Synopsis on

STUDY OF PROJECTILE BREAKUP PROCESSES ON ELASTIC SCATTERING AND FUSION-FISSION REACTIONS AROUND THE COULOMB BARRIER

by

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Introduction

The study of heavy ion elastic scattering at near barrier energies received fresh impetus in mid 1980s with the unexpected discovery of the threshold anomaly ("the strong energy dependence of the optical potential near the Coulomb barrier)" and its association with the dispersion relation between the real and the imaginary parts (V (r,E) and W(r,E)) of the optical potential for ^{16}O + ^{208}Pb system. The absolute value of W(r,E) sharply decreases when energy falls below the Coulomb barrier and that the decrease is accompanied by a bell shaped maximum of V (r,E). One can understand the imaginary potential for heavy ions, at least in the surface region sampled by elastic scattering, weakening as the energy drops below the Coulomb barrier because the non-elastic channels are being effectively closed. It can be seen from the dispersion relation [1,2] that the apparently anomalous behavior of the real potential is associated with the closing of the non-elastic channels. Subsequently this phenomenon has been observed for many other systems involving heavy ion projectiles and is shown to have its physical origin in strong coupling to low lying states populated in inelastic scattering and transfer reactions [3].

In the case of elastic scattering of the tightly bound nuclei from heavy targets, it was found that the optical potential parameters show a strong energy dependence at near barrier energies. The real part of the potential increases around Coulomb barrier energies exhibiting a bell shaped maximum and finally reduces to zero as the beam energy is further reduced while the imaginary part remains more or less constant for above barrier energies while it reduces to zero at below barrier energies. The increase in the real part at these energies could not be understood initially and was thus called anomalous. The observed strong energy dependence was termed the Threshold Anomaly (TA), where the Coulomb barrier acts as the threshold for opening of the non-elastic channels. Later, however, it was shown that the real and imaginary parts are connected by a dispersion relation which explains the above mentioned energy dependence of the potential. However, in the case of scattering of the weakly bound nuclei, the imaginary part has been found to persist even at below barrier energies with a slight reduction of the real part. This new behavior was termed as the Breakup Threshold Anomaly (BTA). The variation of the potential in terms of the dispersion relation can be understood, couplings between the reaction channels and absorption from the elastic channel gives rise to a correction to the real potential called a dynamic polarization potential. In the case of scattering of tightly bound projectiles, this dynamical polarization potential is found to become increasingly attractive with decrease in the projectile energy. On the other hand, in the case of scattering of weakly bound nuclei, it has been found to be increasingly repulsive with decreasing projectile energy. This difference in the energy dependence of the dynamical polarization potential is reflected in the slightly different energy dependence of the effective real part of the potential [4].

The study of the TA has become one of the tools to investigate the influence of the breakup and other reaction mechanisms on the elastic and fusion channels [5]. In the case of elastic scattering for the ^{7}Li projectile on different targets such as ^{59}Co [6], ^{80}Se [7], ^{138}Ba [8], and ^{208}Pb [9], the conventional TA has been identified. In these measurements, an increase in the real part of the potentials at energies around the Coulomb barrier was observed, indicating the presence of the usual TA. Several earlier works on the elastic scattering of ^{6}Li on various targets such as ^{27}Al [10], ^{64}Ni [11], ^{64}Zn [12], ^{80}Se [7], ^{90}Zr [13], ^{116,112}Sn [14], ^{138}Ba [8], ^{144}Sm [15], ^{208}Pb [9], and ^{209}Bi [16] have indicated that results are compatible with the absence of the conventional TA[17]. However, recently Camacho et al. have carried out a detailed analysis of the energy dependence of the optical potentials for the ^{9}Be + ^{208}Pb , ^{209}Bi systems [18]. It has been reported that the fusion imaginary potential indicates the presence of usual TA in these reactions, similar to that observed in tightly bound systems, but the direct reaction imaginary potential shows a BTA behavior. There are very limited elastic scattering data for ^{10}B and ^{11}B projectiles with heavy targets [19, 20, 21].

Objective of the thesis

In the present thesis, the main objective has been to study the effects of projectile breakup near the Coulomb barrier as well as other reaction channels such as transfer, employing different experimental and theoretical techniques. In what follows, involving weakly bound projectiles (^{6,7}Li), and (^{10,11}B) on heavy mass target (^{232}Th) experimental measurements have been carried out in two different experiments.

In the first experiment, simultaneous measurement of elastic scattering angular distribution, have been carried at around the Coulomb barrier energies in the ^{6,7}Li + ^{232}Th reactions, using 14UD BARC-TIFR Pelletron, Mumbai, India [17]. The data has been analysed for both the systems using the optical model ECIS code with phenomenological Woods-Saxon and Sao Paulo double-folding forms of the optical potentials.

Further, In the second experiment of the study the measurement of quasi elastic scattering and transfer angular distribution have been carried out, using $^{10,11}B$ on ^{232}Th target, to extract potential parameters and to study its energy dependence around the Coulomb barrier energies. This experiment has been performed at the 14UD BARC-TIFR Pelletron, Mumbai, India [21]. To study the projectile breakup effect on quasi elastic scattering and transfer angular distributions, the experimental elastic scattering data analyzed by ECIS code.

Plan of the thesis

The present thesis has been organized into five chapters as given below:

Chapter 1 begins with basic nuclear reaction mechanism when projectile and target come close to each other. Further this chapter broadly describes the study involving $^{6,7}Li$ and $^{10,11}B$ on ^{232}Th systems. In the beginning of **Chapter 2** descript a brief introduction to the BARC-TIFR Pelletron accelerator facility at Mumbai is presented. Further this chapter describes the performance characteristics of various radiation detectors used to carry out the experiments discussed in the present thesis work. The chapter also discusses the particle identification technique based on Interaction of charge particles with matter. Further, a brief description about the preparation of the targets used in the present thesis work is outlined. This chapter also have descriptions of the model used in the present analysis have been given, and how the model which we have used is of prime importance for our study has been shown. To check the consistency of the results obtained, we analyzed our data using two different kinds of potential so as to observe the models independence. So regarding those two different kinds of the potential has also been mentioned in this chapter. The **Chapter 3** is devoted essentially to the measurement of elastic scattering angular distribution and dispersion relation of $^{6,7}Li+^{232}Th$ systems. Here also briefly the experimental procedure and analysis work will be discussed along with calculated total reaction cross sections of $^{6,7}Li + ^{232}Th$ systems. Finally will explain of our derived results and conclusions. The **Chapter 4** the measurement of quasi elastic scattering, transfer angular distribution and dispersion relation of $^{10,11}B+^{232}Th$ systems. Here also briefly the experimental procedure and analysis work will be discussed along with calculated total reaction cross sections and transfer cross sections of $^{10,11}B + ^{232}Th$ systems. Finally will explain of our derived results and conclusions. The **Chapter 5** gives a brief summary of the research work carried out in this thesis along with a future outlook.

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PUBLICATIONS:

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1. **Quasi-elastic scattering and transfer angular distribution for $^{10,11}B+^{232}Th$ systems**

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2. **Energy dependence of optical potential in the near barrier elastic scattering of ^{11}B from ^{232}Th**

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1. **Influence of breakup process in reaction cross section for weakly bound projectiles in $^{6,7}Li + ^{232}Th$ reactions**

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