THEORETICAL INVESTIGATIONS IN NUCLEAR OPTICAL MODEL WITH SPECIAL REFERENCE TO ANTIPROTON-NUCLEUS AND NUCLEUS-NUCLEUS SCATTERINGS

ABSTRACT

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ABSTRACT

The optical model for nuclear scattering is very important to analyse the elastic and reaction cross sections in the nucleon-nucleus and nucleus-nucleus scatterings. In this approach, the nucleon-nucleus and nucleus-nucleus systems can be treated as a two body problem governed by complex effective interaction. This effective interaction is known as the optical potential. The availability of many reaction channels in addition to elastic channel in the nuclear scattering leads to the complex effective interaction in the nucleon-nucleus or the nucleus-nucleus scattering. The imaginary part of the complex potential is responsible for the removal of the flux from the incident beam leading to reaction and other non-elastic processes. Thus, the potential based on optical model is a useful tool for the study of nucleon-nucleus and nucleus-nucleus scatterings.

Recently, the production of antiproton ($\bar{p}$) beams with high flux and good resolution from the LEAR facility at CERN has opened up a new and wider field of research work. Due to the advent of the LEAR facility exploration of nucleus using antiproton as probes has become possible. The study of $\bar{p}$-A scattering is of great importance because it may generate new information on nuclear structure, antiproton-nucleus interaction, strange particle production etc. Atomic type bound states of antiproton with the nucleus has generated antiprotonic atom physics research.

We have studied several aspects of low energy $\bar{p}$-nucleus collisions based on some of the experimental results which have become available. In Chapter 2, a brief review of various aspects of low energy $\bar{p}$-nucleus collision, which forms the background for our work, is discussed.

Experimental results and theoretical analyses carried out so far provide interesting similarities between antiproton-nucleus ($\bar{p}$-A) scattering and heavy ion scattering (HIS). The angular distribution of $\bar{p}$-A systems shows a diffraction pattern which is similar to the Fraunhofer diffraction occuring in several cases of HIS. This is in contrast with the corresponding case of proton-nucleus scattering at the same energy. Moreover, both (HIS as well as $\bar{p}$-A) the scattering processes are surface dominant. These similarities indicate that some of the techniques developed for the analysis of HIS can also be adopted for the analysis of $\bar{p}$-A scattering. Semiclassical approaches like one-turning point and three-turning point WKB approximation are found to be quite successful in HIS. It has also been suggested that, for strongly absorbed particles, the elastic and inelastic scattering data can be analysed using a technique known as closed formalism or parametric S matrix approach. In this approach one parametrises the nuclear S matrix in terms of several parameters appropriate to reproduce the scattering data and the associated physical features. Two commonly used parametrisations of S matrix are the Ericson and McIntyre parametrisations. In Chapter 3, we have described antiproton-nucleus collision using semiclassical and closed formalism techniques, thereby demonstrating that

phenomenological and semiphenomenological theoretical approaches which are useful in heavy ion scattering can also be applied in the case of antiproton-nucleus scattering.

Another interesting feature of $\bar{p}$-A scattering that we have studied in Chapter 4 pertains to the relative sensitivity of the optical potential in different regions of the interaction volume. Using the technique of region-wise absorption it is possible to study the absorption of the incident flux in different shells around the scattering centre. In view of the similarity between $\bar{p}$-A and HIS, it is interesting to examine the interaction regions which contribute maximum to the reaction cross section in the $\bar{p}$-A scattering. This, and some related aspects are discussed in Chapter 4.

The heavy ion scattering has been found to be a very powerful tool in the study of nucleus during the last two decades. Many of the important reaction processes which have been studied are elastic and inelastic scatterings, fusion cross section, nuclear-molecular resonances, deep inelastic scattering etc. In Chapter 5, we have described the heavy ion fusion cross section results obtained using the recently proposed effective fusion barrier transmission model. This model is formulated within the framework of nuclear optical model and transmission across the effective barrier and is complimentary to the direct reaction model of fusion. The model is very successful in interpreting the fusion cross section over a wide range of energies below and above the Coulomb barrier. This approach also brings out the role of absorption and transmission across the barrier, in heavy ion

fusion. Thus, the thesis incorporates several aspects of nuclear scattering which are of current and general interest within the broad framework of nuclear optical model.