PHYSICS

Einstein Attacks Quantum Mechanics

Calls One of Science's Most Important Theories "Incomplete" and Anticipates More Satisfactory One

PROFESSOR Albert Einstein will attack science's important theory of quantum mechanics, a theory of which he was a sort of grandfather. He concludes that while "correct" it is not "complete."

With two colleagues at the Institute for Advanced Study at Princeton, N. J., the great relativist is about to report to the American Physical Society what is wrong with the theory of quantum mechanics, it has been learned exclusively by Science Service.

Quantum theory, with which science predicts with some success inter-atomic happenings, does not meet the requirements for a satisfactory physical theory, Prof. Einstein is to report in a joint paper with Dr. Boris Podolsky and Dr. N. Rosen.

In quantum theory as now used, the latest Einstein paper will point out that where two physical quantities such as the position of a particle and its velocity interact a knowledge of one quantity precludes knowledge about the other. This is the famous principle of uncertainty put forward by Prof. Werner Heisenberg and incorporated in quantum theory. This very fact, Prof. Einstein feels, makes quantum theory fail in the requirements necessary for a satisfactory physical theory.

The Requirements

These two requirements are:

1. The theory should make possible a calculation of the facts of nature and predict results which can be accurately checked by experiment; the theory should be, in other words, *correct.*

2. Moreover a satisfactory theory should, as a good image of the objective world, contain a counterpart for things found in the objective world; that is it must be a *complete* theory.

Quantum theory, Prof. Einstein and his colleague will report, fulfills the correctness requirement but fails in the completeness requirement.

While proving that present quantum theory does not give a complete description of physical reality, Prof. Einstein believes some later, still undeveloped theory will make this possible.

He concludes: "While we have thus shown that the wave function (of quantum theory) does not provide a complete description of the physical reality, we left open the question of whether or not such a description exists. We believe, however, that such a theory is possible."

The development of quantum mechanics has proved very useful in exploring the atom. Six Nobel Prizes in physics, including one to Einstein, have been awarded for various phases of the researches leading up to quantum mechanics. The names of Planck, Bohr, de Broglie, Heisenberg, Dirac and Shroedinger, as well as Einstein, are linked with quantum mechanics.

Science News Letter, May 11, 1935

PHYSICS

Physicists' New View of Physical World Explained

By Dr. Boris Podolsky, Prof. Einstein's Associate at Institute for Advanced Study, Princeton, N. J.

PHYSICISTS believe that there exist real material things independent of our minds and our theories. We construct theories and invent words (such as electron, positron, etc.) in an attempt to explain to ourselves what we know about our external world and to help us obtain further knowledge of it. Before a theory can be considered to be satisfactory it must pass two very severe tests. First, the theory must enable us to calculate facts of nature, and these calculations must agree very accurately with observations and experiments. Second, we expect a satisfactory theory, as a good image of objective reality, to contain a counterpart for every element of physical world. A theory satisfying the first requirement may be called a *correct* theory, while, if it satisfies the second requirement, it may be called a *complete* theory.

Hundreds of thousands of experiments and measurements have shown that, at least in cases when matter moves much slower than light, the theory of Planck, Einstein, Bohr, Heisenberg, and Schroedinger known as Quantum Mechanics is a correct theory. Einstein, Podolsky, and Rosen now discuss the question of the completeness of Quantum Mechanics. They arrive at the conclusion that Quantum Mechanics, in its present form, is *not* complete.

In Quantum Mechanics the condition of any physical system, such as an electron, an atom, etc., is supposed to be completely described by a formula known as a "wave function." Suppose that we know the wave function for each of two physical systems, and that these two systems come together, interact, and again separate (as when two particles collide and move apart). Quantum Mechanics, although giving us considerable information about such a process, does not enable us to calculate the wave function of each physical system after the separation. This fact is made use of in showing that the wave function does not give a complete description of physical reality. Since, however, description of physical systems by wave functions is an essential step of Quantum Mechanics, this means that Quantum Mechanics is not a complete theory.

Science News Letter, May 11, 1935

PHYSICS

Exact Wording Of The Original Abstract

THE abstract of the Einstein-Podolsky-Rosen paper follows:

Title: Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?

Authors: A. Einstein, B. Podolsky and N. Rosen, Institute for Advanced Study, Princeton, N. J.

Abstract:

In a complete theory there is an element corresponding to each element of reality. A sufficient condition for the reality of a physical quantity is the possibility of predicting it with certainly, without disturbing the system. In quantum mechanics in the case of two physical quantities described by non-commuting operators, the knowledge of one precludes the knowledge of the other. Then either (1) the description of reality given by the wave function in quantum mechanics is not complete or (2) these two quantities cannot have simultaneous reality. Consideration of the problem of

making predictions concerning a system on the basis of measurements made on another system that had previously interacted with it leads to the result that if (1) is false then (2) is also false. One is thus led to conclude that the description of reality as given by a wave function is not complete.

Science News Letter, May 11, 1935

Among the curious accidents that happen are a number of instances of small live fishes becoming impacted in throats of men.

"The buffalo was the great forerunner of the automobile; he made the best pioneer roads and the widest," says a writer in *Outdoor Indiana.*

PHYSICS

Earth's Lop-Sided Magnetism Provides Check of Cosmic Rays

THE lop-sided magnetism of the earth is now being used to study the nature of cosmic radiation, it was indicated in the address of the world-famous Belgian scientist Abbé Lemaître before the meeting of the American Physical Society.

Father Lemaître read the paper of Prof. M. S. Vallarta of Massachusetts Institute of Technology on the "Longitude Effect of Cosmic Radiation." Prof. Vallarta with Father Lemaître developed the theory of cosmic rays so well supported by scientific evidence which assumes that all the incoming rays are of a particle nature and are charged with electricity.

The earth's magnetic field, Father Lemaître explained, is not perfectly symmetrical, but acts as if its center were about 186 miles from the ideal center of the earth. The resultant field on the outside, therefore, is a bit off-center too.

Calculations on what the magnetic lop-sided effect should be on cosmic ray intensity at widely separated points about the earth gives almost perfect agreement with experimental measurements, Father Lemaître said. Data taken in places all around the world from zero longitude at Greenwich, England, to the Antipodes on the opposite side of the earth all fall on the new calculated curves.

There is but one set of observational data which does not fit the new theoretical curves. These data were obtained by Prof. Robert A. Millikan and Dr. Victor Neher on an automatic instrument placed aboard a ship enroute from Honolulu to Sydney-Melbourne. Other data by these scientists fit perfectly well, Abbé Lemaître explained. The new report lends additional support to the idea that cosmic rays are particles.

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\begin{aligned}
1 \quad & \Psi' = A\Psi = a\Psi \\
2 \quad & \Psi = e^{\frac{2\pi i}{h} p_0 x} \\
3 \quad & P = \frac{h}{2\pi i}\frac{\partial}{\partial x} \\
4 \quad & \Psi' = P\Psi = \left(\frac{h}{2\pi i}\right)\frac{\partial \Psi}{\partial x} = p_0\Psi \\
5 \quad & q\Psi = x\Psi = a\Psi \\
6 \quad & P(a,b) = \int_a^b \bar{\Psi}\Psi\, dx = \int_a^b dx = b-a \\
7 \quad & \Psi(x_1, x_2) = \sum_{n=1}^{\infty} \Psi_n(x_2)\, u_n(x_1) \\
8 \quad & \Psi(x_1, x_2) = \sum_{s=1}^{\infty} \phi_s(x_2)\, v_s(x_1) \\
9 \quad & \Psi(x_1, x_2) = \int_{-\infty}^{\infty} e^{\frac{2\pi i}{h}(x_1 - x_2 + x_0)p} dp, \\
10 \quad & u_p(x_1) = e^{\frac{2\pi i}{h} p x_1} \\
11 \quad & \Psi(x_1, x_2) = \int_{-\infty}^{\infty} \Psi_p(x_2)\, u_p(x_1)\, dp \\
12 \quad & \Psi_p(x_2) = e^{\frac{-2\pi i}{h}(x_2 - x_0)p} \\
13 \quad & P = \frac{h}{2\pi i}\frac{\partial}{\partial x_2} \\
14 \quad & v_x(x_1) = \delta(x_1 - x) \\
15 \quad & \Psi(x_1, x_2) = \int_{-\infty}^{\infty} \phi_x(x_2)\, v_x(x_1)\, dx \\
16 \quad & \phi_x(x_2) = \int_{-\infty}^{\infty} e^{\frac{2\pi i}{h}(x - x_2 + x_0)p} dp = h\delta(x - x_2 + x_0) \\
17 \quad & Q = x_2 \\
18 \quad & PQ - QP = \frac{h}{2\pi i}
\end{aligned}
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EINSTEIN USES THESE COMPLEX EQUATIONS

PHYSICS

Create Forces Equal to 1,200,000 Times Gravity

SPINNING a duralumin rotor in a vacuum, science can create forces equal to 1,200,000 times that produced by the gravitational pull of the earth, it was reported to the American Society by Dr. E. G. Pickels, of the University of Virginia.

Such an enormous force offers the possibility of being able to pull molecules apart. Centrifugal force 1,200,000 times as great as the force of gravity may be explained by saying that gravity makes an object dropped from a high building fall 16 feet in the first second. If the force of gravity were as large as the force in Dr. Pickels' ultracentrifuge, a dropped