DETERMINATION OF THE MACROSCOPIC ISOVECTOR POTENTIAL FROM NUCLEON-NUCLEUS SCATTERING*

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INTRODUCTION

The nucleon-nucleus elastic scattering represents the largest of all partial cross-sections. It is usually described in terms of the optical model potential (OMP). In the past few years much work has been done in the understanding and parameterization of the OMP.

In a mixed audience such as the one we have today, some confusion may arise when one speaks about the OMP. One reason is that experimental and theoretical physicists describe by the word OMP different but somewhat related things. In my talk, I will concentrate on the "empirical OMP", the one used and obtained from phenomenological analyses. We also have the "theoretical OMP" which I understand may be and has been derived in various different ways.

The study of neutron and proton elastic scattering data and its analysis in terms of the OMP leads to a unique way of determining the isovector part of the empirical OMP. We will examine the energy and radial dependence of this part and predict (p,n) quasi-elastic cross sections which will be compared with experimental results.

Recently Jeukenne, Lejeune and Mahaux starting from the Brueckner-Hartree-Fock approximation and Reid's hard core nucleon-nucleon interaction have calculated the isovector part of the theoretical OMP. It will be compared with some of the present phenomenological results.

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OPTICAL MODEL ANALYSIS

The phenomenological OMP \( U(r,E) \) is a complex local potential which consists of a real term, \( V(r,E) \), and an imaginary term, \( W(r,E) \):

\[
-U(r,E) = V(r,E) + i W(r,E)
\]

and has features based on physical intuition. It may be written as a sum of the terms:

\[
-U(r,E) = U_N(r,E) - V_c(r) - U_{so}(r,E)
\]

where \( V_c(r) \) is the Coulomb potential, \( U_{so} \) is the spin-orbit potential and \( U_N \) may be expressed as suggested by Lane\(^2\)

\[
U_N(r,E) = U_0(r,E) + \frac{4}{A} U_1(r,E) \hat{t} \cdot \hat{T}
\]

where \( U_0 \) is the isoscalar and \( U_1 \) the isovector part of the OMP; \( \hat{t} \) and \( \hat{T} \) are the isospins of the incident nucleon and target respectively. The isospin interaction splits the radial part of the potential into two diagonal terms which describe the proton and neutron elastic scattering while the non-diagonal or coupling term describes the \((p,n)\) quasi-elastic scattering. The latter is given by

\[
U_{pn}(r,E) = 2 \sqrt{\frac{e}{A}} U_1(r,E)
\]

where \( e = (N-Z)/A \) is the nuclear asymmetry. The diagonal terms may be written:

\[
U_n(r,E) = U_0(E) f(r) - \varepsilon U_1(E) F(r)
\]

\[
U_p(r,E) = U_0(E) f(r) + \varepsilon U_1(E) F(r) + \Delta U_{c1}(r)
\]

for neutrons and protons respectively. In general \( U \) represents a complex quantity and the term \( \Delta U_{c1}(r) \) is the so called Coulomb correction term first introduced by Lane\(^3\); it is usually parameterized as a single real term \( \Delta V_c f_1(r) = \beta(Z/A^{1/3}) f(r) \). The OMP analysis of neutron and proton scattering on \( T=0 \) (\( \varepsilon=0 \)) nuclei gives a unique way to evaluate empirically the Coulomb correction term. This has been done with available nucleon scattering data on \(^{40}\text{Ca}^4\); the above parameterization for the real term was used and a value \( \beta = 0.46 \pm 0.07 \) was derived.

The equations given above indicate that it is possible to obtain information about the isovector part of the OMP by a simple comparison of neutron and proton OMP analyses of elastic scattering data. Several attempts, based mainly on OMP analyses of proton elastic data, have been reported\(^3\). However, as seen from the above equations, this requires an "a priori" knowledge of \( \Delta U_{c1}(r) \). The