PHYSICS

Einstein Finds Past Events Not Knowable With Certainty

Pioneer in Quantum Research Joins With Drs. Tolman And Podolsky in Extension of Indeterminacy Principle

PROF. ALBERT EINSTEIN has concluded that past events of any sort can not be described with precise certainty.

This amazing extension of the principles of the new physics is contained in a letter to the editor of the *Physical Review,* journal of the American Physical Society. Prof. Einstein, jointly with Prof. Richard C. Tolman and Dr. Boris Podolsky of the California Institute of Technology, wrote this communication just before he left Pasadena to return to Germany.

Not only does Prof. Einstein conclude that there is an uncertainty in the description of what has happened in the submicroscopic world with which the most recent theories of physics usually deal. He applies this disconcerting principle of uncertainty to such everyday happenings as the opening and closing of a shutter on a camera. We can not know exactly just when a shutter opens or closes.

"It is of special interest to emphasize the remarkable conclusion that the principles of quantum mechanics would actually impose limitations on the localization in time of a macroscopic phenomenon such as the opening and closing of a shutter," Prof. Einstein and his two colleagues write.

Theory That Future is Unknown

The idea that it is impossible to predict the exact path of an object in the future was advanced four years ago by a young German physicist, Prof. W. Heisenberg. This principle of uncertainty has had an influence on the philosophy as well as the practice of science comparable with the idea of relativity introduced by Einstein.

As the opening paragraph of the Einstein-Tolman-Podolsky letter states:

"It is well known that the principles of quantum mechanics limit the possibilities of exact prediction as to the future path of a particle. It has sometimes been supposed, nevertheless, that the quantum mechanics would permit an exact description in the past path of a particle."

Prof. Einstein laid one of the foundations of the quantum theory, building on the work of Prof. Max Planck. The Einstein classic paper of 1905 applied the quantum theory of energy to light and electricity. The quantum idea that energy is not continuous but in packets or gobs like matter has been one of the most fruitful conceptions of the new physics.

Now Prof. Einstein adds the latest building block to our conception of matter and energy by telling us that the past as well as the future is uncertain.

Einstein's Associates

Prof. Einstein's associates in his new pronouncement are on the staff of the California Institute of Technology at Pasadena, where he worked during his recent stay in America. Prof. Tolman is one of the leading authorities on thermodynamics. His theory of a non-static universe replaced the Einstein theory of the universe. Dr. Podolsky is a young physicist, Russian born but now an American citizen. He was a National Research fellow in physics for several years.

The letter, under the title "Knowledge of Past and Future in Quantum Mechanics," reads in part:

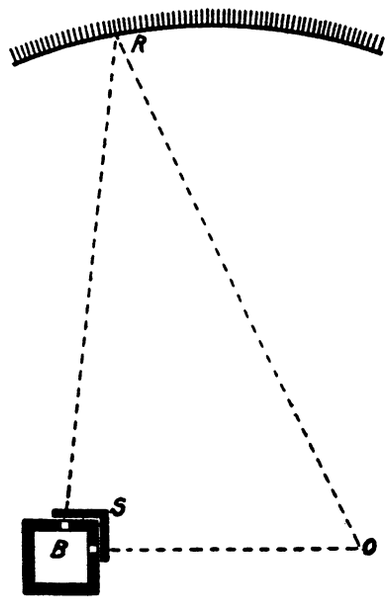
"The purpose of the present note is to discuss a simple ideal experiment which shows that the possibility of describing the past path of one particle would lead to predictions as to the future behaviour of a second particle of a kind not allowed in the quantum mechanics. It will hence be concluded that the principles of quantum mechanics actually involve an uncertainty in the description of past events which is analogous to the uncertainty in the prediction of future events. And it will be shown for the case in hand, that this uncertainty in the description of the past arises from a limitation of the knowledge that can be obtained by measurement of momentum.

"Consider a small box B, as shown in the figure, containing a number of identical particles in thermal agitation, and provided with two small openings which are closed by the shutter S. The shutter is arranged to open automatically for a short time and then close again, and the number of particles in the box is so chosen that cases arise in which one particle leaves the box and travels over the direct path SO to an observer at O, and a second particle travels over the longer path SRO through elastic reflection at the ellipsoidal reflector R.

Box Accurately Weighed

"The box is accurately weighed before and after the shutter has opened in order to determine the total energy of the particles which have left, and the observer at O is provided with means for observing the arrival of particles, a clock for measuring their time of arrival, and some apparatus for measuring momentum. Furthermore the distance SO and SRO are accurately measured beforehand—the distance SO being sufficient so that the rate of the clock at O is not disturbed by the gravitational effects involved in weighing the box, and the distance SRO being very long in order to permit an accurate reweighing of the box before the arrival of the second particle.

"Let us now suppose that the observer at O measures the momentum of the first particle as it approaches along the path SO, and then measures its time of arrival. Of course the latter observation, made for example with the help



EINSTEIN'S DIAGRAM

This figure, which illustrates the letter to the Physical Review, shows paths of two particles escaping from box.

of gamma-ray illumination, will change the momentum in an unknown manner. Nevertheless, knowing the momentum of the particle in the past, and hence also its past velocity and energy, it would seem possible to calculate the time when the shutter must have been open from the known time of arrival of the first particle, and to calculate the energy and velocity of the second particle from the known loss in the energy content of the box when the shutter opened. It would then seem possible to predict beforehand both the energy and the time of arrival of the second particle, a paradoxical result since energy and time are quantities which do not commute in quantum mechanics.

"The explanation of the apparent paradox must lie in the circumstance that the past motion of the first particle cannot be accurately determined as was assumed. Indeed, we are forced to conclude that there can be no method for measuring the momentum of a particle without changing its value. For example, an analysis of the method of observing the Doppler effect in the reflected infra-red light from an approaching particle shows that, although it permits a determination of the momentum of the particle both before and after collision with the light quantum used, it leaves an uncertainty as to the time at which the collision with the light quantum takes place. Thus in our example, although the velocity of the first particle could be determined both before and after interaction with the infra-red light, it would not be possible to determine the exact position along the path SO at which the change in velocity occurred as would be necessary to obtain the exact time at which the shutter was open."

Science News Letter, March 28, 1931

EVOLUTION

Says Tennessee Will Repeal Anti-Evolution Law

Emotional Misunderstandings Aroused by Scopes Trial Declared to Have Passed; Legislature Originated Bill

By JUDGE JOHN R. NEAL
Chief Defense Counsel, Scopes Trial

THE bill to repeal the Tennessee anti-evolution law is a wholly spontaneous movement, originating in the legislature itself. It therefore gives great promise of success.

Courage on the part of the State University and high school authorities in supporting this repeal would secure its passage.

While the Scopes case put an end to the movement for passage of bills similar to the Tennessee anti-evolution law in other states, its effect in Tennessee was not such as had been hoped for by the group of Tennesseeans responsible for originating the famous case. The Supreme Court of Tennessee, while indulging in some dicta upholding the law, based these dicta only on technicalities not relating to the constitutionality of the act, and thus not only prevented an authoritative State decision, but prevented an appeal to the Supreme Court of the United States.

Emotional misunderstandings aroused in Tennessee by the Scopes case have largely passed away, and the people of the state now see the anti-evolution legislation in its true light. They perceive that the sole question it presents is as to whether we are to have freedom of thought and freedom of teaching in Tennessee.

With their minds unconfused as to the real issue, the Tennessee Legislature will undoubtedly bring Tennessee back into the ranks of civilized communities that desire for their youth the privilege of making their decisions for themselves.

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EVOLUTION

Principals in Dayton Case Remote From Repeal

WITH Judge John R. Neal, outstanding figure in Tennessee law and liberal politics, expressing his confidence that the Tennessee state legislature will repeal the law that five and a half years ago made the state a storm center of controversy and ridicule, the rest of the principal figures in the dramatic Dayton trial are remote from the new scene of action. They are not indifferent to the outcome of the effort to obtain a repeal of the anti-evolution law, but they apparently feel that the legislators will do away with the law without the intervention of persons from outside the state.

Possible Opponent Dead

The one man who might return to defend the bill against repeal, William Jennings Bryan, is dead. He was the first to pass of all those involved in the Dayton trial, and he died before the dust of battle was fairly settled, in the town where he had joined issues for a literal interpretation of the Bible against the upholders of science, whom he took to be its enemies.

Bryan's most dramatic opponent, Clarence Darrow, has retired from the practice of law and tries no more cases. He is heard from principally when he splinters a lance in debate over a philosophical or theological question. His associates, Arthur Garfield Hays and Dudley Field Malone, are still in practice in New York, and still make an exciting avocation of championing the cause of the economic and social under-dog. George Rappleyea, the engineer of Dayton whose suggestion over a glass of soda in a drug store started the whole affair, is now in business in New Orleans.

Scopes Now Geologist

John Scopes, the blond-haired, quiet young teacher who consented to be indicted and tried to make a test case of the statute, and to his amazement found himself the center of world-wide disturbance, continues his quiet way along the path of science. The trial crystallized a half-formed resolve he had to become a geologist. The autumn after it was over he entered the graduate school of the University of Chicago, and carried on his studies there for two years. Then he accepted a position as field geologist for an oil company, and spent three years in Venezuela. Not long ago he came back to America, bringing a wife with him—an American girl whom he had met in the tropics—and now he is back at the University of Chicago, finishing his work toward the Ph.D. degree.

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Peruvian Indians used cinchona bark as a remedy for malaria, but the advance step of separating the active constituent quinine from the bark was taken in 1820 by two French chemists.