THE CONCEPTUAL FOUNDATIONS OF QUANTUM MECHANICS

LEONARD EISENBUDE
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“There is no end to our searchings: . . . .
No generous mind stops within itself. Its pursuits
are without limit; its food is wonder, the chase,
ambiguity.”

Montaigne
There are two complementary methods, broadly speaking, used by authors to communicate physics. In the first of these, the "formal method," the manipulatory skills relating to the subject matter of interest are emphasized. It is tacitly assumed that a mastery of the techniques required to solve the standard problems will lead automatically and rapidly to an understanding of the physical meanings of the techniques and their products. In the second, the "conceptual method," physical meanings are investigated carefully with little attention to technique. Once the basic concepts are clearly understood, or so it is assumed, manipulative skills will take care of themselves. Graduates of the formal method calculate easily (at least on textbook problems) but often they know not what they compute. The conceptual method, on the other hand, produces philosophical wranglers who can tear subtle ideas to shreds but who are unable, perhaps, to draw a fresh conclusion from even the most fruitful stock of ideas.

This book, as its title intimates, makes use of the conceptual method and shares in the weaknesses and, hopefully, also in some of the strengths of that method. The book is not (and this negation deserves
emphasis) a text designed to teach the theory of quantum mechanics; at
the end of the book we shall be only at the edges of the formal
structure and explicit content of the theory. It is not possible to learn
from this book how to solve even the simplest of the problems of
quantum mechanics.

But considerable care and attention is given in what follows to an
analysis of the physical meaning and conceptual consequences of the
Heisenberg principle (Chapters 4, 5, and 6) and, in particular, to a close
examination of the incompatibility of pairs of observables. In Chapters
7 and 8, the effects of the concept of incompatibility on the meanings
of “measurement,” “property,” “state,” “indeterminism,” etc. are
studied. An important step beyond what may reasonably be inferred
from the Heisenberg principle is taken in Chapter 9, where the
existence and great significance of “probability amplitudes” are dis-
cussed. But we refrain even after this fairly considerable preparation from
going on to the implicitly promised land. The structure of quantum
mechanics is not formulated here and its explicit content for classical
observables is not given. To repeat what has already been emphasized,
this book is not intended as an exposition of quantum mechanical
theory.

To whom and for what, then, is the book of value? Two distinct
groups may profit from it. Students who have been exposed to highly
formal expositions and are only too painfully aware that they know not
what they compute may find answers to some of their questions in the
following pages. And those blocked from the normal paths which lead
to the quantum mechanics by lack of mathematical skills may be able
to get here at least a partial understanding of some of the significant
ideas of a most important and fascinating theory.

This book is a revised and expanded version of the monograph I
wrote while a member of the Conference on the New Instructional
Materials in Physics. The Conference was held at Seattle in the summer
of 1965 under the auspices of The Commission on College Physics and
the University of Washington. The materials produced at the Con-
ference were subsequently given limited publication by the University
of Washington Press. I am indebted to The Commission on College
Physics and the University of Washington Press for permission to make
use of portions of the monograph in the preparation of this book.

It is a pleasure to acknowledge my extensive debts to Professor
Walter C. Michels. It was at his suggestion that I undertook to revise and expand my monograph for publication in the Momentum Series. I owe him thanks also for his careful and able editing of my manuscript.

I can best remember again the many who helped me at the Seattle Conference by quoting the last paragraph of the preface to my monograph. "I wish to thank Walter C. Michels and Ernest Henley for their helpful comments and criticisms. I am grateful also to Jack Ludwig and Ralph Caplan for showing me that it is easier to read English than Academese; the numerous changes they suggested greatly improved the style of the monograph. My thanks are due also to the officers of The Commission on College Physics and the University of Washington for their support and assistance during the pleasant, stimulating and productive months of the 'Writing Conference.'"

LEONARD EISENBUD
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