INTRODUCTION

1-1) HISTORICAL INTRODUCTION TO THE OPTICAL MODEL :-

When a nucleon or a group of nucleons collides with a nucleus, several process may be take place. Here, this work is concerned only with the simplest of these processes, that of the elastic scattering, where the incident particle loses no energy in the interaction apart from the recoil energy given to the target nucleus. Many models were assumed to treat these processes. The simplest model of the nucleon-nucleon interaction takes no account of the structure of the nucleus and replace the nucleon-nucleon interaction by a simple real potential well characterized by a radius and a depth. The consequences of such a model were studied by Bethe[1] as early as 1935, and it was found that some of them notably the smallness of the predicted neutron capture cross section due to radiative transitions, the wide spacing of the resonances, and the slow change of the cross section with energy, were not in accord with experiment. It was therefore superseded by the compound nucleus model[2] which accounted successfully for the observed large capture cross sections and closely spaced resonance levels. This compound nucleus model was in turn shown to be inadequate by the new results on direct interactions at higher energies, which do not proceed through an intermediate state of energy-sharing among all the nucleons present. It was then found that the old potential model, with the addition of an imaginary component of the potential to produce absorption, is able to give a good account of the data above 10 Mev. This new model occupies an intermediate position between the shell model with its weak absorption and the compound nucleus model with its strong absorption[3]. This model is called the optical model, because replacing the many-body nuclear interaction by a two-body complex nucleon-nucleus potential is analogous to the description of the propagation of light in a refracting and absorbing medium by an index of refraction. It is thus not possible to treat elastic scattering process on its own without considering the accompanying absorption process. To a good approximation all these processes can be lumped together just as a process that removes particles from the incident beam.

Fernbach et al[4] found that the elastic scattering of nucleons by nuclei may be compared with the scattering of a wave by a refracting and absorbing sphere. Classically, this may be represented by a complex refractive index n. Outside the nucleus, the incident nucleon wave has a wave number $K_1 = (2ME)^{1/2}/\hbar$ (M and E are the reduced mass and the energy of the incident nucleon respectively). On the other hand, inside the nucleus, it is moving more rapidly due to the attraction of the nuclear field, and if this field is represented by a square well of depth $V = V_0 + iW_0$, the wave number of the nucleons inside the nucleus K, is given by :-

$$K = K_1 + K_1 + (1/2)\, iK_2 = (\, 2M(E+V)\,)^{1/2}/\hbar \qquad (1\text{-}1)$$

where K_1 and K_2 are the propagation and absorption coefficients respectively. The factor 1/2 is introduced to make the absorption coefficient K_2 equal to the reciprocal of the mean free path of nucleons in nuclear matter.

The refractive index of nuclear matter is then :-

$$n = \left((E+V)/E \right)^{1/2} = 1 + K_1/K_i + iK_2/2K_i \qquad (1-2)$$

For high energy particles $K_1 \ll K_i$ and $K_2 \ll K_i$, so that the refractive index close to unity, and it is sufficiently accurate to take $n^2 - 1 = 2(n-1)$. Using $Mv = \hbar K_i$ (v is the velocity of the incident nucleon), the real, V_o ,and imaginary, W_o , part of the potential may be related to K_1 and K_2 as follows :-

$$V_o = v\hbar K_1 \qquad \text{and} \qquad W_o = \tfrac{1}{2} v\hbar K_2 \qquad (1-3)$$

Fernbach et al[4] also obtained a relation between K_2 and the nuclear parameters (the charge **Z**, the atomic weight **A** and the radius **R**) as :-

$$K_2 = 3A\sigma / 4\pi R^2 \qquad (1-4)$$

where σ is the mean cross section = $(Z\sigma_{np}\alpha_{np} + (A-Z)\sigma_{nn}\alpha_{nn})/A$, α_{np} and α_{nn} allow for the reduction in cross section due to the Pauli principle.

1-2) FORMS OF THE NUCLEAR POTENTIAL :-

A large number of different analytical forms have been adopted for the radial variation of the optical potential. Initially, they were chosen for analytical convenience (square and trapezoidal wells). But now, with the availability of electronic computers, it becomes possible to use more realistic forms that account of the diffuseness of the nuclear surface. The common optical potential form is the **Woods and Saxon**[5] form :