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052157823X - Philosophical Concepts in Physics: The Historical Relation between Philosophy and Scientific Theories

James T. Cushing

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*Philosophical Concepts in Physics* discusses advances in science against the historical and philosophical backgrounds in which they occurred. Readers are given an opportunity to reflect upon the nature of a scientific enterprise that they may previously have come to know only from the perspective of traditional accounts of science or retrospectively from course work in the sciences. A major goal is to impress upon the reader the essential and ineliminable role that philosophical considerations have played in the actual practice of science and in the construction of scientific theories.

Scientific knowledge, because of its putative certainty and objective method of discovery, is often seen as being essentially different from other types of knowledge. As popularly understood, physics and philosophy might seem about as far removed from each other as two intellectual disciplines could be. However, this book illustrates the formative mutual influences that physics and philosophy have had, and continue to have, on each other. The discussion of central philosophical issues is anchored in the specific historical context and in the actual content of relevant scientific activity.

Some necessary introduction to the history of ancient and early modern science is presented first, but major emphasis is given to the watersheds of twentieth century physics: namely relativity and, especially, quantum mechanics. The reader is assumed to have some background in elementary classical physics, but no knowledge of relativity or quantum mechanics is assumed.

The book will be of particular interest to science, engineering, philosophy and general humanities students who have had an introductory course in physics, to scientists with an interest in the relation of philosophy to physics and to philosophers of science. It could also be used as a text in a junior/senior level undergraduate course in the philosophy of science.

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# Philosophical Concepts in Physics

THE HISTORICAL RELATION BETWEEN

PHILOSOPHY AND SCIENTIFIC THEORIES

JAMES T. CUSHING

DEPARTMENT OF PHYSICS, UNIVERSITY OF NOTRE DAME



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For Nimbilasha, Christine and Patricia

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## Preface

This book has grown out of an elective, one-semester junior/senior level interdisciplinary course I have taught for several years to students in arts and letters, science, and engineering at the University of Notre Dame. It allows one to examine a selection of philosophical issues in the context of specific episodes of the development of physical laws and theories. Many students with science and engineering backgrounds find this exercise informative – for some unsettling, but still rewarding. Although a major goal of the exposition is to impress upon the reader the essential and ineliminable role that philosophical considerations have played in the actual practice of science, more space is devoted to the history and content of science than to philosophy *per se*. The reason for this is that I believe that meaningful and useful philosophy of science can only be done within the context of the often tortuous historical route to new insights. Another way to put this is that it takes a lot of history of science to anchor even a little philosophy of science.

Some necessary background from the history of ancient and early modern science is presented first, but major emphasis is given to the immediate precursors to and the content of the watersheds of twentieth-century physics: relativity and, especially, quantum mechanics. This is not a systematic exposition of either the history or the philosophy of science, but an individualistic, perhaps to some even an idiosyncratic, selection of topics and episodes from the history and philosophy of physics. Developments in science are presented against the historical and philosophical backgrounds in which they occurred. At times 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. Quantum mechanics proves to be a particularly rich source of material on this topic.

The reader is assumed to have some knowledge of elementary classical physics at the level of an introductory one-year course in that subject. Since relativity and quantum physics will still be new to such an audience, enough background is provided on those subjects to make them accessible to the readers for whom this book is intended. The quotations at the beginning of each of the nine major divisions (or Parts) of this book, and the supplemental material included at the ends of the chapters, form integral parts of the presentation and are meant to be read. The footnotes (that are gathered together in the *Notes* section after the last chapter of this book) contain literature citations and sometimes expository comments on the text material, including in some cases mathematical details. For these reasons, it

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is important to take cognizance of the information provided in the footnotes. In these notes, GB stands for *Great Books of the Western World* (Robert M. Hutchins, ed.). A few chapters have an appendix in which mathematical details have been isolated in order to make the main body of the text suitable for a wider audience. (The basic ground rule is that advanced mathematics does not appear in the text proper.) Additional references are given at the end of each chapter to facilitate further study on points that may be of particular interest to the reader. Moreover, in the *General References* section near the end of this book, several works are suggested as sources for overall background information. All references cited in this book are listed together in the *Bibliography* section before the *Index*.

Although this book emphasizes an interdisciplinary approach to physics, history and philosophy, and uses some primary source material in the text, a disclaimer (a type of ‘truth in advertising’) is in order here. I am by no means an expert in the history and philosophy of science and have relied heavily on secondary sources. As someone trained as a scientist, I am interested in broadening the view of science students on the connections between philosophy and fundamental science, and in doing this within the context of physics as they recognize it. My hope is that the reader will become sufficiently taken with that question to pursue it further in more formal historical and philosophical treatises. In a classroom situation, the material in the text serves as a basis for discussion and for additional reading on the part of the students. There are surely places where I have been unable to escape from the thrall of the physicist’s folklore ‘knowledge’ and skewed view of history and of philosophy. The style is often informal and it would make the text unreadable to enter all of the caveats that might be necessary. Proper historians and philosophers of science will no doubt be unhappy about some of what I say. I can only apologize in advance for the infelicities that will doubtless stand out to them in these pages and hope that the general reader will, nevertheless, find something of interest and value. I must thank my friends and colleagues here at Notre Dame and elsewhere who have, over many years, helped to reduce somewhat my own ignorance in these subjects. Professor Ernan McMullin first sparked my interest in the history and philosophy of science some twenty or so years ago and for that I thank him – although he is not to be held in any way responsible for the shortcomings of his ‘student’. He, Professors Samir K. Bose, Gerald L. Jones, William D. McGlenn, Stephen M. Fallon and Robert E. Kennedy have been good enough to read through some sections of my manuscript and, thus, save me from certain embarrassments. The remaining flaws are mine alone.

For assistance with the redaction of the manuscript, I am especially indebted to Ms Alisa N. Ellingson and to Dr Yuri V. Balashov, both for the exceptional care they exercised in reading through preliminary drafts of the manuscript and for extremely helpful suggestions that substantially improved the text and references. Their work was supported by the Department of Philosophy and by the Program in the History and Philosophy of Science here at Notre Dame. Mr Neal Nash is responsible for all of the line drawings in the text. I also thank the Department of Physics and the College of Science at the University of Notre Dame – more

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particularly, the Chairman Gerald L. Jones and the Dean Francis J. Castellino – for the freedom over the years to be able to teach interdisciplinary courses in physics and philosophy and to do research in an area that overlaps often disparate academic turfs. Finally, my wife Nimbilasha has for many years shown the patience, support and encouragement without which it would not have been possible to complete a project whose beginnings go back nearly two decades.

*James T. Cushing*

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A book of this nature, with much quoted material from primary sources, would not be possible without the permission granted by many publishers and individuals to use material on which they currently hold, or previously held, the copyright. Even though the fair-use provision of the copyright laws covers many of my citations and some others are now in the public domain, I nevertheless contacted all of the publishers whose material I cite and I wish to list them below in acknowledgment. Every quotation in this text is cited by publisher in an accompanying footnote and any figure based on copyrighted material is so indicated (as ‘adapted from’) in a footnote keyed to the first reference that appears to that figure. Although I am grateful to all of these publishers and individuals, I must recognize the extraordinary generosity of The American Physical Society, Encyclopaedia Britannica, University of California Press, Cambridge University Press, The University of Chicago Press, Dover Publications, Mrs Melitta Mew, Northwestern University Press, Open Court Publishing Co. and Oxford University Press for releases that went far beyond anything supported merely by the concept of fair use of copyrighted material.

Here, then, are the names of all of those publishers and individuals whom I acknowledge for use of copyrighted material. All references are to the Bibliography at the end of this book.

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