$p:q:r$ but not necessarily for the absolute values of these parameters. Measurements at smaller values of θ give similar results with smaller values of q/p.

This equation agrees well with Eq. (1) and shows that the coefficient of $\cos 2\phi$ is very small or zero, at least in the cases investigated up to now.

A possible explanation which is consistent with the usual spin-orbit model has been pointed out by Dr. M. Ruderman. If it is assumed that the deuteron polarization originates in an $\mathbf{L}\cdot\mathbf{S}$ coupling which acts in the scattering process in addition to a central force, and if the magnitude of the spin-orbit potential is small compared to the central part, it then follows that the $\cos 2\phi$ term is negligible because $\langle T_{22}\rangle$ is very small.

It must be noted that the description of the polarization of a deuteron beam is substantially more complicated than the similar description for particles of spin $\frac{1}{2}$, and that our analysis gives only a small part of the relevant information.

* This work was done under the auspices of the U. S. Atomic Energy Commission.

[1] Oxley, Cartwright, and Rouvina, Phys. Rev. **93**, 806 (1954).
[2] Chamberlain, Segrè, Tripp, Wiegand, and Ypsilantis, Phys. Rev. **93**, 1430 (1954). Figure 1 of the reference paper is applicable to the present work and the same notations are used throughout.
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Mechanism of Proton Polarization in High-Energy Collisions*

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RECENT experimental evidence has accumulated showing that high-energy collisions of protons with various nuclei induce a considerable polarization in proton beams[1–3] and mechanisms have been proposed to account for this effect.[4–9] We have tried to investigate this phenomenon experimentally and we present here a brief summary of our results.

For the sake of discussion we shall distinguish three types of collisions: (a) elastic collisions in which the struck nucleus is left unexcited; (b) inelastic collisions in which the struck nucleus is left in an excited state; (c) the limiting case (quasi-elastic) in which the impinging proton can be considered to collide with a specific nucleon of the target and recoils almost as in a free nucleon-nucleon collision.

The theory proposed in references 4 through 7 applies specifically to elastic collisions and should be applicable especially to diffraction scattering. This we have tested by measuring the differential cross section for left and right scattering for a polarized 300-Mev proton beam obtained as described in reference 2. The scatterers studied are carbon, aluminum, calcium, and iron, as well as several others less completely.

One of the important requirements of the experiment is that the scattering be elastic. This is at least partially achieved by using a detecting telescope with enough absorber to exclude all protons that have suffered an appreciable energy loss in the target. In Fig. 1, we

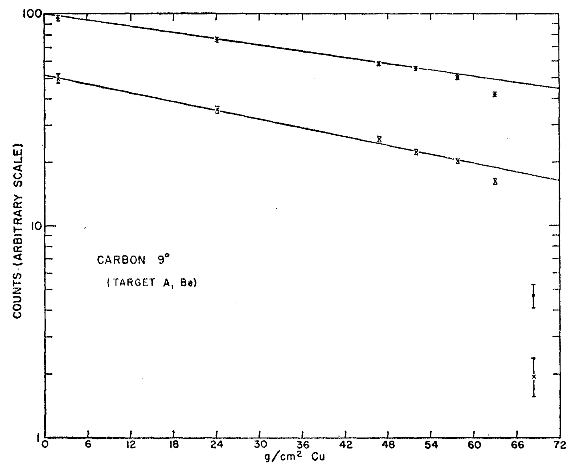

FIG. 1. Counting rate as a function of the absorber thickness in the counter telescope. Target B: carbon; beam polarization 0.64, $\theta=9°$. Dots: left scattering; crosses: right scattering. Proton energy 300 Mev.

show absorption curves for the scattered protons taken at an angle $\theta=9°$ for left and for right scattering from carbon. The curves show the effect of nuclear absorption and also the end of the range of the protons. From curves of this type one can derive values of the asymmetry e as a function of the energy of the scattered protons. The asymmetry shows an increase at high energy which indicates a high degree of polarization of the protons scattered elastically, as predicted.[4–7] However, our resolution in energy (limited by range straggling) is insufficient to distinguish the fluctuations in cross section corresponding to the levels of the residual nucleus. Fortunately, for small θ, diffraction scattering accounts for most of the scattering cross section and it is possible, by using a thick absorber in the telescope, to obtain scattering curves that show the characteristic diffraction pattern.[10] This is shown in Fig. 2, in which left and right scattering are plotted separately. The corresponding values of e are plotted in Fig. 3 and show fluctuations which we think are due to the operation of the $\mathbf{L}\cdot\mathbf{S}$ coupling as expected.[4–7] The minimum is not as pronounced as predicted by the simplified theories,[4–7] but there are probably two causes for this: Experimentally the lack of energy and angular resolution does not permit measuring elastic scattering only; theoretically the simplified models

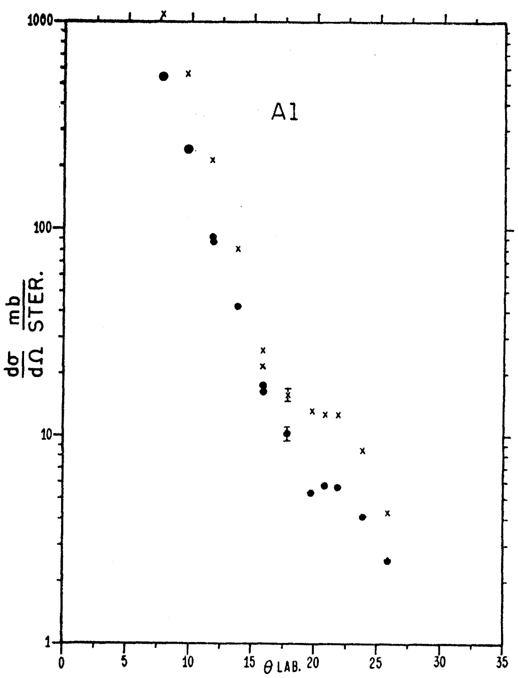

FIG. 2. "Elastic" scattering by aluminum. Target A: Be. Crosses: left scattering; dots: right scattering. Typical errors are indicated. Incident beam polarization 0.64. Proton energy 300 Mev.

used are too crude (as pointed out by some of the authors) and the true minima may be less prominent than calculated on the simplified assumptions.

Even scattering that is definitely inelastic shows a considerable degree of polarization. In the case of quasi-elastic scattering this corresponds, qualitatively at least, to the results of n-p scattering[11] and p-p scattering,[2] as is to be expected.

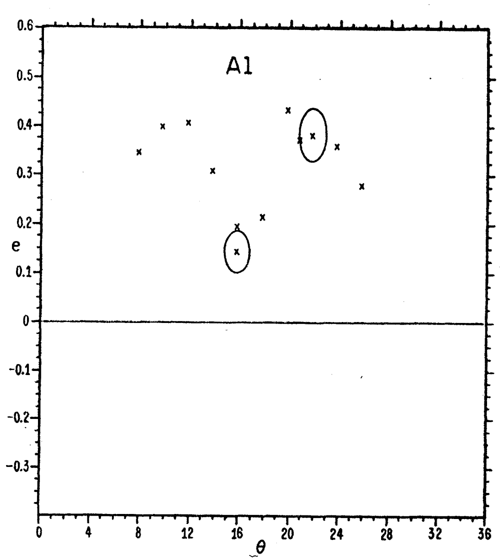

FIG. 3. Plot of the asymmetry corresponding to Fig. 2. Typical errors indicated.

For the intermediate region a study should be made to try to discern the influence on the polarization of the excitation state of the residual nucleus. This, however, is beyond our present experimental possibilities.

A detailed account of these experiments will be published later.[12]

The notation is the same as that used in reference 2.

* This work was done under the auspices of the U. S. Atomic Energy Commission.
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Nuclear Elastic Scattering of Photons*

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IN a recent note[1] an experiment was described in which the differential cross section at 120° for the nuclear elastic scattering of photons in the energy range 10–25 Mev was measured for Au, Pb, and U targets. These experiments have been extended to include the target elements Cu, Mn, Sn, Au, Bi, and Pb and the energy range 4 to 28 Mev. For all these elements but gold, in addition to the maximum associated with the "giant resonance," a pronounced peak has been found near the (γ,n) threshold. The measured points for lead are shown in Fig. 1, and Table I contains the data for the other elements.

The data given above have all been corrected for the electronic absorption of the primary and scattered photon beams in the target. No corrections have been made for nuclear self-absorption. These corrections are important for those energies where the nuclear absorption cross section is of the same order or greater than the total electronic absorption cross section, i.e., below the (γ,n) threshold where the scattering is presumably due to sharp, well-defined levels. For dipole transitions the maximum absorption cross section in these levels could be as high as $6\pi\lambdabar^2 \simeq 10^{-22}$ cm^2. Although this self absorption is partially compensated for by small-angle Compton scattering, preliminary estimates indicate that below the (γ,n) threshold a correction for self-absorption could raise the mean scattering cross