A Physicist's View of The Role of Philosophy in Science

Philosophical Concepts in Physics: The Historical Relation between Philosophy and Scientific Theories

James T. Cushing
Cambridge U. P., New York, 1998. 424 pp. $74.95 hc ($29.95 pb)
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Reviewed by Sunny Auyang

When scientists in the course of the "science wars" criticize some extreme aspects of science studies, they should not simply flash the word "science" to assert their possession of absolute truth. That would lend substance to the caricature that portrays scientists as thinking naively outside their narrow fields of expertise. A better way for scientists to combat irrationality is for them to exercise the same rational attitudes they apply to scientific research: to understand their opponents and explain their errors clearly and to understand themselves by reviewing critically their own history and practice, analyzing the assumptions hidden in their beliefs and justifying their reasons for accepting a theory or preferring it to rivals. These are the tasks that James Cushing undertakes with the care characteristic of a good physicist in his *Philosophical Concepts in Physics*.

Cushing declares the central goal of the book to be the uncovering and explaining of the "essential and ineliminable role that philosophical considerations have played in the actual practice of science." Unlike most philosophical expositions, which argue in the vacuum, Cushing's book examines philosophical considerations in concrete historical and intellectual contexts. A large portion of the book is devoted to the presentation of major theories in the history of physics: the Ptolemaic and Copernican models; the Galilean and Newtonian revolution; the mechanical versus the electromagnetic world views; the special and general theories of relativity; quantum mechanics and its interpretations. In each case, the physics is presented both in the now-accepted form and as it was debated by the physicists when they struggled with it. Copious quotations of historical texts enable students to get a flavor of science in action and to appreciate the difficulty and hence the significance of a theory, which they can easily miss when they receive it fully cooked on a plate.

The historical accounts show that often there is more than one way to represent the same phenomenon. Why does a physicist think about a problem in a particular way? What are the criteria by which the physics community eventually accepts a specific theory? Through numerous case studies, Cushing argues that philosophical assumptions and social contexts influence scientific reasoning and the processes by which theory is accepted. "At times," he writes in his preface, "the term 'construction' may seem more appropriate than 'discovery' for the way theories have been developed and, especially in the later chapters, the question of the influence of historical, philosophical and even social factors on the very form and content of scientific theories is discussed."

Relativity and, especially, quantum mechanics receive particular emphasis. For example, a chapter on Walter Kaufmann's experiment on the electron mass and Max Planck's subsequent analysis shows that science does not always proceed in the simple schema of hypothesis, prediction, experiment, refutation. Even more philosophical lessons are drawn from a detailed account of the development of quantum mechanics, including the Copenhagen interpretation, the Bohr–Einstein debate, the Einstein–Podolsky–Rosen paradox, the Bell experiments, and the Bohmian alternative version of quantum mechanics. Is quantum mechanics complete? What is the notion of reality it implies? Does quantum mechanics explain, or does it merely predict? Do we understand it? Did historical contingency play a role in the form of quantum mechanics that physicists use today? These are some of the mind-teasing questions that the book confronts.

The book grew out of a one-semester interdisciplinary course that Cushing gave at the University of Notre Dame to advanced undergraduates in the arts, sciences, and engineering. It will serve well as a textbook for similar courses. Its clear explanations will make it accessible to anyone who has taken a course in physics.

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The Feynman Processor: Quantum Entanglement and the Computing Revolution

Gerard J. Milburn
Helix Books (Perseus Books), Reading, Mass., 1998. 213 pp. $23.00 hc ISBN 0-7382-0016-6

The last 15 years or so have seen the publication of dozens of books that aim to explain the mysteries of quantum mechanics to a lay audience. The quality ranges from excellent (Nick Herbert's *Quantum Reality*, Anchor Press/Doubleday, 1985) to abysmal (better not identified). In Gerard Milburn's *The Feynman Processor*, which, despite its somewhat breathless style, ranks fairly high on the list, the peg on which the presentation is hung is the new field of quantum computing. This is a topic to which the author has himself made important contributions.

It is difficult for a reviewer already familiar with most of the subject matter of such a book to judge its comprehensibility to a reader approaching it from scratch. I have one particular worry in this connection: The author seems to have taken to heart, with a vengeance, the opinion attributed by Stephen Hawking to one of his advisers, that "each equation included in the book would halve the sales." No doubt this may be so, but, from any but a commercial perspective, a more interesting question is what effect each equation will have on the percentage of readers who will get out of the book the level of understanding intended. It is here that I think the author (who includes no equations at all) may be unduly pessimistic: Eschewing equations does not make the basic concepts of quantum mechanics any less subtle. I would suspect that any lay reader who is prepared to make the not in-