

Preface

This book is a collection of papers and writings from the past 100 years on ideas and problems related to gravity, gauge fields and accelerated frames. The grand triumphs of Einstein's theory of gravity and Yang-Mills' theory in physics are well known. It is believed that both theories are based on the principle of 'gauge invariance,' although not on the same kind of action. Einstein's theory is linear in spacetime curvature, while Yang-Mills' theory is quadratic in gauge curvature. Now, at the dawn of the 21st century, invariance principles in physics have transcended the kinematical and dynamical contexts from which they originated to become the foundation of our understanding of the physical world. Using this framework of invariance principles, this book surveys the development of gravitational and Yang-Mills fields, as well as spacetime transformations of accelerated frames. It also attempts to reveal the problems and limitations of various formulations of gravitational and Yang-Mills fields. The intent is to enlarge and broaden the reader's views on the subjects.

As TIME magazine's person of the 20th century (cf. TIME magazine), Einstein's contributions to physics are arguably incomparable, aside from Newton's. The gravitational force and accelerated frames were two ingredients in the young Einstein's 'happiest thoughts' in 1907. The simple thought that 'If a person falls freely he will not feel his own weight,' made a deep impression on him and impelled him toward a successful theory of gravitation. Unfortunately, accelerated spacetime transformations for non-inertial frames have still not been well developed. However, they are important because one cannot claim to have a complete understanding of the physical world, especially the basic gravitational and Yang-Mills fields, if one understands physics only from the viewpoint of the special and limited class of inertial frames. Strictly speaking, all real frames of reference in the physical world are non-inertial because of the long range of the gravitational force. In particular, when one talks about an inherent property of nature (e.g., values of fundamental constants such as the fine structure constant and the speed of light), a reasonable criterion is that the property must be present in both inertial and non-inertial frames. In this sense, the book suggests that the present understanding of gravitational and Yang-Mills fields is far from complete.

The formulations of the gravitational and Yang-Mills theories are both an effect and a cause of scientific development in experiment and theory. Progress in physics is made through the collective effort of many physicists. The community of physicists is like the thousand-hand Guan-Yin: Each hand accomplishes only a partial or small task, yet the overall accomplishment is enormous. As we shall see in this volume, in the pursuit of physical laws, the right track has often been discovered only after many failures by well-known and not-so-well-known pathfinders.

Nowadays, the spectacular success of Einstein and Yang-Mills' profound thoughts is often emphasized while the lessons of the struggle in their birth and development is lost. Furthermore, there is little chance for making progress simply by going over their success repeatedly.

The aim here is to present some of the leading ideas and problems discussed by physicists and mathematicians, highlighting three aspects:

- (1) the idea of gravity as a Yang-Mills field, first discussed by Utiyama;
- (2) the problems of quantum gravity, discussed by Feynman, Dyson and others;
- (3) spacetime properties and the physics of particles and fields in accelerated frames.

It is hoped that the present volume will bring some of the unfulfilled aspects of the profound thoughts to the attention of physicists and mathematicians of the 21st century. For various reasons, research in the areas of spacetime symmetry and special relativity are sometimes discouraged by general editorial policy. Fortunately, so far this is not true in the cases of general relativity and Yang-Mills theory. If the deepest insights of Einstein and Yang-Mills can inspire its readers to pursue these subjects further, the chief purpose of the book will have been achieved.

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