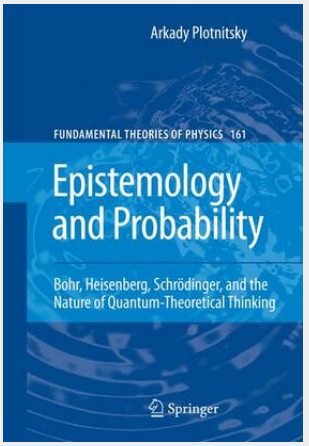
Plotnitsky

Epistemology and Probability

Bohr, Heisenberg, Schrödinger, and the Nature of Quantum-Theoretical Thinking



This book offers an exploration of the relationships between epistemology and probability in the work of Niels Bohr, Werner Heisenberg, and Erwin Schro- ¨ dinger, and in quantum mechanics and in modern physics as a whole. It also considers the implications of these relationships and of quantum theory itself for our understanding of the nature of human thinking and knowledge in general, or the ‘‘epistemological lesson of quantum mechanics,’’ as Bohr liked 1 to say. These implications are radical and controversial. While they have been seen as scientifically productive and intellectually liberating to some, Bohr and Heisenberg among them, they have been troublesome to many others, such as Schro¨ dinger and, most prominently, Albert Einstein. Einstein famously refused to believe that God would resort to playing dice or rather to playing with nature in the way quantum mechanics appeared to suggest, which is indeed quite different from playing dice. According to his later (sometime around 1953) remark, a lesser known or commented upon but arguably more important one: ‘‘That the Lord should play [dice], all right; but that He should gamble according to definite rules [i. e., according to the rules of quantum mechanics, rather than 2 by merely throwing dice], that is beyond me. ’’ Although Einstein’s invocation of God is taken literally sometimes, he was not talking about God but about the way nature works. Bohr’s reply on an earlier occasion to Einstein’s question 1 Cf.

Quantum mechanics, discovered by Werner Heisenberg and Erwin Schrödinger in 1925-1926, is famous for its radical implications for our conception of physics and for our view of human knowledge in general. While these implications have been seen as scientifically productive and intellectually liberating to some, Niels Bohr and Heisenberg, among them, they have been troublesome to many others, including Schrödinger and, most famously, Albert Einstein. The situation led to the intense debate that started in the wake of its discovery and has continued into our own time, with no end appearing to be in sight. Epistemology and Probability aims to contribute to our understanding of quantum mechanics and of the reasons for its extraordinary impact by reconsidering, under the rubric of "nonclassical epistemology," the nature of epistemology and probability, and their relationships in quantum theory. The book brings together the thought of the three figures most responsible for the rise of quantum mechanics—Heisenberg and Schrödinger, on the physical side, and Bohr, on the philosophical side—in order to develop a deeper sense of the physical, mathematical, and philosophical workings of quantum-theoretical thinking. Reciprocally, giving a special emphasis on probability and specifically to the Bayesian concept of probability allows the book to gain new insights into the thought of these figures. The book reconsiders, from this perspective, the Bohr-Einstein debate on the epistemology of quantum physics and, in particular, offers a new treatment of the famous experiment of Einstein, Podolsky, and Rosen (EPR), and of the Bohr-Einstein exchange concerning the subject. It also addresses the relevant aspects of quantum information theory and considers the implications of its epistemological argument for higher-level quantum theories, such as quantum field theory and string and brane theories. One of the main contributions of the book is its analysis of the role ofmathematics in quantum theory and in the thinking of Bohr, Heisenberg, and Schrödinger, in particular an examination of the new (vis-à-vis classical physics and relativity) type of the relationships between mathematics and physics introduced by Heisenberg in the course of his discovery of quantum mechanics. Although Epistemology and Probability is aimed at physicists, philosophers and historians of science, and graduate and advanced undergraduate students in these fields, it is also written with a broader audience in mind and is accessible to readers unfamiliar with the higher-level mathematics used in quantum theory.

213,99 €
199,99 € (zzgl. MwSt.)

Lieferfrist: bis zu 10 Tage

Artikelnummer: 9781461424833
Medium: Buch
ISBN: 978-1-4614-2483-3
Verlag: Springer
Erscheinungstermin: 25.02.2012
Sprache(n): Englisch
Auflage: 2010
Serie: Fundamental Theories of Physics
Produktform: Kartoniert
Gewicht: 657 g
Seiten: 402
Format (B x H): 155 x 235 mm

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