In Eqs. (4), (6), and (8)–(11) we have neglected relativistic corrections.

For $\vartheta=\pi/2$ the relations (2) and (9) vanish whereas (10) and (11) become identical. There remain therefore six independent relations between the coefficients $b(\pi/2)=-c(\pi/2)$, $d(\pi/2)$, and $e(\pi/2)$, i.e., between five real parameters which determine the transition matrix $T(\pi/2,\phi)$ except for an absolute phase factor. For angles $0<\vartheta<\pi/2$, one can obtain eleven relations for nine parameters. The experimental quantities are of course not single-valued functions of these parameters, but the ambiguities may be reduced by comparing solutions for different angles and energies. At lower energies also a phase shift analysis can be helpful. A more complete discussion, especially of the correlation experiments, will be published later.

The author is very grateful to Professor G. Wentzel for interesting discussions. Thanks are also due Professor M. L. Goldberger, Dr. S. Cohen, Dr. Leona Marshall, and Dr. H. Miyazawa for helpful comments.

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* Work supported by the U. S. Atomic Energy Commission.

[1] Ypsilantis, Wiegand, Tripp, Segrè, and Chamberlain, Bull. Am. Phys. Soc. 29, No. 8, 19 (1954).

[2] L. Wolfenstein and J. Ashkin, Phys. Rev. 85, 847 (1952); R. H. Dalitz, Proc. Roy. Soc. (London) A65, 175 (1952).

[3] R. Oehme, Phys. Rev. 98, 147 (1955), Eqs. (12) and (13).

[4] We find

$$C^p(\mathbf{p},\mathbf{q})=\frac{N(\mathbf{p},\mathbf{q})+N(-\mathbf{p},-\mathbf{q})-N(\mathbf{p},-\mathbf{q})-N(-\mathbf{p},\mathbf{q})}{N(\mathbf{p},\mathbf{q})+N(-\mathbf{p},-\mathbf{q})+N(\mathbf{p},-\mathbf{q})+N(-\mathbf{p},\mathbf{q})},$$

where $N(\mathbf{p},\mathbf{q})$ is the number of events in which the spin of the "scattered" proton is in the direction $\mathbf{p}$ and the spin of the "recoil" proton in the direction $\mathbf{q}$.

[5] L. Wolfenstein, Phys. Rev. 96, 1654 (1954). The author is indebted to Professor Wolfenstein for sending him a copy of this paper.

[6] H. P. Stapp, Bull. Am. Phys. Soc. 29, No. 8, 19 (1954); the author wishes to thank Dr. Leona Marshall for showing him a preprint of this paper.

[7] These are practically quadruple scattering experiments, but they might be somewhat easier than straightforward quadruple scattering.

Electron Scattering from the Proton*†‡

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WITH apparatus previously described,[1,2] we have studied the elastic scattering of electrons of energies 100, 188, and 236 Mev from protons initially at rest. At 100 Mev and 188 Mev, the angular distributions of scattered electrons have been examined in the ranges 60°–138° and 35°–138°, respectively, in the laboratory frame. At 236 Mev, because of an inability of the analyzing magnet to bend electrons of energies larger than 192 Mev, we have studied the angular distribution between 90° and 138° in the laboratory frame. In all cases a gaseous hydrogen target was used.

We have found that deviations in excess of Mott scattering are readily apparent at large scattering angles. The early results (reported at the Seattle meeting, July, 1954) at smaller angles showed the expected agreement with the Mott formula within experimental error. Deviations from the Mott formula such as we have found may be anticipated at large angles because of additional scattering from the magnetic moment of the proton.[3] We have observed this additional scattering but in an amount smaller than predicted by theory.

The experimental curve at 188 Mev is given in Fig. 1. It may be observed that the experimental points do not fit either the Mott curve or the theoretical curve of Rosenbluth,[3] computed for a point charge and point (anomalous) magnetic moment of the proton. Furthermore, the experimental curve does not fit a Rosenbluth curve with the Dirac magnetic moment and a point charge. The latter curve would lie close to the Mott curve and slightly above it. Similar behavior is observed at 236 Mev.

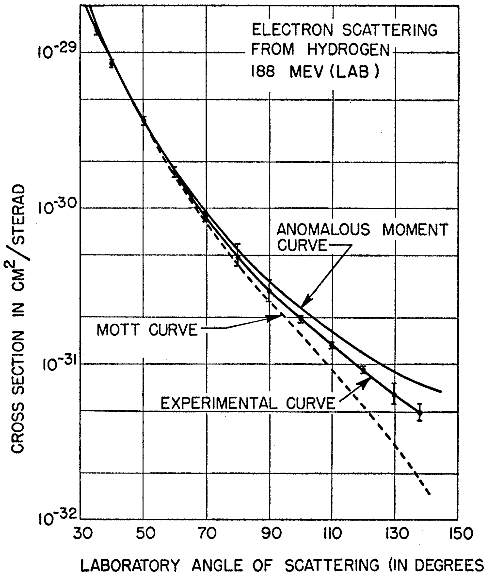

FIG. 1. The figure shows the experimental curve, the Mott curve, and the point-charge, point-magnetic-moment curve. The experimental curve passes through the points with the attached margins of error. The margins of error are not statistical; statistical errors would be much smaller than the errors shown. The limits of error are, rather, the largest deviations observed in the many complete and partial runs taken over a period of several months. Absolute cross sections given in the ordinate scale were not measured experimentally but were taken from theory. The radiative corrections of Schwinger have been ignored since they affect the angular distribution hardly at all. The radiative corrections do influence the absolute cross sections. Experimental points in the figure refer to areas under the elastic peaks taken over an energy interval of ±1.5 Mev centering about the peak. The data at the various points are unchanged in relation to each other when the energy interval is increased to ±2.5 Mev about the peak; the latter widths include essentially all the area under the peak.

The correct interpretation of these results will require a more elaborate explanation (probably involving a good meson theory) than can be given at the moment, although Rosenbluth already has made weak-coupling calculations in meson theory which predict an effect of the kind we have observed.[4]

Nevertheless, if we make the naive assumption that the proton charge cloud and its magnetic moment are both spread out in the same proportions we can calculate simple form factors for various values of the proton "size." When these calculations are carried out we find that the experimental curves can be represented very well by the following choices of size. At 188 Mev, the data are fitted accurately by an rms radius of $(7.0\pm 2.4)\times 10^{-14}$ cm. At 236 Mev, the data are well fitted by an rms radius of $(7.8\pm 2.4)\times 10^{-14}$ cm. At 100 Mev the data are relatively insensitive to the radius but the experimental results are fitted by both choices given above. The 100-Mev data serve therefore as a valuable check of the apparatus. A compromise value fitting all the experimental results is $(7.4\pm 2.4)\times 10^{-14}$ cm. If the proton were a spherical ball of charge, this rms radius would indicate a true radius of 9.5×10^{-14} cm, or in round numbers 1.0×10^{-13} cm. It is to be noted that if our interpretation is correct the Coulomb law of force has not been violated at distances as small as 7×10^{-14} cm.

These results will be reported in more detail in a paper now in preparation.

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[†] Aided by a grant from the Research Corporation.

[‡] Early results were reported at the Seattle Meeting of the American Physical Society [Phys. Rev. **96**, 854(A) (1954)]. More recent results were presented at the Berkeley meeting of the American Physical Society [Bull. Am. Phys. Soc. **29**, No. 8, 29 (1954)].

[1] Hofstadter, Fechter, and McIntyre, Phys. Rev. **92**, 978 (1953).

[2] Hofstadter, Hahn, Knudsen, and McIntyre, Phys. Rev. **95**, 512 (1954).

[3] M. N. Rosenbluth, Phys. Rev. **79**, 615 (1950).

[4] See also the classical calculation of L. I. Schiff reported in Rosenbluth's paper.

Capture of Negative *K* Mesons*

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SEARCH for negative *K* mesons has been continued[1] with essentially the same arrangement as previously reported,[2] but with 2.8-Bev protons. The stack of stripped emulsions now receives a collimated beam of negative particles of momentum 316 Mev/*c* (average spread ±8 Mev/*c*) emitted from a Be target at 4° to the proton beam.

Each emulsion was scanned, near its edge through which the beam entered, for tracks of the beam direction (within ±1°) and of about twice minimum grain density, appropriate to the *K* mesons. All such tracks were then followed to their ends.

In this way, 13 stars made by K^- mesons at the end of their range were found; 3 stars made by K^- mesons in flight were found in ~58 cm of *K*-meson track followed. Therefore, the K^- mean-free path for star-producing collisions approximately equals the geometric mean-free path of emulsion (27 cm).

The flux of K^- mesons relative to π^- mesons in the emulsions (beam tracks of minimum grain density, $g_{\min}$) was 2×10^{-5}. The mass of each K^- particle, from preliminary measurements of momentum *vs* range, in some cases of grain count *vs* range and, for *K* mesons producing stars in flight, of scattering *vs* grain count, was consistent with the tau mass within about 10 percent.

In five K^- stars, described in Table I and, for four cases, in Fig. 1, a charged unstable heavy particle (UHP) is emitted. The other K^- stars show 1 to 7 heavy prongs and, in all but two cases, a single light track consistent with a pion of ~100 Mev, and have visible energies $\lesssim 300$ Mev, sufficiently less than the 500 Mev available to allow the possibility of Λ^0 emission.[3]

In Fig. 1, tracks (1) are due to K^- coming to rest at *S*, tracks (2) to the UHP, tracks (3) to light particles emerging from the end of tracks (2) at *P*, tracks (5) to light particles from *S*, and tracks (4) and (6)–(11) to stable particles.

TABLE I. Characteristics of K^--capture stars with unstable heavy particle emission. *F* = star made in flight; (a) possibly bound; (b) particle present, unanalyzed; (c) high energies have no upper limits; (d) energies were calculated for pions. Errors include both statistical and systematic uncertainties.

	Unstable heavy particle		Light secondary at *P* energy (c, d)	Light particle at *S* energy (d)	Visible star energy
NK	Identity	Energy Mev	Mev	Mev	Mev
8	Σ^+	10	$93_{-14}^{+?}$	63_{-6}^{+16}	480
1	$\Sigma^\pm$	30	$120_{-40}^{+?}$	57_{-6}^{+16}	490
5	Σ^- or	10	18, π^-	none	420
	Λ^0 bound	$\gtrsim 18$			$\gtrsim 380$
4	$Y^{\pm(a)}$	~120	$120_{-40}^{+?}$	none	$\gtrsim 410$
14*F*	(b)		none	(b)	

In star *NK*8, particle (2) comes to rest at *P*. From scattering and range, its mass is $(0.7_{-0.3}^{+0.4})m_p$. The energy of particle (3) is consistent with a pion from the charged hyperon Σ^+ ($Q = 110$ Mev). Accordingly, the UHP can be identified as Σ^+.