2.47** MeV in the $\alpha + t$ channel, it has a bound excited state at **0.478** MeV. So, nuclear reaction studies with ^{7,6}Li stable beams continue to be of interest. Many papers have been published by different groups around the the world. Out of many investigation aspects, one focused interest is the well known **Threshold Anomaly** (TA) which we **pin-point** as **Threshold Resonance** (TR) (manifestation of **doorway state**). In many systems like, ^{6}Li + ^{209}Bi [3], ^{6}Li + ^{138}Ba [4], ^{6}Li + ^{59}Co [5], ^{6}Li + ^{28}Si [6], …normal TA/TR has **not** been observed. Or, exhibits **unusual** potential behaviour (also called breakup threshold anomaly /resonance—BTA/BTR) compared to normal threshold behaviour, for example, ^{6}Li + ^{208}Pb [7]. However, with ^{7}Li, normal TA/TR is still present in the above mentioned systems with the exception of ^{7}Li + ^{27}Al system [8].

There is **no** generalisation to **predict** whether normal TA/TR will be present for ^{6}Li induced reactions while one can have some guide line for ^{7}Li as it has a bound excited state at 0.478 MeV. So, it is of interest to investigate TA/TR in ^{7,6}Li + ^{74}Se (a **shape co-existing** nucleus) systems by measuring elastic scattering angular distributions around the Coulomb barrier (V_b^{lab} ~ 16.0 MeV). In the present contribution we report our measurement of the same for ^{6}Li + ^{74}Se system.

Experiment and Results

In the experiment, enriched (99.99%)^{74}Se (Z=34) of thickness 260 μg/cm^2 with carbon backing of thickness 60 μg/cm^2 was used as target. 10 silicon surface barrier detector telescopes (ΔE—E type) were used to detect and measure the angular distributions of elastically scattered particle at 9 ^{6}Li-beam energies (E_{lab} = 14 to 18 MeV at 1 MeV step, 20, 22, 26 & 30 MeV). To investigate any possible contribution from carbon backing in the elastic counts, carbon target of thickness 60 μg/cm^2 was also bombarded with the same beam energy. It was found elastically scattered ^{6}Li from ^{74}Se and ^{12}C are well separated at all beam energies and angles. The measured elastic scattering angular distributions, ($\sigma_{el}/\sigma_{Ruth}$) vs $\theta_{c.m.}$, from below to above barrier energies along with optical model best fits using the search code SFRESCO have been shown in Fig. 1 and 2.

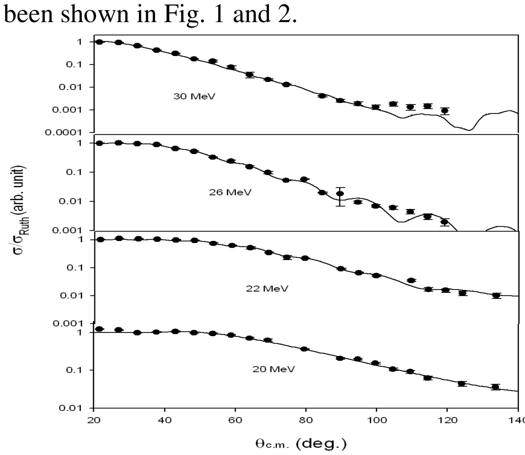
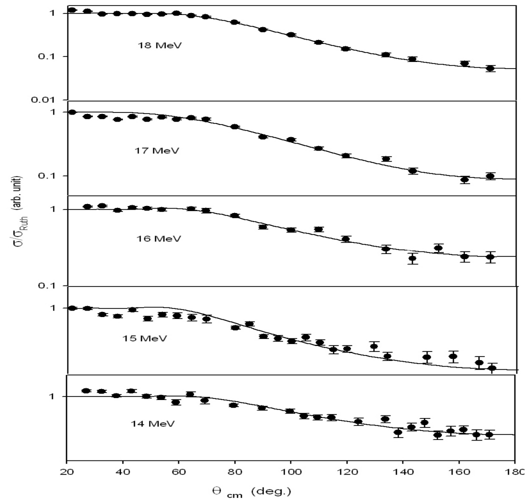


Fig. 1(above) & **2** (below)**:** Elastic scattering angular distributions at different beam energies. Solid lines are the best fits from SFRESCO.



In Fig. 3, real (V) and imaginary (W) part of the optical potentials obtained with the best fit phenomenological model are shown. The detailed analysis of the data with different models, like double folding, CDCC and also sensitivity and dispersion analysis along with the analyses of our already measured data for ^{7}Li + ^{74}Se system are in progress.

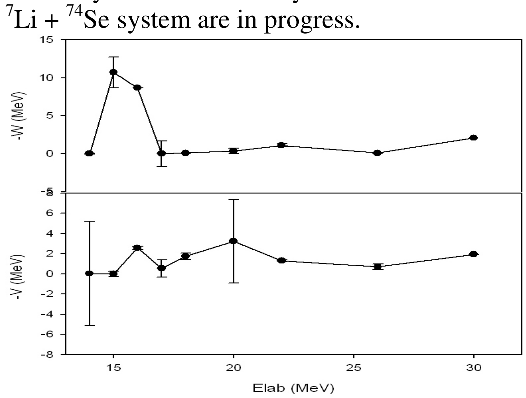


Fig. 3: Real and imaginary part of the optical potentials at R = 10.0 fm obtained from best fits phenomenological potentials.

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