LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the eighteenth of the preceding month, for the second issue, the third of the month. Because of the late closing dates for the section no proof can be shown to authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Communications should not in general exceed 600 words in length.

The Ratio e/m for *Primary* Beta-Rays from Radium E

It has recently been suggested by cloud chamber experiments, that primary beta-particles may carry with them a greater energy than that conventionally indicated by the curvature of their paths in a magnetic field.[1] Under such circumstances the mass of the beta-particles should be greater than that for normal electrons; and a measurement of the ratio e/m should give direct information in this connection.

It is of interest to note that the original experiments of Bucherer and of Neumann were made with beta-particles from radium, consisting chiefly of secondary, or internal conversion, electrons, and at a time when the primary and secondary rays had not yet been clearly identified. Therefore it appears that up to the present time no direct determination of the specific charge has been made for pure primary beta-rays as distinguished from the secondaries.

If one makes the assumption, suggested by the well-known beta-ray paradox, that all the primary beta-rays actually carry the same total energy, i.e., the energy corresponding to the upper limit of the continuous spectrum, and therefore that for momenta below the upper limit some of the total energy is "concealed" in a form other than kinetic,—then one calculates that for the beta-rays of radium E of momentum $2000H\rho$ the mass should be about twice that for normal Lorentz electrons. Therefore a rough measurement of e/m should suffice as a test for the above-mentioned assumption.

For the latter purpose we have devised a modification of the original Bucherer experiment, which consists essentially in reversing the order of the experiment. Bucherer first selected a particular velocity from the spectrum by letting the rays pass through crossed electric and magnetic fields, and then determined the momentum of the same rays by letting them pass some distance through the magnetic field alone and measuring their deflection on a photographic plate. On the other hand, with our present modification, the momentum is selected first, and then the velocity is determined by observing the value of the electric field which permits the rays to pass through the condenser. With this method the rays may be detected by means of a Geiger counter in a *fixed* position at the far end of the condenser. The experimental procedure consists simply in varying the voltage on the condenser until a "peak" of beta-rays is counted. The momentum is specified by the position of the source relative to the condenser, and by the magnetic field, which is kept constant. This arrangement seems to have a number of advantages over the original method. For example, with Bucherer's arrangement almost half of the total radiation from the source should be absorbed at the plates of the condenser; and scattering must therefore play a large rôle—while with the present modification the number of particles entering the condenser is of the same order of magnitude as the number transmitted when the voltage is adjusted for the peak. Further advantages and improvements and a discussion of the original experiments of Bucherer and Neumann will be given in a later article.

Observations have been made in the following manner: A line source of radium E of about one millicurie intensity was placed about 10 cm from one end of an electric condenser and a circular arc of about 16 cm radius. The condenser consisted of two brass plates 6 cm long and separated by about 0.5 mm. The whole was placed in vacuum and in a magnetic field of about 125 gauss, produced by a set of Helmholtz coils. The Geiger counter was placed just outside a one mil aluminum window in the vacuum chamber.

In this case one should observe a peak: for normal electrons, with about 1400 volts on the condenser; and for the "heavy" electrons, at about half this value. Actually the observations show a peak corresponding to the mass of the ordinary Lorentz electron to within about ten percent, and on the side of the heavier electrons. *Hence these results show quite definitely, that the assumption of the previously mentioned type of heavy electron is untenable*, but it is not yet quite clear whether or not the discrepancy lies within the limits of experimental error. Besides, side-peaks were observed, the one on the side of the lighter mass showing a definite maximum, and the other not quite resolved.

A complete mathematical analysis of the system of rays in this experiment has been carried out to determine the shape and intensity of the peak to be expected in the absence of scattering, but no side-peaks are predicted by these calculations. In order to determine the nature of these side-peaks and to improve the experimental accuracy a new apparatus is being constructed, with such modifications as are necessary for distinguishing between scattering and other effects.

We are indebted to Dr. J. A. Bearden and to Mr. C. M. Herget of The John Hopkins University for their generosity in supplying the radium E source; to Mr. J. L. Lawson for the loan of a Geiger counter scale-of-eight circuit and assistance with the same; and to Dr. O. S. Duffendack and to Mr. Harold Lifschutz for the loan of a Geiger counter. We also wish to express our appreciation, variously

for their interest and help, to Drs. R. L. Thornton, H. L. Crane, S. A. Goudsmit, J. Turin, D. S. Bayley, and to Mr. W. C. Parkinson and others. Finally we gratefully acknowledge support from the Horace H. Rackham School of Graduate Studies of the University of Michigan.

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[1] See reference to Crane's report on the possible difference between nuclear beta-particles and electrons, G. Breit, Third Washington Conference on Theoretical Physics, Rev. Sci. Inst. **8**, 141 (1937).

Further Search for Transmutations with Possible Emission of Negative Protons

I have been privileged to use the Berkeley cyclotron, to try again[1] to detect reactions in which there could be a chance of a negative proton being ejected during the transmutation.

The existence of the negative proton has been shown by G. Gamow[2] to be not impossible. In fact, Dirac's equation, being valid only for elementary particles of radius smaller than h/mc, does not apply to the proton whose radius is of the same order of magnitude as is its de Broglie wave-length (1.3×10^{-13} cm). Thus, no analogy to the "hole" positron theory is here required and therefore the proton—positive or negative—can be imagined as being a complex particle (neutron+positron+anti-neutrino, or, neutron +electron+neutrino).[3] Furthermore the existence of the negative proton would tentatively explain the possibility of the formation of isomeric nuclei such as: $UX2$ and UZ, Pb^{210}(?) and RaD, Br^{80} (18 min. and 4.2 hr.).[4] Attempts by various workers to detect the negative proton in a Wilson chamber having failed, and no evidence[5] having been found yet in any of the cosmic-ray tracks, I have looked for some process in which the detection of the negative proton was not essential to prove its existence. Radio-elements such as those formed according to the schematic reaction:

$$_ZX^M+{}_0n^1\rightarrow{}_{Z+1}Y^M+{}_{-1}H^1;\quad {}_{Z+1}Y^M\rightarrow e_++{}_ZX^M \qquad (1)$$

if detected would give some support to the possible existence of the negative proton. The element bombarded should be of high isotopic content, and should not give any other positronic radioelement whose lifetime is comparable to the one looked for. The lifetime of $_{Z+1}Y^M$ should be very well established by means of a different nuclear reaction, and not be too short, so that chemical separation could be possible. Those conditions and energetic considerations lead to a very restricted choice of possible radioelements. Thus radiocarbon (C^{11}, 21.3 min.) radioaluminum (Al^{26}, 7 sec.) or radiosilicon (Si^{27}, 2.6 min.) are favorable cases.

Attempts to detect C^{11} and Si^{27} after bombardment of boron and aluminum with fast neutrons (deuterons of about 7 Mev on Be or Li targets) have completely failed to show any activity with a thin Geiger-Müller counter, or any track in a Wilson chamber, which could not be traced to an impurity or a contamination.

The disintegration cross section for reaction (1) is therefore found to be smaller than 10^{-27} cm^2.

It is a pleasure to acknowledge my indebtedness to Professor E. O. Lawrence, Dr. D. Cooksey and co-workers for their friendly hospitality.

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[1] M. E. Nahmias and R. J. Walen, J. de phys., April 1937, p. 159.
[2] *Atomic Nuclei* (1937), p. 14.
[3] J. Solomon, J. de phys., May 1937, p. 182.
[4] A. H. Snell, unpublished.
[5] J. Crussard and L. Leprince-Ringuet, J. de phys., May 1937, p. 216.
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Grating Space of Barium-Copper-Stearate Films

We have recently shown[1] that films of barium stearate built according to the method of Dr. Katharine Blodgett[2] give sharp x-ray diffraction. A preliminary determination made by one of us[3] of the grating-space of several barium-copper-stearate films indicated fairly good agreement between x-ray measurements and measurements made with an interferometer from films of known numbers of layers. A more thorough investigation of these films now discloses the fact that the x-ray and optical measurements do not agree.

Interferometer measurements give 48.40A for the mean thickness of the double-layers of stearates deposited on glass. X-ray measurements, based upon the crystal wave-length[4] of 1.47336A for the tungsten $L\alpha_1$ line, give 50.31A for the grating-space of the films for an infinite order. With Bearden's[5] weighted average of 1.00248 as the ratio between ruled-grating and crystal wave-length values, the grating-space of the films in terms of the ruled-grating scale is found to be 50.43×10^{-8} cm. The observed position of the $M\alpha$ line is also consistent with these values for the grating-space. The values given are corrected for the refraction of the x-rays, our experiments giving a unit decrement of 5.4×10^{-6} for the $L\alpha_1$ line of tungsten.

We find also that the films designated by Dr. Blodgett as X films,[6] have approximately the same x-ray grating-space as do the Y films. The similarity in structure of the X and Y types of films and the lack of agreement between the x-ray and optical measurements of the grating-space, are difficult to reconcile with the idea that the crystalline structure of the films used in these experiments is imparted to them by the dipping process used in their construction.

A detailed report of the work will be given at a later date.

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[1] Clifford Holley and Seymour Bernstein, Phys. Rev. **49**, 403 (1936).
[2] Katharine B. Blodgett, J. Am. Chem. Soc. **57**, 1007 (1935).
[3] Clifford Holley, Phys. Rev. **51**, 1000 (1937).
[4] M. Siegbahn, *Spektroskopie der Röntgenstrahlen*, second edition (1931), p. 237.
[5] J. A. Bearden, Phys. Rev. **48**, 385 (1935).
[6] Blodgett, reference 2, p. 1011.