excitation increases, at least for a time, as the excess energy available increases. This view is supported by the fact that all three systems are strongly developed in the helium mixture. Several bands belonging to the comet tail and Baldet-Johnson systems not previously reported were observed in our spectrograms of the carbon monoxide-helium mixture.

The failure of the Baldet-Johnson bands to appear in the neon mixture and their strong development in the helium mixture is significant. According to Birge,[3] these bands constitute a combination system between the initial states of the first negative and the comet tail systems. If this were true, they would have the same excitation potential as the first negative bands and should be excited by neon ions. Their experimentally determined excitation potential[1] is in agreement with their behaviour in the neon and helium mixtures. This confirms the assignment of this system to a higher initial state of the CO$^+$ ion as made by Duffendack and Fox.[2] It might be added that Miss Ann Hepburn, at the Chicago meeting of the American Physical Society, corrected her published abstract[4] and reported the excitation potential of this system to be 23·0 volts, in agreement with the value given above.

The appearance of the negative band systems of carbon monoxide and of nitrogen in our discharges is in harmony with their appearance in geissler tube discharges through similar mixtures as observed by Merton and Johnson[5] and by Cameron.[6] Their presence can be accounted for on the basis outlined above, and slight discrepancies can be explained by the less definite limitation of the maximum speeds of the electrons in geissler discharges. Similar discrepancies can be produced in our discharges by increasing the voltage, or the current density, or the percentage of carbon monoxide, or in any way increasing the probability of excitation of the carbon monoxide molecules by direct electron impacts.

There is no reason to believe that this method of excitation of radiation from an ionised molecule is limited to the ions of the rare gases or to multi-atomic molecules. The same process may be expected to occur in any mixture of gases or vapours, and should find application in the production of the first spark spectra of atomic ions to the exclusion of higher spark spectra, and in the approximate determination of the excitation potentials of the spark lines. This process may also explain the enhancement of certain lines in discharges through mixtures of gases and the origin of certain radiations of astronomical interest.

We wish to express our gratitude to Dr. W. E. Forsythe of the Nela Research Laboratory (where these experiments were begun during the summer of 1926) for the argon, and to the U.S. Bureau of Mines for the helium used in these experiments.

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University of Michigan,
Ann Arbor, Mar. 15.

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[3] Birge, NATURE, 116, 207; 1925.

[4] Hepburn, *Phys. Rev.*, 29, 212; 1926.

[5] Merton and Johnson, *Roy. Soc. Proc.*, A, 103, 383; 1923; Johnson and Cameron, *ibid.* 106, 195; 1924; Johnson, *ibid.* 108, 343; 1925.

[6] Cameron, *Phil. Mag.*, 1, 405; 1926.

Spinning Electron and Wave Mechanics.

IN order to obtain an interpretation of the anomalous Zeeman effect, the multiplet structure, etc., Uhlenbeck and Goudsmit (*Physika*, 1925; *Naturw.*, 953, 1925; NATURE, 117, 264; cf. Thomas, NATURE, 117, 514; Slater, NATURE, 117, 587; London, *Naturw.*, 15, 15, 1927; Darwin, NATURE, 119, 282) assume that the magnetic moment corresponding to the spinning movement of the electron is just twice as great as that of the revolving electric point-charge with the same mechanical angular momentum. In the following, an attempt is made to derive this assumption from the relativistic Schrödinger wave equation in connexion with the electrodynamic meaning of the wave function ψ.

The relativistic wave equation for forceless movement of the electron is:

$$\Delta\psi - \frac{1}{c^2}\frac{\partial^2\psi}{\partial t^2} - \frac{4\pi^2}{h^2}m_0{}^2c^2\psi = 0. \qquad (1)$$

(Schrödinger, *Ann. d. Ph.*, 81, 133, and other authors.) The solution, in the rest-system of the electron, may be reduced to the following form (r, z, ϕ being columnar co-ordinates, which are suitable to the purpose):

$$\left.\begin{aligned}\psi &= f(r,z)\ \text{exp.}\ is\phi\ \text{exp.}\ \frac{2\pi i}{h}m_0c^2t\\ &= F(r,z,\phi)\ \text{exp.}\ \frac{2\pi i}{h}m_0c^2t\end{aligned}\right\}. \qquad (2)$$

F satisfies the equation: $\Delta F = 0$, and is therefore harmonic in the rest-system.

The equation of the continuity of electricity is:

$$\text{div.}\left\{\frac{h}{2\pi i}(\psi\ \text{grad.}\ \bar\psi - \bar\psi\ \text{grad.}\ \psi)\right\} + \frac{\partial}{\partial t}\left\{-\frac{h}{2\pi i}\frac{1}{c^2}\left(\psi\frac{\partial\bar\psi}{\partial t} - \bar\psi\frac{\partial\psi}{\partial t}\right)\right\} = 0. \qquad (3)$$

(See W. Gordon, *Zs. f. Phys.*, 41, 117, see p. 121, and O. Klein, *ibid.* 41, 407, see p. 414.)

We multiply the expressions in brackets by the specific charge $\frac{e}{m_0}$ of the electron (the introduction of the factor $\frac{1}{2}$—as introduced by Klein—cannot be justified in our case) and get for the electric density:

$$\rho = \frac{e}{m_0}\left\{-\frac{h}{2\pi i}\frac{1}{c^2}\left(\psi\frac{\partial\bar\psi}{\partial t} - \bar\psi\frac{\partial\psi}{\partial t}\right)\right\}, \qquad (4a)$$

and for the density of current:

$$j = \frac{eh}{2\pi i m_0}(\psi\ \text{grad.}\ \bar\psi - \bar\psi\ \text{grad.}\ \psi). \qquad (4)$$

From the non-relativistic form of the wave equation only half the density of current follows (cf. Schrödinger, *l.c.*). From that Fermi (NATURE, 118, 876) and Klein (*Zs. f. Phys.*, 41, 425) have derived the magnetic moment for the revolving movement of an electric point-charge, namely:

$$\mu' = -\frac{e}{m_0}\frac{h}{4\pi}s', \qquad (5')$$

whilst the magnetic moment corresponding to the density of current (4) is:

$$\mu = -\frac{2e}{m_0}\frac{h}{4\pi}s. \qquad (5)$$

μ may be regarded as the magnetic moment of the spinning movement, being twice as great as μ' in agreement with the assumption mentioned in the beginning. The conjectures of Slater and London that the rest-energy m_0c^2 is of rotatory character and that the 'internal phenomenon' of L. de Broglie of the frequency $\nu_0 = \frac{m_0c^2}{h}$ causes it and therefore the magnetism of the electron itself, are supported by this.

The necessary half quantum-numbers for s follow readily if one adapts the Schrödinger conditions for the wave function ψ to our problem.

Only the doublet $(\frac{1}{2}, -\frac{1}{2})$ and no higher quantum-states of rotation appear.

We hope, in an early communication, to return to the question of fine structure and analogous problems.

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