# 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 twenty-eighth of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.*

## The Diffraction of Hydrogen Atoms by the Mosaic Structure of Crystals

The de Broglie wave spectra of a beam of hydrogen atoms produced by reflection from a crystal of lithium fluoride have been photographed under conditions of improved technique with the primary features described in abstract No. 2 of the 1930 Chicago Meeting of the American Physical Society. Still more recent plates with higher resolution show another type of spectrum which will be referred to as the secondary spectrum. Although the resolution is still too low in this spectrum to separate the maximum of its wave-length distribution from the specularly reflected zero order beam, it is sufficient to show that the secondary spectrum has four branches lying in the directions corresponding to diffraction by a grating whose lines are parallel to the cleavage planes of the crystal. The fact that the maximum of the wave-length distribution is not resolved permits it to be said that the spacing of the secondary lattice is greater than 50A, and the observations are not in disagreement with a spacing of more than 100A.

These facts are believed to support Zwicky's theory of the mosaic structure of crystals (Helvetica Physica Acta **III**, 269, 1930). Although the writer is not familiar with any calculations applying to the structure of LiF the spacing of the secondary lattice of these crystals should not differ in order of magnitude from that of rock salt for which Zwicky calculates 110A.

In the experiments the crystals were heated before the exposure was started to the point that the secondary structure of the crystal might well have been developed on the surface by evaporation.

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## On Some of the New Ultra-Ionization Potentials of Mercury Vapor

In view of the recent interest in the ultra-ionization potentials of mercury vapor (A. L. Hughes and C. M. Van Atta, Phys. Rev. **36**, 214, 1930, Philip J. Smith, 166th Meeting of the American Physical Society and Curtis R. Haupt, 167th Meeting of the American Physical Society) I would like to call attention to some observations of Mr. R. D. Potter, made at Duke University under my direction and published in the Journal of the Elisha Mitchell Scientific Society, **44**, 31, 1928. Inasmuch as the results of the experiment described in this paper do not seem to have come to the attention of other workers in this field, a brief statement of the results may be of interest.

Electrons from a tungsten filament were projected parallel to the axis of a tube and were collimated by means of a coaxial magnetic field of approximately 250 gauss. Collisions between electrons and mercury atoms occurred in a space midway between two rows of parallel and plane electrodes symmetrically placed with respect to the electron beam. A small electric field between these plates served to draw out positive ions formed in the region of the beam. The electrons after passing between the sets of parallel plates were collected by an electron trap. An accelerating potential of 125 volts inside the electron trap made it a good absorber of electrons. Since the primary electrons were collimated into a beam by the magnetic field they did not strike the edges of the slits in the accelerating plates. This prevented the formation of secondary electrons.

The procedure was to measure the saturated positive ion current and total electron current for successive values of the accelerating potential, observations being taken at 0.10 volt intervals.

A plot of the ratio of positive ion to total electron current showed a series of abrupt changes in slope which resembled the familiar ones of Franck and Einsporn rather than those reported by J. C. Morris (Phys. Rev. **32**, 447, 1928). Critical potentials were observed at 10.40, 10.66, 11.00, 11.41, 11.72, 12.06, 12.40, 12.80 and 13.25 volts. The values given have been corrected for initial thermal energies, etc., by assuming the potential at which ions were first detectable to be 10.40 volts.

An examination of the results indicates that in the main there is good agreement between the above critical ultra-ionization potentials and those reported in subsequent work mentioned at the beginning of this letter.

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## Projective Relativity and the Quantum Field

A recent paper[1] by O. Veblen and the present writer showed that the "five-dimensional" relativity theory of Kaluza and O. Klein is to be regarded as a four-dimensional projective theory; a natural generalization of the formalism from this point of view led to a set of field equations which contained not only gravitational and electromagnetic field equations as in the usual relativity theory but also the relativistic Schrödinger equation.

The formalism was based on the symmetric projective tensor $G_{\alpha\beta}$ which may be decomposed as

$$G_{\alpha\beta} = \gamma_{\alpha\beta}\Phi^2 = (\delta_\alpha{}^a\delta_\beta{}^b g_{ab} + \phi_\alpha\phi_\beta)\Phi^2,$$

as explained in P. R.

I have been able to obtain a set of four-dimensional projective field relations which is to the field relations of P. R. what the Dirac wave equation is to the relativistic Schrödinger equation.

The basic quantity of space-time is taken to be a projective vector, $H_\alpha$, of index $N$ with which is associated one of zero index denoted by $h_\alpha$. The components of these vectors are not assumed to obey the commutative law of multiplication; they may be regarded as matrices. The restrictions are imposed that

$$H_\alpha H_\beta + H_\beta H_\alpha = 2G_{\alpha\beta} \qquad (1)$$

$$h_\alpha h_\beta + h_\beta h_\alpha = 2\gamma_{\alpha\beta} \qquad (2)$$

where $G_{\alpha\beta}$ and $\gamma_{\alpha\beta}$ commute with everything they multiply. $\gamma_{\alpha\beta}$ are now associated tentatively with the similar quantities of P. R.

Indices of the $h$'s are raised by means of the $\gamma$'s and the field equations are taken to be

$$h^\alpha\left(\frac{\partial H_\beta}{\partial x^\alpha} - \frac{\partial H_\alpha}{\partial x^\beta}\right) = 0. \qquad (3)$$

A realization of (1) and (2) may be obtained in terms of projective ennuples of vectors in the tangent spaces[2] and a basis consisting of five four-rowed square matrices satisfying[3]

$$E_\sigma E_\tau + E_\tau E_\sigma = 2\delta_{\sigma\tau}1.$$

Denoting the components of the vectors of an ennuple by $h_{\alpha\sigma}$ we set

$$h_\alpha = h_{\alpha\sigma}E_\sigma.$$

Realization of the $H$'s is effected by the introduction of a one-columned four-rowed matrix, $\Psi$, by

$$H_\alpha = h_\alpha\Psi$$

together with a suitable definition of matrix multiplication.

With the above realization the field Eqs. (3) can be shown to contain Dirac's wave equation for a single electron as a special case (i.e. when gravitation is neglected) of the scalar part of the projective set.

If we inserted the relations

$$G_{\alpha\beta} = \gamma_{\alpha\beta}\Phi^2 \qquad (4)$$

together with (1) and (2) we would be unable to obtain a satisfactory realization on account of the difference between spatial and temporal coordinates. A realization in terms of eight-rowed square matrices for the $E$'s avoids this difficulty but introduces the new difficulty that although the scalar part is still equivalent to Dirac's wave equation the whole set of equations numbers forty and we have merely twenty-eight functions entering them.

The Dirac equation is obtained as a special

[1] O. Veblen and B. Hoffmann, Phys. Rev. **36**, 810 (1930); referred to as P. R.

[2] See the "five-dimensional" formulation due to Zaycoff, Zeits. f. Physik **58**, 833 (1929).

[3] See for example Eddington, Proc. Roy. Soc. **A126**, 696 (1930).