# PREFACE

This book is based on a lecture course that I taught in Israel, entitled 'Concepts of Modern Physics.' It was given in the spring term, 2006, in the Philosophy Department, University of Haifa.

The main emphasis of this course is the *concepts* of modern physics: the quantum theory and the theory of relativity, and their relation to problems of modern astrophysics and cosmology. The discussion is largely from the point of view of the ideas of modern physics, rather than from their mathematical expressions. [*The reader may skip some of the unavoidable mathematical terms, especially in Lecture VI on the quantum theory, without losing too much of the thread of ideas of the entire book.*]

As a professional physicist, I learned in the early stages of my career that physics without philosophy does not fulfill the goal of science. It does fulfill its obligation of providing empirical descriptions of the ways of nature. This is the *descriptive stage* of science. But it is essential that one must then proceed to the *explanatory stage*, including some of the philosophical understandings. Einstein made the following poignant comment: "Physics without Philosophy would be blind; Philosophy without Physics would be lame."

Some who attended my Haifa lectures asked this question: Is not a *complete* description of a phenomenon in nature a sufficient explanation of it? My answer is No! The goal of science — the truths about the natural world — comes in the two stages. The first

stage is at the *descriptive* level. It is based on experimentation. Once this is achieved, one must then use rational analyses as well as human intuition to proceed to the second stage — the stage of *explanation*. The explanation is in terms of underlying principles. With logical and mathematical analyses, one may then deduce *from these alleged first principles* the features of the derived facts of natural phenomena. If these are in agreement with the empirical facts, one may then claim (at least contigently!) to have achieved an increase in our comprehension of the real world.

This course consists of ten lectures: I. Philosophy of Science, II. Classical Precursors for the Concepts of Modern Physics, III. Nineteenth Century Physics: Atomism and Continuity, IV. Early Anomalies and Elementary Particles, V. From the Old Quantum Theory to Quantum Mechanics, VI. Quantum Mechanics: Heisenberg's Matrix Mechanics and the Copenhagen School, VII. Concepts of the Theory of Relativity, VIII. From Special to General Relativity, IX. The Universe, X. Conflicts in the Foundations of the Quantum and Relativity Theories.

The idea of this course of lectures is to discuss modern physics primarily from a critical point of view — *thus the view of philosophy* — as well as the view of the history of science.

The ideas expressed in these lectures evoked controversial discussions about the concepts of modern physics. Out of these controversies, I believe that: (1) There developed an incitement for the participants in the course to think for themselves about the ideas of science, (2) the idea was conveyed that controversy is essential for progress in science (and in any other fields of ideas that search for the truth), (3) a belief that we can never reach a *complete* understanding of the real world. Thus, physics remains a never-ending adventure into unknown territory. We have indeed achieved more comprehension about the real world at this stage of our history than was achieved in past times. But we should also know that our comprehension of the world, so far achieved, is infinitesimal in comparison with what there is to be understood!

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