SPIN AND TORSION IN GRAVITATION

SPIN AND TORSION IN GRAVITATION

This page is intentionally left blank

SPIN AND TORSION IN GRAVITATION

Venzo de Sabbata
Dept. of Physics, Bologna University, Italy;
Dept. of Physics, Ferrara University, Italy;
World Laboratory, Switzerland

C. Sivaram
Indian Institute of Astrophysics, India;
World Laboratory, Switzerland

World Scientific
Singapore • New Jersey • London • Hong Kong

Published by

World Scientific Publishing Co. Pte. Ltd.

P O Box 128, Farrer Road, Singapore 9128

USA office: Suite 1B, 1060 Main Street, River Edge, NJ 07661

UK office: 73 Lynton Mead, Totteridge, London N20 8DH

SPIN AND TORSION IN GRAVITATION

ISBN: 981-02-1766-8

Printed in Singapore by JBW Printers & Binders Pte. Ltd.

PREFACE

This book deals with spin and torsion in gravitation. The earlier on "Introduction to Gravitation" (World Scientific, 1985) gave a detailed exposition of the General Theory of Relativity developed by Einstein and others: in this book (of the year 1985) there is a chapter on the Einstein-Cartan theory and now we like to extend exhaustively this theory, that is the introduction of the spin in General Relativity, considering all possible physical consequences, spin being another universal attribute of matter besides the mass.

The spin of elementary particles was to play a profound role in atomic, nuclear and particle physics. The unity of special relativity and quantum mechanics through the Dirac equation led to spectacular new results in physics: the prediction of antiparticles and the intrinsic magnetic moment of elementary particles, to name e few. The spin of elementary particles manifested itself in several new effects in fundamental interactions such as splitting of nuclear energy levels and non-degeneracy of hadronic states in strong interactions, parity violation in weak interactions etc.

The fact that the effects of spin when considered in gravitational interactions can also lead to several interesting physical phenomena in both the micro and macro-world is not so well known. The literature is mostly confined to specialized articles read by only those few directly working on the subject. Even most physicists working on gravitation theory are not much aware of the interesting consequences of spin modified gravitational effects, especially those caused by torsion which is the geometric effect of spin in space-time (analogously to mass causing space-time curvature).

The book we are contemplating could fill this gap and give an exposition of both the old and new results of spin and torsion effects on gravitational interactions with implications for particle physics, cosmology etc.

The stress would be more on the physical aspects with a discussion of measurable effects in relation to other areas of physics (with a discussion of orders of magnitude and number involved). We would thus have for instance a discussion of the analogy between torsion and magnetism (with consequences for astrophysics and cosmology), we will consider the Dirac equation in general relativity with torsion developed in a gauge theoretic manner with its implications for weak interactions and for strong interactions. We could have clear cut alternative ways of unifying gravity with electroweak and strong interactions by an energy dependent spin torsion coupling constant. The idea that all interactions can be understood as originating in spin curvature coupling is discussed.

The Maxwell equations when coupled to gravity in a space-time with torsion also gives rise to novel effects, there being effects due to polarisation of photons and neutrinos. We have analogy of Faraday polarisation, and other gravimagnetic effects distinct from Lense-Thirring precession, wmith is often confused which such effects.

Non-singular solutions of electrodynamics with gravity and torsion give rise to the possibility of finite classical stable models of elementary particles like the electron, the charge being derived from spin and magnetic moment.

We have a discussion of the possibility of cosmological models with torsion providing a possible solution of the cosmological constant problem.

Finally it is shown that torsion can lead directly to the quantization of space-time itself, the defects in space-time induced by torsion behaving like a string with a tension determined by the spin-torsion coupling in space-time.

An energy dependent tension at various energy scales, then gives the fundamental couplimg constants of the various interactions. This direct quantization of space-time leads not only to a minimal length but also to a minimal time with interesting consequences for early universe cosmology and physics of evaporating bleck holes. The quantum general relativistic principles take on an especially transparent and consistent form when torsion is taken into consideration. Thus the inclusion of torsion effects on space-time (after all this happens when intrinsic spin, a universal property of elementary particle like mass, is also a source of gravity) could help to resolve some of the complex conceptual issues inherent in the unification of quantum mechanics with general relativity. In addition it shows promise of resolving some fundamental problems in particle physics and cosmology. Some connecting links with twistors are also considered in this context.

It is hoped that this book, while presenting all the above aspects and more in concise terms with emphasis on the physical principles involved, would help to bring these interesting topics within range of physicists working on diverse fields like gravitation, cosmology and elementary particles.

We strongly believe that a book of this sort would draw many more physicists from different areas into this field.

Venzo de Sabbata
C.Sivaram

This page is intentionally left blank

CONTENTS