Absolute Cross Section for Electron Scattering from Protons*

ROBERT W. MCALLISTER†

Department of Physics and High-Energy Physics Laboratory, Stanford University, Stanford, California

(Received October 12, 1956)

WITH apparatus described in part previously,[1–3] 189.6-Mev electrons have been scattered through 60° in the laboratory frame from polyethylene and carbon targets. Results of this investigation have yielded an absolute cross section for scattering from protons under these conditions.

Electron scattering from protons in the energy range 100 Mev to 550 Mev has been studied previously,[4–6] but absolute cross sections have been obtained only approximately. Results of the relative scattering are compared with the Rosenbluth[7] formula interpreted as if the proton had a diffuse charge and a diffuse magnetic moment.[5] In this manner shapes and sizes of the charge and magnetic moment distributions are obtained. The radiative correction calculated by Schwinger[8] does not enter in a sensitive manner into such a relative comparison since its angular dependence is very small. The present determination of an absolute cross section eliminates one degree of freedom in the comparison with theory and provides a check on the radiative correction.

The choice of conditions (189.6 Mev, 60°) for this determination was convenient. Thus, scattering from the proton's magnetic moment contributes only ~7% to the cross section under these conditions. Hence the interpretation of the experiment is not sensitive to existing uncertainties in the size of the magnetic moment distribution ($d\sigma/\sigma \cong 0.02dR_2/R_2$), which makes only a small uncertainty in the 7% contribution. In addition, values of the momentum transfer q in the center-of-mass system are small enough, so that the squares of the form factors are determined to within 1% by the rms radius of the distributions ($F^2 \cong 1-\frac{1}{3}q^2R^2$). The shapes of the density distributions thus need not be known accurately in order to interpret the experiment. The recoil energy of the proton is ~17 Mev, so that the hydrogen and carbon scattering peaks present in the scattering from polyethylene are well separated. For this reason the carbon contributes only a 15% background to the hydrogen peak area.

Now charge scattering contributes ~93% to the cross section, and, since the finite size makes an ~17% contribution to the square of the charge form factor (F_1^2), the cross section is somewhat sensitive to the charge radius ($d\sigma/\sigma \cong -0.3dR_1/R_1$). This fact is desirable from the standpoint of obtaining information about the size of the charge distribution alone. It is undesirable from the standpoint of checking the radiative correction. The interpretation of the experiment consists in determining whether or not the experimental cross section is consistent with the radiative correction and existing values of the charge radius.

A preliminary analysis of the data yields a differential cross section of $(1.20\pm 0.07)\times 10^{-30}$ cm^2. The fractional energy resolution, $\Delta E/E$, required for the radiative correction is approximately just the peak width observed in the experiment. However, the radiative correction is very insensitive to $\Delta E/E$ for values in this range. The experimental peak widths are very nearly 1% so that a value 0.01 can be assumed for $\Delta E/E$, yielding a radiative correction of 0.836. This correction is applied to the Rosenbluth formula for a diffuse proton,[5] assuming a magnetic moment rms radius of 0.77×10^{-13} cm. The result is compared with the above central experimental value, and an rms radius of 0.75×10^{-13} cm is determined for the charge. This radius is consistent with existing values.[6]

The details of the experimental arrangement and procedure and a more thorough analysis of the data will be presented in a paper to be submitted soon to the Physical Review. It may be possible at that time to establish smaller limits of uncertainty on the experimental cross section.

The author wishes to thank Dr. Robert Hofstadter for suggesting this problem and for making many valuable suggestions contributing toward its solution. Dr. J. A. McIntyre and Mr. A. W. Knudsen have presented many worthwhile ideas. Miss Monica Eder has been very helpful in taking data.

* The research reported in this document was supported jointly by the U. S. Navy (Office of Naval Research) and the U. S. Atomic Energy Commission, and by the U. S. Air Force through the Air Force Office of Scientific Research, Air Research and Development Command. It was also aided by a grant from the Research Corporation.

† Now at the University of Zurich, Zurich, Switzerland.

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