## The Corbino Effect and the Change of Resistance in a Magnetic Field

K. M. Koch
*Technische Hochschule, Wien, Austria*
(Received March 12, 1951)

In measuring the change of resistance in a magnetic field in a circular disk through which the current $J_r$ flows radially, while the magnetic field acts vertically to the plane of the disk (Fig. 1), it

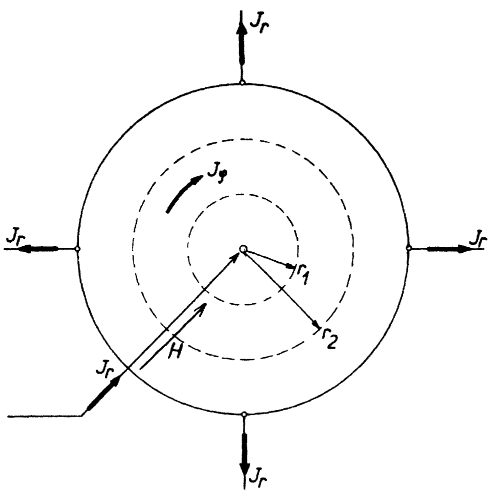


FIG. 1. Arrangement for measuring change of resistance in a magnetic field.

is found that $(\Delta R/R)_H$ decreases appreciably if the flow of the Corbino current $J_\varphi$ is prevented or at least hindered by a radial slit. We have examined this phenomenon, already observed by Ettingshausen,[1] with Bi at a temperature of 80°K and found that $(\Delta R/R)_H$ decreases from 51.8 percent to 38 percent ($H=700$ oersted) if the disk is slit in the manner described above. (Of course, the slit cannot cause a change in the value of $R$ at $H=0$; this constitutes a control for the radial character of the current.) The Hall constant also could be measured on the slit disk; it decreases perceptibly at this temperature if the field strength increases (especially in Bi which is not extremely pure). At $H=700$ oersted, we found $R_H=28$ emu.

The knowledge of $R_H$ enables us to calculate $J_\varphi$ and the Joule heat $Q$ generated by it. It can be assumed that $Q$ corresponds to the work necessary to overcome the additional resistance $\Delta R$.[2] If we put the results of our measurements into the equation $Q=J_r^2\Delta R$, we find that $Q$ accounts for only approximately $\frac{1}{5}$ of $J_r^2\Delta R$. Better conformity is achieved by putting $Q=J_r^2(\Delta R-\Delta R')$, where $\Delta R'$ means the change of resistance in the magnetic field which remains after the slitting of the disk.

To examine these relations under somewhat altered conditions, we measured the Hall electromotive force $E_H$ in a plate, as shown in Fig. 2. The broadened side parts were intended to make possible

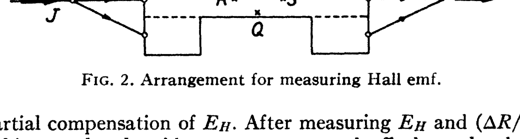


FIG. 2. Arrangement for measuring Hall emf.

a partial compensation of $E_H$. After measuring $E_H$ and $(\Delta R/R)_H$ on this sample, the side parts were sawed off along the dotted lines. As expected, the measurement now showed approximately an 18 percent increase of $E_H$ but a 2 percent decrease of change of resistance. (These measurements were carried out at 293°K.)

Detailed theoretical and experimental research is now in progress to ascertain whether more than one mechanism of change of resistance must be considered for the explanation of the results described above. At any rate, it will be necessary to consider these effects as a source of error in determining the change of resistance in a magnetic field.

[1] A. v. Ettingshausen, Wien. Berichte **XCV**, II, 737 (1887).
[2] P. W. Bridgman, Phys. Rev. **24**, 644 (1924).

## $\pi^+$ Meson Mass Determination*

W. F. Cartwright
*Radiation Laboratory, Department of Physics, University of California, Berkeley, California*
(Received February 9, 1951)

In a previous letter,[1] initial results were reported on measurements made, at the 184-in. synchrocyclotron, of the cross section for the production of $\pi^+$ mesons at zero degrees by proton-proton interaction.

The high peak in the meson spectrum at maximum meson energy results from the strong interaction of the product nucleons. This sharp peak provides a method of measuring the $\pi^+$ meson mass, since the meson energy at the peak depends only on the meson mass, the proton beam energy, and the total mass of the resulting nucleons. (The possibility of deuteron formation had been suggested earlier.[2,3] If a deuteron is formed, its binding energy is available to the reaction.)

The effect of the interaction of the product nucleons on the meson production cross section has been investigated theoretically by Watson and Brueckner,[4] following a suggestion by Brueckner, Chew, and Hart. We have improved the measurement of the meson spectrum so that, with the increased resolution, we can now more critically compare the experimental results with the theoretical spectra. We have concluded from this comparison that meson production at maximum meson energy is accompanied by the formation of a deuteron.[5]

The resolution, determined by the proton beam energy spread, the straggling in range, and the multiple small angle scattering of the mesons, has been estimated. Figure 1 shows the result of folding the resolution into two of the theoretical curves of Watson and Brueckner. Curve I is for the case in which the product nucleons are in the triplet $S$ state. Some deuteron formation would be expected in this case. Since the main feature of this spectrum

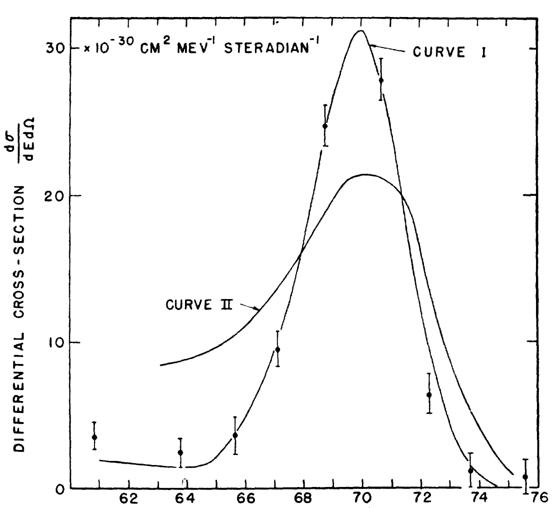


FIG. 1. Differential cross section for the production at zero degrees of $\pi^+$ mesons by 340-Mev protons on protons. Curve I: product nucleons in $^3S$ state. Curve II: product nucleons in $^1S$ state. The curves have been normalized so that the area under each, from 65.5 Mev to 76.0 Mev, is equal to the area under the experimental points in the same energy interval.

is a line displaced upward by 4 Mev from a continuum, this curve is essentially a plot of the estimated resolution. Curve II, for the case in which the product nucleons are in the singlet $S$ state, also exhibits a peak because of the resonance resulting from the low energy virtual state. It is clear that the experimental points, also plotted, are not in agreement with either the half-width or the asymmetric character of curve II. On the other hand, the close fit of curve I with the experimental results is strong evidence that the peak corresponds to deuteron formation. Therefore, it is the deuteron mass which should be used in the calculation of the $\pi^+$ meson mass from the meson energy at the peak.

The proton beam energy was measured from its Čerenkov radiation by R. Mather to an accuracy of about $\pm 1$ Mev. The energy of each meson was found from its range, as calculated from the most recent range-energy curves.[6–8]

The $\pi^+$ meson mass, as determined by this experiment, is $275.1\pm 2.5$ electron masses. The estimated systematic errors account for most of the quoted probable error.

The details of the entire experiment will be published later.

It is a pleasure to acknowledge the help and encouragement of Professors C. Richman and H. A. Wilcox, and Dr. K. M. Watson.

* This work was performed under the auspices of the AEC.

[1] Cartwright, Richman, Whitehead, and Wilcox, Phys. Rev. **78**, 823 (1950).
[2] Morand, Cüer, and Moucharafyeh, Compt. rend. **226**, 1974 (1948).
[3] Walter Barkas, Phys. Rev. **75**, 1109 (1949).
[4] K. M. Watson and K. A. Brueckner, to be published.
[5] In addition to the evidence presented below, Crawford, Crowe, and Stevenson recently detected directly the deuteron in this reaction. [Phys. Rev. **82**, 97 (1951)].
[6] Aron, Hoffman, and Williams, AECU 663 (unpublished).
[7] C. J. Bakker and E. Segrè, Phys. Rev. **81**, 489 (1951).
[8] R. Mather and E. Segrè, private communication (to be published later).

## Photonuclear Effects in Carbon from 100-Mev Betatron X-Rays

E. R. GAERTTNER AND M. L. YEATER
*General Electric Research Laboratory, Schenectady, New York*
(Received March 16, 1951)

A METHANE-FILLED cloud chamber[1] has been used to observe the photodisintegration of carbon nuclei by x-rays from a 100-Mev betatron. The disintegrations are produced in the gas at one-half atmosphere pressure by a collimated beam of x-rays which passes diametrically through the cloud chamber. The present results are based on the examination of 1800 disintegrations involving the emission of charged particles.

The observed disintegrations form "stars," consisting of three or more tracks with a common origin, and "flags," consisting of a short heavy track from the residual nucleus and a longer, lighter track from a single emitted charged particle. The ratios of flags to 3-prong stars to 4-prong stars are found to be 31:5.5:1 at a peak x-ray energy of 100 Mev and 60:5.5:1 at a peak x-ray energy of 50 Mev. Two 5-prong stars were observed.

About ninety percent of the flags from carbon represent the emission of a charged particle alone, without an accompanying neutron. The identification procedure is the same as previously described.[2] Not more than ten percent of the flags can be ascribed to $C^{12}(\gamma, np)B^{10}$. It is believed that the $C^{12}(\gamma, p)B^{11}$ reaction is principally involved, although a contribution from the $(\gamma, d)$ or $(\gamma, He^3)$ reactions is not ruled out by the present evidence. The reaction $C^{12}(\gamma, He^4)Be^8$ is, of course, excluded as an origin of flags by the instability of the $Be^8$, but it is undoubtedly responsible for some of the observed 3-prong stars.

The yield of flags in methane has been referred to the yield of flags in nitrogen,[3] for which the approximate integrated cross section has been previously determined, by comparing x-ray intensities with an ionization chamber. In this way, we obtain an integrated cross section for the carbon flags, which is $0.22\pm 0.09$ Mev-barn, for a peak x-ray energy of 100 Mev.

The angular distribution of the flags from carbon for a peak x-ray energy of 100 Mev is shown in Fig. 1. The angle measured is

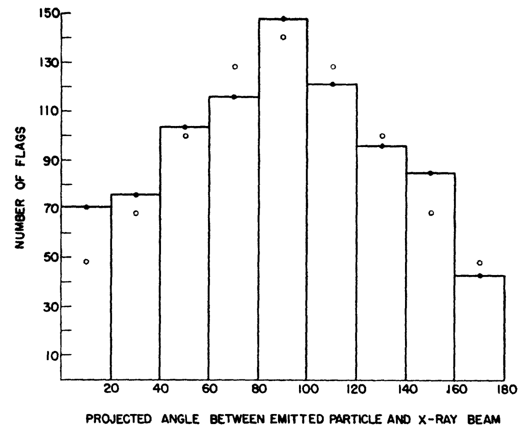


FIG. 1. The angular distribution of the carbon flags in methane. The angles are measured between the x-ray beam and the projection in the plane of the cloud chamber of the track of the emitted particle. The points indicated by open circles are calculated from the space distribution $f(\theta)d\Omega \sim (1+3\sin^2\theta)d\Omega$ by a transformation appropriate to the cloud chamber geometry.

that between the x-ray beam and the projection in the plane of the cloud chamber of the track of the emitted particle. Flags which obviously involve neutron emission are not included. This angular distribution, when transformed into a space distribution, can be represented approximately by the function

$$f(\theta)d\Omega \sim (1+a\sin^2\theta)d\Omega,$$

where $\theta$ is the space angle between the x-ray beam and the path of the emitted particle, and $a\cong 3$. This differs from the helium photo-proton distribution,[4] which is compatible with a pure $\sin^2\theta$ function.

We wish to thank Dr. E. E. Charlton for support of our research program with the 100-Mev betatron. The cloud chamber equipment was developed with funds from the ONR.

[1] E. R. Gaerttner and M. L. Yeater, Rev. Sci. Instr. **20**, 588 (1949).
[2] E. R. Gaerttner and M. L. Yeater, Phys. Rev. **79**, 401 (1950).
[3] E. R. Gaerttner and M. L. Yeater, Phys. Rev. **77**, 714 (1950).
[4] E. R. Gaerttner and M. L. Yeater, Phys. Rev. (to be published).

## Coincidence Studies on the Radiations from $Ba^{131}$

W. H. CUFFEY
*Physics Department, Indiana University, Bloomington, Indiana**
(Received February 26, 1951)

THE half-life of $Ba^{131}$ is 12 days, and it can be formed by neutron capture in barium. It is the parent in the chain $Ba^{131}\rightarrow Cs^{131}\rightarrow Xe^{131}$. The properties of the radiations from $Ba^{131}$ were first investigated by Yu, Gideon, and Kurbatov[1] using absorption and cloud-chamber techniques. These investigations showed that no positrons were emitted and established the fact that $Ba^{131}$ decays by orbital electron capture. Internal conversion electrons were found. Absorption experiments in lead of the gamma-rays showed three gamma-rays of energies 0.220, 0.500, and 1.7 Mev. Katcoff[2] performed similar absorption experiments and found gamma-rays of energy 0.26, 0.5, and 1.2 Mev. In addition, he measured the absorption of the electrons in aluminum and found two groups at energies of 0.42 and 0.24 Mev. Finally, Dale, Richert, Redfield, and Kurbatov[3] and Zimmerman. Dale, Thomas, and Kurbatov[4] have measured the spectrum of the gamma-rays in a magnetic lens spectrograph and found two lines—one at 0.496 and the other at 0.213 Mev.

Since the investigation of the $Ba^{131}\rightarrow Cs^{131}$ chain is under investigation in this laboratory, the present experiments were undertaken to obtain more information, especially on the high energy gamma-ray.