QUANTUM GRAVITY

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Edited by
M. A. Markov
Academy of Sciences of the USSR
Moscow, USSR
and
P. C. West
King's College
London, England

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PREFACE

Three years have passed after the First Moscow Seminar on Quantum Gravity. It is a rather long time interval for the modern theoretical physics. The talks given at the present Second Seminar which took place in October 13-15, 1981 in Moscow contain the discussion of new results obtained during this period and the problems which arose. More than one hundred Soviet scientists and a number of the foreign guests attended this Seminar, which as the previous one was held by the Nuclear Physics Department of the Academy of Sciences of the USSR and the Institute for Nuclear Research of the Academy of Sciences of the USSR.

The aim of the Seminar was to discuss the most important problems of the modern Quantum Gravity, namely: i) Quantum Gravity: the state of art; ii) Quantum effects in Cosmology; iii) Quantum black-hole physics; iv) the recent development in Supergravity and v) Quantum Gauge Theories.

The Editorial Board expresses its sincere gratitude to all physicists who have contributed to these Proceedings for their cooperation with the Board in respect of time limitation, accurate and patient fulfilment of all tiresome requirements, set by the Board. The talks in the Proceedings are arranged in sections in accordance with their presentation at the Seminar.

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FOREWORD

In recent years it has emerged that the nuclear weak, nuclear strong and electromagnetic forces are mediated by spin one particles whose dynamics are controlled by gauge theories within the framework of relativistic quantum field theory. Further, there is now dramatic experimental confirmation of the unification of the electromagnetic and nuclear weak forces and there exist theories which unify all of these three forces. Gravity on the other hand, the only other force of nature, is mediated by a spin two particle described by Einstein's theory of general relativity. A theme running through many articles in this book is the place of Einstein's theory in relation to the rest of physics.

A major obstacle to progress in discovering the relation between the force of gravity and the other three forces of nature is the inconsistency, noticed as long ago as the 1930's, between Einstein's theory of general relativity and quantum theory as embodied in perturbative relativistic quantum field theory. One possible solution to this problem, which is discussed in several articles, is to modify Einstein's theory by adding terms involving higher derivatives. Also discussed is the way these modifications may help alleviate one of the other problems of general relativity; namely the occurrence of singularities.

Gravity is the most complex quantum field and investigation of its structure has often lead to a better understanding of quantum field theory in general. Three articles are devoted to the interplay of renormalization and symmetry within the context of gauge theories.

One area where both gravity and the other forces of nature are important is in the early universe. A substantial part of the book is devoted to the processes that occur in this exotic domain. These include a discussion of how particles could have been created, in particular, the development of baryon asymmetry and how the inhomogenities which have led to galaxies could have emerged. One of the exciting possibilities that is considered in this context is that the universe underwent a period of exponential expansion. It is examined to what extent this overcomes many of the problems of the standard big bang cosmology.

Much work on the interplay between gravity and quantum mechanics was stimulated by the discovery that black holes can emit radiation

and matter. Eight articles are devoted to a discussion of this effect. They include the ways the laws of quantum mechanics are modified, the possibility of very small black holes, the role of thermodynamics and the effect these objects could have on the evolution of the universe.

Finally several authors discuss supersymmetry. This symmetry provides the only known non-trivial extension of general relativity. The extent to which these supergravity theories can provide a consistent theory of gravity and quantum mechanics or may unify gravity with the three other forces of nature is examined.

P.C. West

CONTENTS

SECTION I. QUANTUM GRAVITY

SECTION II. QUANTUM EFFECTS IN COSMOLOGY

SECTION IV. SUPERSYMMETRY

SECTION V. GAUGE THEORIES. TWISTORS