DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

DESY 67/18
May 1967

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by

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THE CHARGE FORM FACTOR OF THE PROTON AT A MOMENTUM TRANSFER OF 75 F^{-2}

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The contribution of the proton charge form factor $G_E(q^2)$ to the elastic electron-proton scattering cross section decreases rapidly with increasing momentum transfer. Consequently, precise cross section measurements are required to determine G_E at large momentum transfers. For $q^2 \geq 75\ f^{-2}$ the published data[1)2)3)] cannot distinguish between $G_E = 0$ and $G_E = G_M/\mu$. The aim of the experiment described here was to clarify this problem at $q^2 = 75\ f^{-2}$.

For this purpose a cross section measurement at $q^2 = 75\ f^{-2}$ was made in which the recoil protons were detected at $\psi = 17^\circ$, corresponding to electrons scattered at $\theta = 88.1^\circ$. The measurement was performed using the same apparatus as in a precious experiment[2)] at the same momentum transfer in which the scattered electrons were detected at $\theta = 19.5^\circ$. The ratio $G_E/(G_M/\mu)$ is determined only by the ratio of the two cross sections $\left(\frac{d\sigma}{d\Omega}\right)_{19.5^\circ}/\left(\frac{d\sigma}{d\Omega}\right)_{88.1^\circ}$, in which certain systematic uncertainties cancel. Therefore, a smaller error was obtained for the ratio of the form factors than for G_E. The error in this ratio was dominated by statistical uncertainties in the two cross section measurements.

The spectrometer[4)] used in the experiment allowed elastically scattered protons to be clearly separated from those scattered inelastically, since the threshold for inelastic processes occurs at a momentum of 0.5% less than that of the elastic peak and the overall resolution of the set-up was better than 0.2%. The protons were registered in a 16-channel hodoscope triggered by a system of scintillation counters. The efficiency of the hodoscope was $(99.5 \pm 0.5)\%$. Discrimination against π^+-mesons and lighter particles was provided by a threshold gas Čerenkov counter in anticoincidence with the trigger signal. The number of pions was counted in a separate coincidence channel and found to be negligible. A correction of $(2.5 \pm 0.5)\%$ for proton absorption in the counter material was applied to the counting rate.

The cross sections and their ratio are given in table I. From the ratio $\left(\frac{d\sigma}{d\Omega}\right)_{19.5^o}/\left(\frac{d\sigma}{d\Omega}\right)_{88.1^o}$ one can deduce (using the Rosenbluth formula) the ratio of the form factors $G_E/(G_M/\mu)$ (see table II). It is important to note that this ratio is almost 4 standard deviations from zero and less than 1 standard deviation from unity.

The two cross sections (table I) are sufficient to separate G_E and G_M, but since a third precise measurement at $q^2 = 75\ f^{-2}$ is now available[5], i.e.

$\theta = 75.8^o$; $E_1 = 2.372$ GeV; $\frac{d\sigma}{d\Omega} = 2.76 \cdot 10^{-35}$ cm^2/sr ($\pm 4.3\%$),

we also use this point. Plotting $\frac{d\sigma}{d\Omega}/\left(\frac{d\sigma}{d\Omega}\right)_{Mott}$ as a function of $tg^2\frac{\theta}{2}$ and adjusting the Rosenbluth straight line by a least square fit, we find the two form factors given in table II. The Rosenbluth straight line and the three experimental points are shown in figure 1. We note that

1) the experimental data at $q^2 = 75\ f^{-2}$ are consistent with the Rosenbluth formula within the limits of error;

2) the charge form factor of the proton is different from zero at $q^2 = 75\ f^{-2}$ and, within the limits of error, is consistent with the scaling law $G_E = G_M/\mu$.

The model of Massam and Zichichi[6], which is based on SU_3 symmetry and in which the coupling of the vector mesons to the nucleon is described by a common form factor, predicts that G_E crosses zero somewhere between $q^2 = 74.5\ f^{-2}$ and $q^2 = 76.5\ f^{-2}$ for any physically reasonable $(\omega-\phi)$ mixing angle. This model is not consistent with the above data.

The authors would like to acknowledge the assistance of the entire DESY staff who made this experiment possible. We are very much indepted to Professors W.Jentschke, P.Stähelin, and H.Joos for their continuous support and interest. Two of us (B.Dudelzak and H.Nguyen-Ngoc) are grateful to Professor Blanc-Lapierre for his constant support and encouragement while on leave from CNRS.

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TABLE AND FIGURE CAPTIONS

Table I — Forward and backward cross sections and their ratio at $q^2 = 75\ f^{-2}$.

Table II — The charge G_E and magnetic G_M form factors of the proton and their ratio at $q^2 = 75\ f^{-2}$.

Figure I — The Rosenbluth straight line at $q^2 = 75\ f^{-2}$.

TABLE I

θ (degrees)	E_1 (GeV)	$\frac{d\sigma}{d\Omega}$ (10^{-35} cm^2/sterad)
19.5	5.883	95.20 (±4.0%)
88.1	2.233	1.88 (±4.5%)

$$\left(\frac{d\sigma}{d\Omega}\right)_{\theta=19.5^\circ} / \left(\frac{d\sigma}{d\Omega}\right)_{\theta=88.1^\circ} = 50.64\ (\pm 4.1\%)$$

TABLE II

$\frac{G_E \cdot \mu}{G_M}$	G_E	G_M/μ
0.90 ± 0.24	0.037 ± 0.014	0.041 ± 0.001

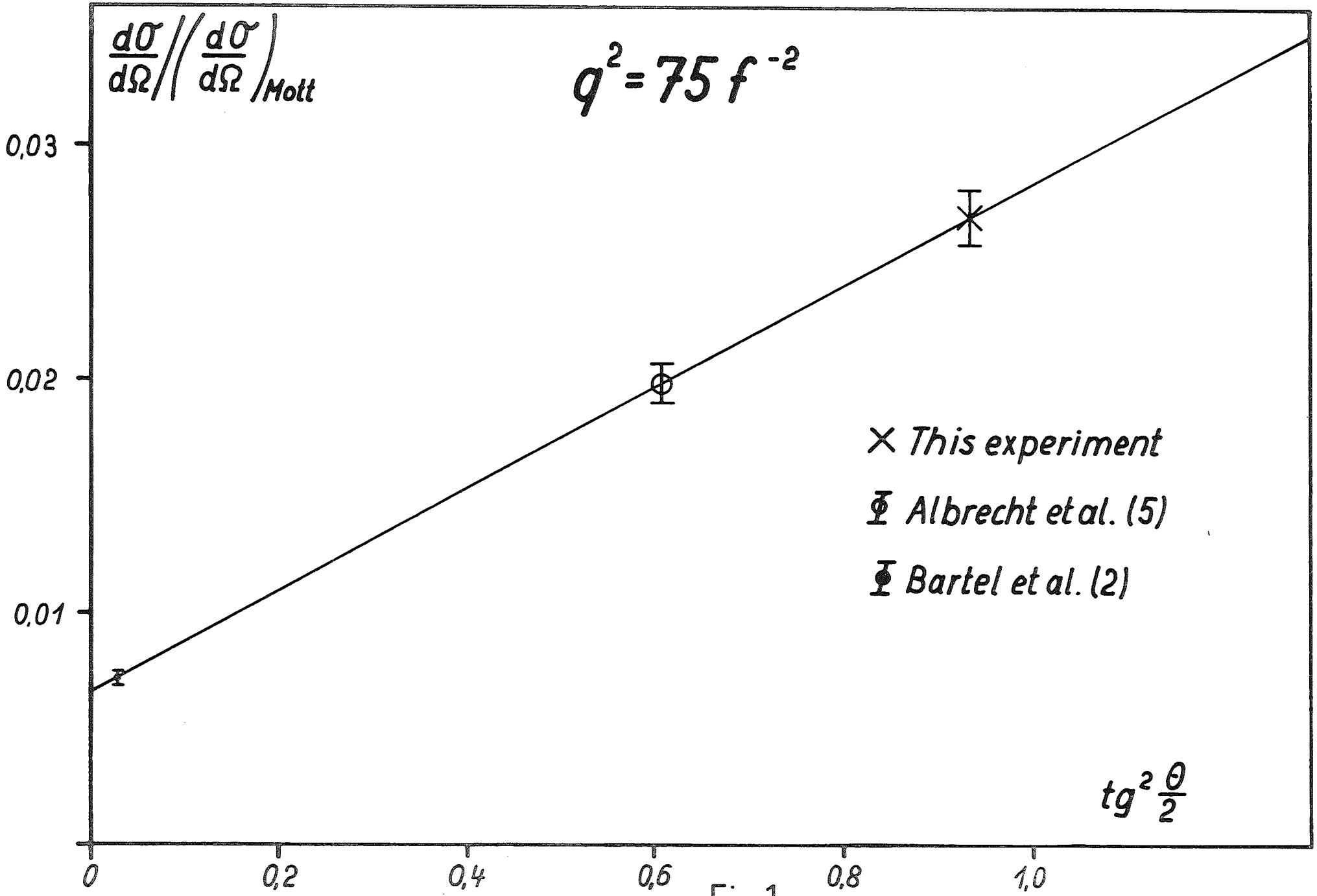
$\frac{d\sigma}{d\Omega}/\left(\frac{d\sigma}{d\Omega}\right)_{Mott}$
$q^2 = 75\ f^{-2}$
0,03
0,02
0,01
0
0,2
0,4
0,6
0,8
1,0
$tg^2\frac{\theta}{2}$
× This experiment
Φ Albrecht et al. (5)
Φ Bartel et al. (2)

Fig. 1