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The polarization of high-energy nucleons elastically scattered from spin-zero nuclei must be a consequence of an effective spin-orbit potential in the nucleon-nucleus interaction. This suggests a simple generalization of the conventional optical model of the nucleus by the addition of a spin-orbit potential.[1] Calculations of the polarization to be expected from this model as applied to beryllium and carbon have been made in several instances.[1] The results are in qualitative agreement with the experimental measurements in that they show that a small spin-orbit potential, of the order of 1 Mev, can lead to the large polarizations observed. However, the calculations indicate that in the region of the diffraction minima, the polarization shows a double reversal of sign within an angular region of a few degrees. This double reversal, or dip, is not experimentally observed in Be or C.[2] It has been suggested that this dip as it appears in the calculations is a reflection of the use of a square-well central potential.[3] Our calculations for the polarization of 290-Mev neutrons elastically scattered from carbon indicate that if the real central potential is taken to be zero or sufficiently small compared to the imaginary potential, the dip is not eliminated by rounding off the edges of the square well.[4] However, if for a given potential-well shape the real central potential is increased sufficiently, relative to the imaginary central potential, the dip in the polarization becomes of less significance, so that experimentally it would not be observed. Both the shape of the well and the magnitudes of the potentials should of course be fixed by a comparison with the experimental scattering measurements. It is felt, though, that the measurements at 300 Mev are not sufficiently extensive or accurate to fix all the parameters involved.

In addition to the above considerations there is another still unconsidered point that has a bearing on the interpretations of the calculations. A formal analysis of the justification of the optical model of high-energy nucleon-nucleus scattering has been made, which leads to the conclusion that in general the predictions of this model are valid only for small scattering angles. The exact line between small- and large-angle scattering is, of course, not precise. For the light elements, Be and C, however, the predicted first diffraction minima and the associated polarization phenomena occur at an angle $\simeq 20^{\circ}$. One notes that not only is the dip in the polarization not observed, but also that the first diffraction minimum is not observed. Now if the absence of these phenomena in Be and C can be ascribed to the lack of validity of the model for large scattering angles, one would expect that for the heavier nuclei, where the diffraction and polarization occur at smaller angles, these phenomena would manifest themselves according to the predictions of the calculations. Such indeed is the case. Chamberlain, Segre, Tripp, Wiegand, and Ypsilantis[5] have found that a dip in the polarization occurs for the elements Al, Ca, and Fe, in the region around the diffraction minima. The calculated polarization of 290-Mev neutrons elastically scattered from Al, assuming a parabolic-shaped central nuclear potential is shown in Fig. 1, along with the experimentally observed polarization for 290-Mev protons elastically scattered from aluminum. The second dip that is predicted by the model would not be expected to be experimentally observed because of the probable lack of validity of the model for such large angles of scattering.[7] The effect of including the Coulomb potential in the calculations to describe the scattering of protons will be to decrease the maximum polarization and to widen the region of the dip in the polarization.

We wish to thank O. Chamberlain, E. Segre, R. Tripp, C. Wiegand, and T. Ypsilantis for discussions relating to their experiments. This work was performed under the auspices of the Atomic Energy Commission.

A full account of the above material will soon be submitted to the Physical Review for publication.

REFERENCES

1. E. Fermi, Nuovo cimento 11, 407 (1954); W. Heckrotte and J. V. Lepore, Phys. Rev. 94, 500 (1954); B. J. Malenka, Phys. Rev. (to be published); G. A. Snow, R. M. Sternheimer, and C. N. Yang, Phys. Rev. 94, 1073 (1954).

2. H. G. Carvalho, J. Marshall, and L. Marshall, Phys. Rev. (to be published); O. Chamberlain, E. Segre, R. Tripp, C. Wiegand, and T. Ypsilantis, Phys. Rev. 93, 1430 (1954).

3. Suggested by E. Fermi and C. N. Yang. See also calculations of R. M. Sternheimer, Phys. Rev. (to be published).

4. Parabolic and Gaussian well shapes were assumed for the central potential. The spin-orbit potential was taken to be proportional to the derivative of the central potential.

5. O. Chamberlain, E. Segre, R. Tripp, C. Wiegand, and T. Ypsilantis, Phys. Rev. (to be published).

6. The nuclear potential was taken to be

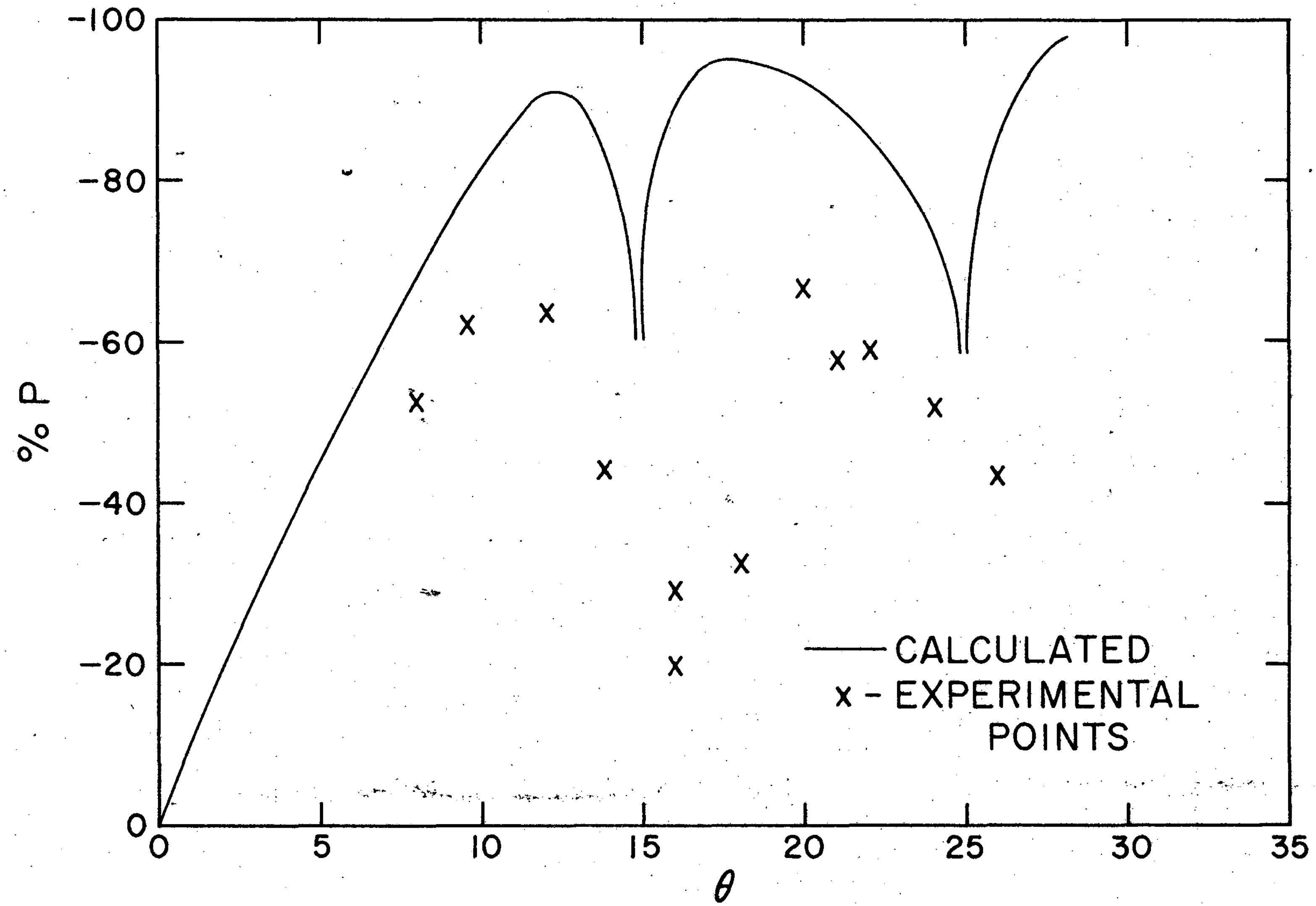
$$V = -\left\{(18 + i30)(1 - r^2/R^2) + 1.2\vec{\sigma}\cdot\vec{L}/\hbar\right\} \text{Mev}$$

for $r \leq R = 4.8 \times 10^{-13}$ for Al. The calculation was done with W. K. B. approximation.

7. It must be recognized, though, that the experimental difficulties for such large-angle scattering are quite pronounced and might make the resolution of a dip, if such existed, very difficult.

FIGURE CAPTION

Figure 1: The calculated polarization of 290-Mev neutrons elastically scattered from aluminum. The crosses, x , are the experimentally measured polarizations for protons elastically scattered from aluminum as given by Reference 5.



-100
-80
-60
-40
-20
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% P
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10
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CALCULATED
x - EXPERIMENTAL POINTS