CHAPTER 1

INTRODUCTION

The subject of elastic scattering occupies a place of fundamental importance in the study of Nuclear Physics. Historically also the birth of Nuclear Physics started with Rutherford model of the atom and observation of deviations from Rutherford elastic scattering of alpha particles, leading to the surprising results that the atoms are essentially hollow and all the nucleus resides in a compact and dense space of the order of fermis. More man hours have been spent on the study of nuclear charge and matter distribution by way of study of elastic scattering than on any other problem in all the leading accelerators of the world. Study of elastic scattering between two nucleon systems has contributed solely to our present knowledge however limited, of the nature of nuclear force and nucleon-nucleon potential, with a degree of reliability. However when it comes to an assembly of nucleons as in a nucleus, it is a many body system and quite complex in character and it is the ultimate aim of nuclear physicists whether they can build up this macroscopic system from a microscopic approach and the success obtained so far is rather limited. Nevertheless probing of the nucleus is done by using different projectiles like electron, proton, neutron, deuteron, helions, alphas and heavy ions virtually using away the entire
periodic table with the modern light ion and heavy ion accelerators carrying them to their limiting energies to obtain, coordinate and put together the different information and synthesise them to a meaningful whole and elastic scattering plays a major role in all these investigations, by not only giving information on the effective potential between interacting systems but also providing the starting point for generating the distorted matter waves that are absolutely necessary for the evaluation of matrix elements for the different nuclear reactions.

In the absence of a very successful microscopic description of the elastic scattering process, one takes recourse to models and the most successful to date is the optical model. Although phenomenological in character, it has been able to fit thousands of elastic angular distributions and polarizations from various nuclei. Although the phenomenological optical model is reasonably successful, it is lacking in physical content because the information on the 'effective potential' obtained is not unique, as many different potentials are known to account for the observed elastic scattering giving equally good fit to the experimental distributions. The situation is more serious with composite particles than with nucleons as they are strongly absorbing, interact essentially at the surface and hence only determine the tail region of the effective potential. The well known discrete and continuous ambiguities of the optical potential and the
associated families of potential is a consequence of this fact. Although these ambiguities disappear and unique potentials are obtained at sufficiently high energies where the Nuclear Rainbow effect is seen and experimental data is taken beyond the rainbow angle and optical model fit is made, it is essential for us to know which of the discrete families at low energies corresponds to the unique one at high energies so that extrapolations can be made. These different families of potentials are characterized by definite values for the volume integrals which are very helpful in choosing the right potential family and eliminating the others.

These volume integrals of the optical potential have a certain amount of invariance built into them and are physically more meaningful than the potentials themselves and have an integrated effect of both the magnitude and geometry of the nuclear interaction, and it is essential for us to know the energy, mass and isotopic dependence of these volume integrals so that optical potentials can be kept track of on a global scale. In addition it is essential for us to know these systematics of the volume integrals so that they can be properly explained by a microscopic model from a more fundamental point of basic nucleon-nucleon interactions.

At the current state of these developments, work has been done on the volume integrals of optical potentials of nucleons.
and successfully explained by the microscopic theories. Systematics have also been empirically found for the real part of the optical potential of deuterons, tritons, heliums, alphas and lithium-6 particles. However no work exists so far on the volume integrals of the imaginary part of optical potentials for these composite particles.

The aim of the thesis is to obtain for the first time these imaginary volume integrals of the optical potentials for the above mentioned composite particles on a global scale and examine the possible systematics contained in these volume integrals, providing more data for microscopic theories to explain.

Chapter II deals with the description of elastic scattering of composite particles by the different models and their difficulties and the importance of volume integrals.

Chapter III deals with brief essentials of scattering theories, calculation and analysis, presently known behavior of volume integrals of the real part of the optical potential for these particles and their observed systematics.

Chapter IV deals with computations in tabular form of the imaginary volume integrals on a global scale for deuterons, heliums, tritons, alphas and lithium-6 particles for all available energies and over the entire mass range from $^{12}$C to $^{208}$Pb.
Chapter V deals with the analysis of the systematics of the volume integrals of chapter IV and discussion of these systematics, individually for each projectile as well as collectively for all projectiles including data available on nucleons from other works.

Chapter VI deals with the conclusions of the findings of this thesis.

References are given for all the chapters at the end.