Rational Reconstructions of Modern Physics

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Rational Reconstructions of Modern Physics

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Preface

The present book on Rational Reconstructions of Modern Physics has evolved from investigations, lectures, and discussions with many colleagues in Physics and Philosophy during the last 10 years. Selected problems of this treatise were presented at various conferences, as the biennial meetings of the "International Quantum Structures Association" (IQSA) in 2002, 2006, and 2010, and at the annual conferences of the "Académie Internationale de Philosophie des Sciences" (AIPS), for instance in 2004. In particular, I mention here the lectures and discussions that I could contribute to the informal research seminars in Philosophy of Physics, which were organized by Brigitte Falkenburg at the University of Dortmund over a period of several years. – The stimulating discussions at all these events, the critique of my new approach but also the encouragement to continue this way of reasoning, are gratefully acknowledged.

The aim of this book is to summarise the results of these efforts which were partly scattered throughout various journals, proceedings of conferences, festschrift-volumes, etc. and to reorganize them in a new and systematic order. The results and implications of the present investigations are partly new and they are in general not in accordance with the well known interpretation of Modern Physics in the light of classical physics. The goal of this attempt is a rational reconstruction of the leading theories of Modern Physics, the Theories of Special and General Relativity and Quantum Mechanics, a project that will be further elucidated and motivated in the "Introduction" of the main text.

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At the first place, I want to thank Brigitte Falkenburg for her continuous, stimulating advise during the last 10 years, and for the encouragement to write this book. Furthermore, I thank Kristina Engelhard for the discussion of many detailed questions of my partly unconventional proposals. – The kind and very effective cooperation with Tobias Schwaibold of *Springer* was a pleasure and should be gratefully acknowledged. Last but not least I mention the helpful and constructive critique of the anonymous referee of *Springer*.

Introduction

Even without a fully elaborated idea of the development of physical theories, we expect – at least among physicists – a wide spread agreement with the hypothesis that the progress in physics consists of an interplay between experimental results and theoretical drafts. A successful theory summarises a large number of experimental results in a formal mathematical and conceptual system – a so called "theory" – where new and additional experiments will contribute either to a confirmation or – what is usually more important – to a refutation of the theory by means of falsification. A refutation of this kind is then a challenge to formulate a new theoretical concept, an improvement of the first preliminary theory. In this way, the development and the progress of physics seems to consist in a stepwise accumulation of new results and thus in a permanent increase of knowledge.

Also the idea of the dynamical development of physical theories as it was conceived by Thomas Kuhn[1] and others can be incorporated into this very general conception, however with an important additional distinction. Whereas in the phases of "normal science" the accumulation of physical knowledge takes place by summarising more and more experimental results into an already existing theory – whose domain of validity is extended in this way often by rather artificial assumptions – in the phases of "revolution" the extended and exhausted old theory is replaced by a completely new theory, which will again be subject to the interplay of confirmation and falsification. One clue of this argument is, that physical theories cannot really be falsified, since in most theories there are ways to extend the theory by additional assumptions such that by fully exhausting the new theory all known results can be incorporated. Hence, from time to time "revolutions" seem to be unavoidable.

Accordingly, the progress in physics seems to consist of an increase of knowledge, of the increasing number of experimental results and of permanently improved theories that summarise these results and interpret them on the basis of theoretical connections between various results. There is, however the important

[1]Thomas S. Kuhn (1962), Paul Feyerabend (1970).

argument of the advocates of Kuhn's ideas, that the formulation of a new theory after a revolution is by no means unique but depends, except from the scientific situation, also from the historical, sociological and psychological background of the involved scientists. We will not go into the details of the long lasting controversial debate about the justification of these arguments, since for the most important theories of modern physics, the Theory of Relativity and Quantum Theory, there are essentially no alternative approaches known.[2]

The present investigation will not follow these two ways of reasoning, neither the traditional idea that the progress in science consists of continuous accumulation of new results, nor Kuhn's modification of this idea that the development of physics takes place in a sequence of large steps, which correspond to phases of revolution and consolidation. Instead of these well known alternatives we argue in favour of a completely different way for explaining the progress in physics, in particular of physical theories in the last century. We will show, that the two models mentioned for the progress in science are not able to grasp the most radical and at the same time very simple change from the so called "classical" Newtonian physics to the theories of "modern physics" in the twentieth century.

In particular we will show, that the transition from classical physics to the three leading theories of modern physics, Special Relativity, General Relativity and Quantum Mechanics cannot adequately be understood as an increase of knowledge about various new empirical facts. In contrast, the very progress of these transitions consists of a stepwise reduction of prejudices, i.e. of quite general hypothetical assumptions of classical mechanics, that can be traced back to the metaphysics of the seventeenth and eighteenth centuries. Accordingly, our proof of these statements will be a constructive one: We start from Newton's classical mechanics and show, that by abandoning or relaxing the various not justified metaphysical hypotheses contained in it, the theories of "modern physics" can be constructed. In this way, we can demonstrate two important results. On the one hand we show, how the theories of modern physics can be justified and that, without explicit reference to new experimental results. On the other hand, the original difficulties of understanding the new theories can now convincingly be explained and at the same time completely be eliminated.

[2]Except perhaps from the "Bohm" theory of Quantum Mechanics, and the "Jordan-Brans-Dicke" theory of General Relativity.

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