X-ray photographs do not disclose any marked non-random distribution of the larvæ, though some small evidence of peripheral migration is afforded by the presence of circumferential tunnels.

Fig. 2.

This problem is being investigated experimentally, and also from the point of view of a mathematical analysis, and will be reported on later in a publication made elsewhere. I wish to acknowledge the financial support of the National Research Council of Canada and the Science Research Committee of Queen's University in connexion with the work on the growth of populations of *Tribolium*, of which this is a part.

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Limits of Validity of Quantum Mechanics

WE proposed some years ago¹ a modification of the formalism of the quantum theory for the cases in which the following condition is satisfied:

$$\xi = \left| \left(\vec{p}_1 - \vec{p}_2 \right)^2 - \frac{1}{c^2} (E_1 - E_2)^2 \right| \gtrsim p_0^2 \quad (1)$$

$$p_0 = \frac{h}{r_0} \sim 137 mc,$$

where $\vec{p}_1$, E_1 and $\vec{p}_2$, E_2 are 4-vectors corresponding to two states of a particle in a quantum transition, and r_0 is a universal length, $r_0 \sim 10^{-13}$ cm.

Such a method consists in the introduction of some relativistic 'convergence-factors' $G(\xi)$, which $\rightarrow 0$ if $\xi \rightarrow \infty$ and which give rise to convergent results instead of many divergent results of the present quantum theory. In the cases where $\xi < p_0^2$, $G(\xi) \cong 1$ and the rules of the ordinary quantum theory are obviously obtained. This condition $\xi < p_0^2$ is therefore the condition of validity of the quantum mechanics and it can be examined independently of the method of the 'convergence-factors'.

Let us show that by operating within the limits of validity of the present quantum theory, the measurement of a co-ordinate x cannot be made with $\Delta x < r_0$. Such a measurement can only be performed by using incident waves of a wave-length $\lambda < r_0$ and by

operating in such a manner that the scattered radiation which enters the measuring apparatus (for example, the Heisenberg microscope) has also a wave-length² $\lambda < r_0$; $|\vec{p}_2| > p_0$. We have indeed:

$$\Delta x \cong \frac{\lambda_2}{\sin \alpha}. \quad (2)$$

Thus we can suppose

$$|\vec{p}_1| \gtrsim |\vec{p}_2| \gg p_0 > mc,$$

and, from the condition of validity of quantum theory $\xi < p_0^2$, we obtain the following condition for the angular deviation θ in the collision process:

$$\xi = \vec{p}_1^2 + \vec{p}_2^2 - 2 |\vec{p}_1| |\vec{p}_2| \cos \theta - (E_1 - E_2)^2 \sim 2 |\vec{p}_1| |\vec{p}_2| (1 - \cos \theta) < p_0^2. \quad (3)$$

$$\left(2 \sin \frac{\theta}{2} \right)^2 < \frac{p_0^2}{|\vec{p}_1| |\vec{p}_2|}; \quad 0 < \frac{p_0}{p_2}; \quad (|\vec{p}_2| = p_2).$$

Only by operating within these limits can we be sure of not introducing unknown phenomena and of being able to apply the ordinary rules of the quantum theory. But in the case we are dealing with, when the measuring apparatus is, for example, a γ -ray microscope, we can only use scattered particles within a small angle α . The numerical aperture of the microscope $\sin \alpha$ must satisfy the condition

$$\sin \alpha < p_0/p_2. \quad (4)$$

From (2) and (4) we have

$$\Delta x \gtrsim \left(\frac{h}{p_2} \right) / \left(\frac{p_0}{p_2} \right) = r_0. \quad (5)$$

The nuclear phenomena belong to the condition $\xi \sim p_0^2$. It is very remarkable that, in the cosmic radiation, phenomena belonging to the condition $\xi \gg p_0^2$ have not been observed so far. This seems to justify the assumption that such phenomena have a very small probability of occurrence, a fact in agreement with the assumptions of the method of the 'convergence-factors'.

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¹ *Z. Phys.*, **88**, 92 and 547 (1934). *C.R.*, 232, 833 (1936). *La Ricerca Scientifica*, S. II, Anno IX, 1.

² Heisenberg, W., *Ann. Phys.*, **32**, 20 (1933). *Z. Phys.*, **110** (1933).

³ *NATURE*, **142**, 393 (1938). *C.R.*, **207**, 353 and 421 (1938).

Hyperfine Structure in the Spark Spectrum of Iodine

IN a recent short note¹, Th. Schmidt states that he cannot agree with my measurements and conclusions relating to the hyperfine structures of two lines in the iodine spark spectrum. In my analysis of 33 terms in this spectrum², I found that in eight there were deviations from the interval rule. Amongst these the terms with $J = 2$ did not fit the quadratic interaction law of the type suggested by Schüler and Schmidt³ and by Casimir⁴, but could be fitted into a cubic law:

$$E = A + B \cos IJ + C \cos^2 IJ + D \cos^3 IJ.$$

In particular, I have found it necessary to employ this formula for the structure of (²D) 6s ³D₂, which