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Nucleons of low or moderate energy which are elastically scattered from nuclei should be partially polarized[1] by the strong spin-orbit potential underlying the predictions of the shell model of the nucleus. This spin-orbit potential is a consequence of the collective action of many nucleons on the particular nucleon. Thus for incident nucleons whose wavelength is greater than the nuclear spacing ($E \lesssim 50$ Mev), it would be expected that the spin-orbit potential of the shell model would make itself felt. For progressively higher energies the incident nucleon begins to see only one nucleon at a time and while a spin dependence of the elastic scattering can still be expected, it would be more a reflection of the individual nucleon-nucleon interactions than of the spin-orbit potential of the shell model. It will be supposed that even at these higher energies the spin dependence has the form of the usual spin-orbit potential. In either case this spin dependence of the elastic scattering can be investigated phenomenologically by treating the interior of the nucleus in terms of a spin-dependent complex index of refraction[2]—an obvious generalization of the optical model of the nucleus[3].

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1 Warren Heckrotte and Joseph V. Lepore, University of California Radiation Laboratory Report 2152, p. 32, March 1953.

2 This method has been suggested in connection with low energy neutron scattering by R. K. Adair. Private communication from K. M. Watson.

3 S. Fernbach, R. Serber, and T. B. Taylor, Phys. Rev. 75, 1352 (1949).

For low or moderate energies there is no suitable approximate method for treating the elastic scattering--a phase shift analysis is necessary. Also, at high energies any polarization calculations using conventional approximation methods[4] are made uncertain by the direct dependence of the polarization on the phase of the scattered wave. A phase shift analysis for various energies is therefore being undertaken on the Univac at UCRL Livermore in collaboration with S. Fernbach.

An estimate for small angles of scattering, though rough at best, may be readily obtained by making several simplifying assumptions. The magnitude of the polarization is given by

$$P = \frac{AB^{*} + A^{*}B}{d\sigma/d\Omega} \sin\theta \quad . \qquad (1)$$

Here A and B represent the scattering amplitudes corresponding to the spin independent and spin dependent parts of the interaction, respectively. The known experimental value for the differential cross section $d\sigma/d\Omega$ may be used. The amplitude, B, for spin dependent scattering may be estimated by using the Born approximation. Then only the imaginary part of A contributes to P. For small angles this is approximately proportional to the total cross section.

For 300 Mev neutrons incident on carbon, for example, a square well spin orbit interaction ($R = 1.4\ A^{1/3} \cdot 10^{-13}$ cm.) of 2 Mev depth gives a polarization of 40 percent at five degrees. Though this is probably an overestimate it suggests that the existence of a small spin orbit interaction in the nuclear potential will provide large polarizations. Finally, aside from the interest of investigating one more phase of nuclear structure,

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[4] For example in the special case of real potentials the Born approximation always gives a vanishing polarization.

this phenomenon, because of the large diffraction cross sections, provides a relatively good source of polarized particles.

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