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Quantum Formalism

Overview

1. Many-Worlds Interpretation I

Many-Worlds Interpretation I

History

1953– Hugh Everett III, started as a graduate student at Princeton University supervised by John Archibald Wheeler

1957– Everett presented his thesis titled “On the foundations of quantum mechanics” and in the same year published the paper “Relative State” formulation of quantum mechanics [2]. In this paper, he proposed a new formulation of a quantum theory “proper for application on General Relativity”

1959– Everett traveled to Copenhagen to show his results to Niels Bohr’s group. However, these results were not well accepted and most of his ideas were rejected. By this time, He was working at the American Pentagon and stopped his academic career.

History

1967– Bryce DeWitt, used Everett's ideas to give rise to his program of the quantization of gravity.
1971– Probably the first time that term "many-worlds" appears in a publication [3]
1977– Everett participated in a conference about his ideas and a new generation of physicists (such as David Deutsch) helped in its development
1982– This is the year of Everett's death

This interpretation of QM has become one of the favorite views of cosmologists, and particle physicists since they are most interested in the quantization of the gravitational field, since

- It is a theory where the Lorentz group is satisfied
- As in dBB theory, the collapse postulate is not necessary
- And it is a quantum theory that is applicable in any physical system

The Theory

- It seems that Everett never used the term many-world in his papers. Instead, he used the expression “different states from the same physical system”
- The idea of many worlds turned out to be used by DeWitt. However, this was not consensual since the term “ many-minds” was also used [4]
- Broadly speaking, Everett was interested in obtaining a formulation to QM that could apply to any physical system, including systems that are not subject to an external observation
- In the fundamental principles of this new view there wasn’t any reference to the external classical world of the physical system - Classical Mechanics was just a “sub-product” of the quantum theory

The Theory

In this context, it follows the hypothesis:

1) Any physical system subject to external observation can be considered as part of a larger isolated system
2) There always exists a complex wave function able to provide a complete mathematical description of any isolated physical system, including the universe itself.
3) The evolution of this wave function is linear and unitary in any situation and in general, it is described by the Schrödinger equation

Ψ) Thus, the theory is deterministic, where every physical system is completely described by a mathematical entity $[\psi(\vec{r}, t)]$ whose value is well determined by any time

Superposition

- Considering a system in superposition state

$$|\psi\rangle = \frac{|0\rangle + |1\rangle}{\sqrt{2}}$$

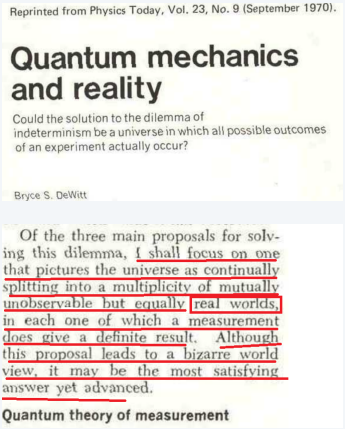
- To interpret the measurement output of this state, Everett considered the observer splits between two different states. Thus, one of these states corresponds to $|0\rangle$ and the other to $|1\rangle$. Even though Everett was not clear about the nature of the split
- Sometimes this interpretation is called “Everett’s relative state” interpretation, where one observer state corresponds to $|0\rangle$ and the other to $|1\rangle$ relative to the first
- The origin of the quantum probability is just a subjective probability imposed by the observer

Cosmology

- In the orthodox theory, a quantum system (QS) is considered to be isolated from the outside world. This system then interacts with a classical apparatus (classical world) that gives the output result. From QM postulates we suppose that the wave function collapses
- When we say "...isolated from the outside world" it is supposed the existence of some boundaries in spacetime, that separates the classical from the quantum
- However, if we wish to apply this program to the entire Universe, it would be trouble to define these boundaries of the QS

Many-Worlds

It was DeWitt who interpreted Everett's obscured ideas to the many-worlds interpretation



Reprinted from Physics Today, Vol. 23, No. 9 (September 1970).

Quantum mechanics and reality

Could the solution to the dilemma of indeterminism be a universe in which all possible outcomes of an experiment actually occur?

Bryce S. DeWitt

Of the three main proposals for solving this dilemma, I shall focus on one that pictures the universe as continually splitting into a multiplicity of mutually unobservable but equally real worlds, in each one of which a measurement does give a definite result. Although this proposal leads to a bizarre world view, it may be the most satisfying answer yet advanced.

Quantum theory of measurement

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