

Lecture Notes in Physics

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Unified Theories of Elementary Particles

Critical Assessment and Prospects

Proceedings of the Heisenberg Symposium
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Edited by P. Breitenlohner and H.P. Dürr



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Preface

Many attempts are presently being made to establish a common dynamical basis for the various forces and the particle structure observed in nature. The quest for a unified theory governing the dynamics of all material bodies has a very long tradition in this Institute.

Albert Einstein was appointed first director of this Institute in 1913, which then was called the Kaiser-Wilhelm-Institut für Physik and was situated in Berlin-Dahlem. In 1915 Einstein succeeded in formulating his General Theory of Relativity which led to a union of space-time geometry and gravitation. During the second half of his life he tried very hard to find appropriate generalizations to incorporate Maxwell's electrodynamics into the geometrical scheme as well. This ambitious attempt to arrive at a "einheitliche Feldtheorie" of all the forces known at that time ultimately failed for essentially two reasons. First, Maxwell's electrodynamics in the course of time - and, in fact, as an immediate consequence of Einstein's own famous paper on the photoelectric effect in 1905 - changed from a classical theory to a quantum theory, into quantum electrodynamics. Secondly, new types of forces were discovered in probing the atomic nuclei, the hadronic and weak interactions, which could only be accommodated into the framework of quantum field theories. Einstein's generalizations on his General Theory of Relativity did not allow accounting for the quantum structure and did not provide the proper features for a geometrical interpretation of the new forces.

It was Werner Heisenberg who was the first to attempt a unification of all forces within the framework of a quantum field theory and elementary particle physics. For nearly three decades he was the director of this Institute, first in Berlin, then in Göttingen and finally in Munich, until his retirement in 1970. His interest in the unification or rather in the formulation of a fundamental law underlying the dynamics of elementary particles goes back to the late thirties, stimulated by observations of the multiple production of elementary particles in cosmic rays.

We have proclaimed this Symposium in memory of Werner Heisenberg who died five years ago. This year, on December 5th, we will celebrate his 80th birthday, on which occasion, according to a decree of the Max Planck Society, this Institute will receive the additional name "Werner-Heisenberg-Institut".

The two different approaches to unification of the general dynamics in nature - the classical geometrical approach and the quantum mechanical elementary particle approach - will be the main topics of this Symposium. It appears, at first, that both approaches have very little in common because they are established on different levels which makes a direct comparison difficult. In the course of time, however,

we have learned that, despite their different points of departure, there are many interesting points of contact. Important links are provided by the gauge features of the fundamental particle interactions which allow a geometrical interpretation, and the nontrivial properties of the quantum-mechanical ground-state and soliton-type solutions which exhibit classical aspects in a purely quantum mechanical description. One of the goals of the Symposium was to emphasize these points of contact and to stimulate looking at the same problem from different angles.

Besides the plenary lectures presented in this volume, two discussion sessions were arranged during the Symposium on the general topics: "Unification and Subquark Schemes" and "Geometrical Approaches to Unification". These discussion sessions - with the plenary lecturers serving as a panel - aimed at a critical assessment of the presented theories and an estimation of their future prospects. Unfortunately, these lively and articulate discussions were not recorded and hence could not be included in the proceedings.

The editors would like to take the opportunity to express their sincere gratitude to all the speakers who have so spontaneously agreed to participate in this Symposium. Their continued readiness to frankly express their hopes and fears has helped greatly to reach a better understanding of the subject matter. The editors would also like to thank them for their cooperation in preparing the manuscripts for these proceedings.

The Heisenberg Symposium would not have been possible without generous financial support from the Max Planck Society and the assistance of the Organizing Committee and many members of the Max-Planck-Institut für Physik. This is gratefully acknowledged.

München, September 1981

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