

Gregg Jaeger: Entanglement, Information, and the Interpretation of Quantum Mechanics (The Frontiers Collection)

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In the Information era Quantum Mechanics has found a new life. This is not just a response to the promises of the quantum-information technology, but because day after day it is becoming evident that Quantum Mechanics is not really about “physics”, but more about “information”. The notion of Entanglement is the keystone for understanding this new conceptual revolution. In his book Gregg Jaeger is guiding the reader to understanding this paradigm metamorphosis inside the most successful and debated theory of all times.

Entanglement is the main subject of the first chapter, being the most distinctive feature of quantum mechanics, and, at the same time, the crucial resource in applications of quantum information. Besides an originally presented short review on non-locality in relation to hidden variable models, local operations and no-signaling, the chapter also gives an interesting presentation of fundamental concepts such as quantum interference and uncertainty, in a manner emphasizing their foundational aspects and relation to information. The second chapter continues with an analysis of the mathematical formalism in connection to the role played historically in clarifying the foundations of the theory, e.g. including a brief survey on quantum probability and quantum logic. It then focuses on a synthetic introduction to the theory of quantum measurements along with the relevant thought experiments, to enlighten the significance of the quantum measurement in the history of the interpretations. After these two introductory chapters, the third chapter, which represents the core of the book, contains probably the only available up-to-date coverage of the different interpretations of Quantum Mechanics. It critically examines the most prominent interpretations in the light of the results described in the first two chapters. Much attention is devoted to the most recent interpretations in which information is taken to play a dominant role.

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The presentation runs with physics and philosophy constructively coming together, within an account reporting the opinions of both historical and contemporary authors, starting from the meaning itself of “interpretation”, and running into the problems of realism, determinism, and the empiricism, and the relation between interpretation and metaphysics. For those interested in this subject, the chapter is a mine of ideas and contains numerous interesting quotations from several authors. After an uncommon account on the “basic interpretations” (von Neumann, Dirac, the eigenvalue-eigenstate link, and the projection postulate), on the Copenhagen’s, the collapse-free (both many worlds and consistent histories) and on the “naive realistic” ensemble interpretation, Jaeger presents the first report on the increasingly popular Radical Bayesian interpretation, currently advocated by Fuchs, according to which the quantum state is a “state of the observer’s belief”, in other words is a set of “gambling commitments” apt to make correct prediction of forthcoming experiments. With the aim of solving the measurement problem within the subjectivist Bayesian-de Finetti interpretation of probabilities, the Radical Bayesianism program is aimed to substituting the projection postulate with a new kind of Bayesian update rule (likely via the so-called sic-POVM’s), and in this sense it has still the status of a proto-interpretation. One of the main outcomes of this interpretation is that it directly leads to the “informational” interpretation of the quantum state, which is at the core of the homonymous interpretation of quantum mechanics, one of the main focuses of the last chapter. The last chapter also reconsiders the relation between quantum information and quantum mechanics, coming back to its relationship to entanglement, and articulates this relationship upon briefly reviewing the work of Popescu and Rohrlich on the entanglement measure for pure states on one side, and on the no-signaling correlations in abstract operational theories on the other sides (the so-called PR-boxes).

With his gifted style Jaeger succeeds in treating the delicate matter of the book in a lucid and engaging way, which is suitable to a reader ranging from the inexperienced researcher to the sophisticated philosopher of physics. The presentation often deliberately reflects the author’s personal opinions, in a discussion-provocative way. The matter is very thoroughly documented, with a very extensive (although carefully selected) bibliography of more than 500 items.