Cosmology and Gravitation
Spin, Torsion, Rotation, and Supergravity

Edited by
Peter G. Bergmann
Syracuse University
Syracuse, New York

and
Venzo De Sabbata
University of Bologna
Bologna, Italy
and
University of Ferrara
Ferrara, Italy

PLENUM PRESS • NEW YORK AND LONDON
Published in cooperation with NATO Scientific Affairs Division
## CONTENTS

**PART I: THEORIES WITH TORSION**

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generalities on Geometric Theories of Gravitation</td>
<td>1</td>
</tr>
<tr>
<td>A. Trautman</td>
<td></td>
</tr>
<tr>
<td>Four Lectures on Poincaré Gauge Field Theory</td>
<td>5</td>
</tr>
<tr>
<td>F.W. Hehl</td>
<td></td>
</tr>
<tr>
<td>The Macroscopic Limit of the Poincaré Gauge Field Theory of Gravitation</td>
<td>63</td>
</tr>
<tr>
<td>J. Nitsch</td>
<td></td>
</tr>
<tr>
<td>QuasiClassical Limit of the Dirac Equation and the Equivalence Principle in the Riemann-Cartan Geometry</td>
<td>93</td>
</tr>
<tr>
<td>H. Rumpf</td>
<td></td>
</tr>
<tr>
<td>Contracted Bianchi Identities and Conservation Laws in Poincaré Gauge Theories of Gravity</td>
<td>105</td>
</tr>
<tr>
<td>W. Szczyrba</td>
<td></td>
</tr>
<tr>
<td>The Gauge Symmetries of Gravitation</td>
<td>117</td>
</tr>
<tr>
<td>M.A. Schweizer</td>
<td></td>
</tr>
<tr>
<td>The Motion of Test-Particles in Non-Riemannian Space-Time</td>
<td>125</td>
</tr>
<tr>
<td>D.-E. Liebscher</td>
<td></td>
</tr>
<tr>
<td>Torsion and Strong Gravity in The Realm of Elementary Particles and Cosmological Physics</td>
<td>139</td>
</tr>
<tr>
<td>V. de Sabbata and M. Gasperini</td>
<td></td>
</tr>
</tbody>
</table>

**PART III: SUPERSYMMETRIES, TWISTORS AND OTHER SYMMETRY GROUPS**

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Fading World Point</td>
<td>173</td>
</tr>
<tr>
<td>P.C. Bergman</td>
<td></td>
</tr>
</tbody>
</table>
Superalgebras, Supergroups, and Geometric Gauging .... 177
Y. Ne'eman

Four Lectures at the 1979 Erice School on Spin, Torsion, Rotation, and Supergravity .... 227
P. van Nieuwenhuizen

Self Dual Fields .... 257
J.N. Goldberg

An Introduction to Complex Manifolds .... 275
E.T. Newman

A Brief Outline of Twistor Theory .... 287
R. Penrose

PART III: EXPERIMENTAL RELATIVITY AND OTHER TOPICS

Experimental Gravitation with Measurements Made from Within a Planetary System .... 317
R.D. Reasenberg

Tests of General Relativity at the Quantum Level .... 359
E. Fischbach

The Mass-Angular Momentum-Diagram of Astronomical Objects .... 375
P. Brosche

Bimetric General Relativity Theory .... 383
N. Rosen

Covariance and Quantum Physics-Need for a New Foundation of Quantum Theory? .... 407
E. Schmutzer

Relativistic Equations of Motion of "Spin Particles" .... 423
B. Średniawa

Angular Momentum of Isolated Systems in General Relativity .... 435
A. Ashtekar

Isometries and General Solutions of Non-Linear Equations .... 449
F.J. Chinea
CONTENTS

On the Visual Geometry of Spinors and Twistors ........... 457
H. Hellsten

Gravitation Photoproduction in Static
Electromagnetic Fields and Some
Astrophysical Applications ................. 467
S.R. Valluri

APPENDIX

Invariant Deduction of the Gravitational
Equations from the Principle of
Hamilton ........................................ 479
A. Palatini

On a Generalization of the Notion of
Reimann Curvature and Spaces with
Torsion ......................................... 489
E. Cartan

Comments on the Paper by Elie Cartan: Sur
une Generalisation de la Notion de
Courbure de Riemann et les Espaces
a Torsion ...................................... 493
A. Trautman

INDEX ........................................... 497