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.

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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.

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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