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General Relativity and Gravitation

One Hundred Years After the Birth of Albert Einstein

Volume 2

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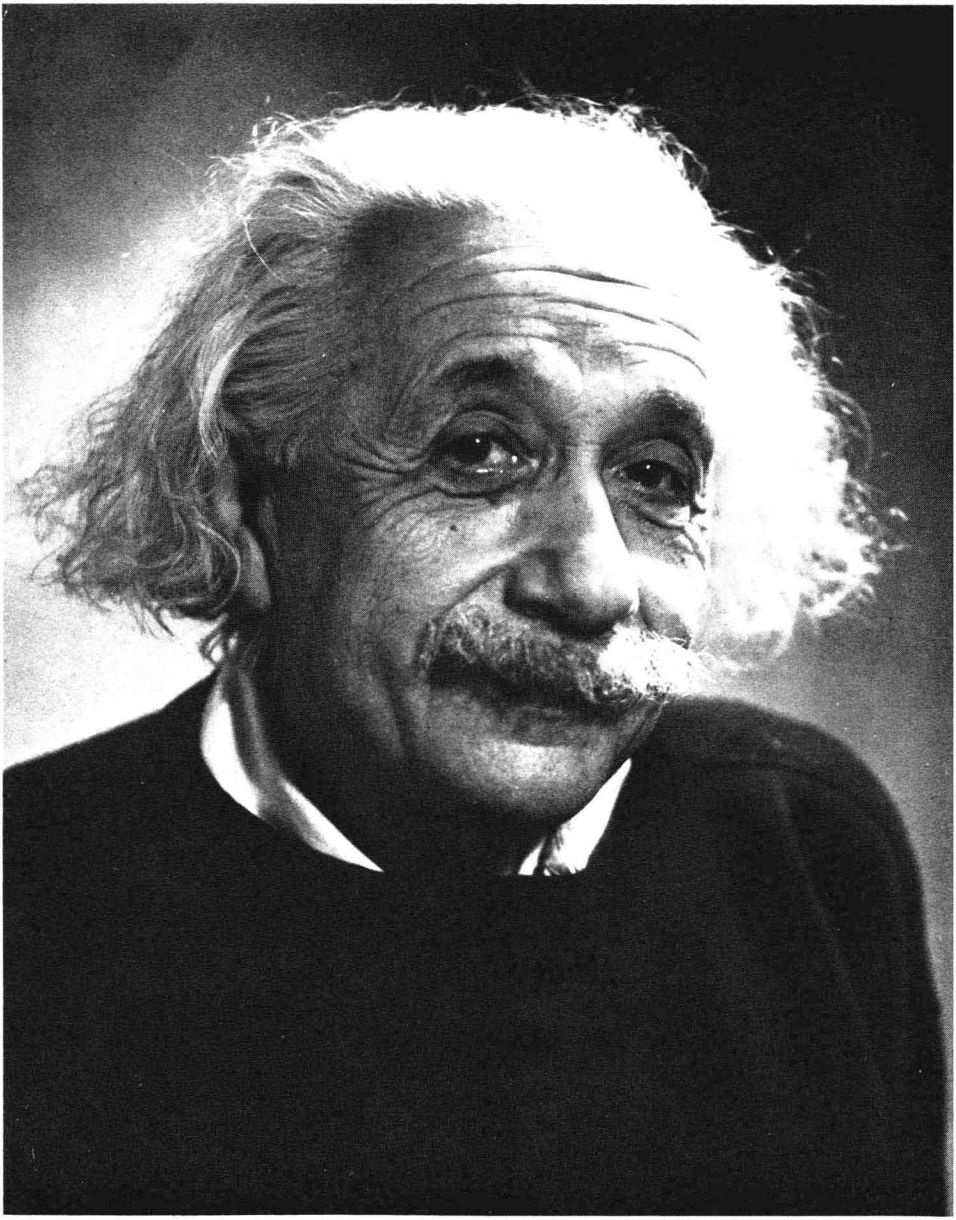

ALBERT EINSTEIN

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Foreword

The year 1979 is the one-hundredth anniversary of Albert Einstein's birth. The International Society for General Relativity and Gravitation, which has yet to celebrate the tenth anniversary of its birth, has decided to mark the Einstein Centenary by offering to the community of scientists this collection of articles.

Albert Einstein was a towering personality in theoretical physics. The general theory of relativity was perhaps his greatest achievement, and it is certainly the one that most people associate with his name. Einstein also was a philosopher and a social activist who hated passionately war and every form of violence. Our organization was founded as an international society because the modest number of relativists throughout the world made a single organization the most rational way for promoting our common aims, as well as to emphasize the international nature of the search for scientific knowledge and, by our common efforts, perhaps to make some small contribution toward the cooperation and friendship of all peoples. We believe that we are acting in the spirit of the man whom we are honoring by dedicating these volumes to his memory.

Peter G. Bergmann
President

Preface

Together with the decision to produce these volumes came the realization that one cannot hope to cover adequately all of the significant activities in general relativity even in two books devoted primarily to review articles. Quantitatively the research now covers too wide a front for that; qualitatively no one individual, even when writing on a specific topic, can hope to do justice to all the different attitudes toward the subject that exist within the community of relativists. The editors of these volumes have tried to present books that represent a good number of the facets of the field and to some extent we feel that we have succeeded although there do remain obvious gaps.

Without doubt the problem considered most pressing by the majority of today's relativists is the apparent incompatibility between the two major physical theories of the twentieth century, namely relativity and quantum theory. As a reflection of this concern these books offer a number of articles dealing with quantization and general relativity. Within this field there are several approaches. The oldest of these uses the canonical approach to relativity, a topic to which a large portion of Volume 1 is devoted. In addition to the article on quantization, other problems that are discussed using this formalism are the Cauchy problem, the positive mass conjecture, and the Hamiltonian structure of space–time. The necessary background is covered in an extensive review article.

Volume 1 also contains several articles expounding the gauge theory and the supergravity outlook. The more exotic approach through the use of twistors is described in Volume 2.

In recent years much work has also been devoted to the question, "What is the effect of a curved space–time on the quantum theory as we know it?" Investigations of this question have led to the discovery of such effects as black hole evaporation and to possible explanations of processes prevalent in the initial stages of the universe, thus providing further impetus for its study. We provide an introductory article to the subject in Volume 1.

Since the early 1960s, when conformal structures were introduced into the study of asymptotic properties, a number of important related themes

have been studied. These studies form the basis of the first part of Volume 2, beginning with analyses of null and spatial infinites (as explained in three different articles). These investigations lead naturally to the use of complexified space–times as a mathematical device. How this is done is explained in an article on complex variables in relativity. The application of complex variables to $\mathcal{H}$ and $\mathcal{H}\mathcal{H}$ spaces is given in a further article.

Also dating from the sixties is the interest in singularities, whether and how they arise, together with their classification. Volume 2 contains a major review of this aspect of relativity theory.

Among the more important recent developments have been the astounding improvements in modern computers. It is no longer a question of computers merely being used for numerical integrations. They can now be applied constructively to the more elegant aspects of relativity. Details appear in an article which relates what has been done, explains different computing systems, and gives an intriguing hint of the future.

No survey of the fields would be complete without some review of the less spectacular but nonetheless necessary background mathematical work which still goes on and forms a necessary part of the repertoire of every relativist. To this end Volume 1 contains articles on fiber bundles, the problem of embedding, the separability of the Hamilton–Jacobi equation, conserved quantities, and the method of two-timing.

In this maze of beautiful mathematics and theories, one must not lose sight of the fact that Einstein, like every good physicist, was concerned primarily with the real world. Our work regains contact with the cosmos in Volume 2 with articles on cosmology and on gravitational collapse. Finally it comes down to earth in the form of discussions on the detection of gravitational waves, experimental tests of relativity, and statistical mechanics.

Included in Volume 1 are two articles with an historical flavor. Insight into the development of the general theory is given by the first, which traces the interaction between Einstein and the rotating disk. The second reports on Einstein's contribution to the theory of the laser. Who knows, perhaps if the technology had been available . . . .

We hope that this two-volume work will serve as a quasi-textbook with something in it of benefit to the student launching his studies in this perhaps most fascinating field of modern physics as well as to the experienced researcher, who might just obtain from it a spark of inspiration to lead him in a new direction.

The Editors

Contents of Volume 1

1. Einstein and the Rigidly Rotating Disk
John Stachel

2. Einstein's Photon Distribution for Blackbodies and the Discovery of the Laser
Heinrich Hora

3. Canonical Gravity
James Isenberg and James Nester

4. The Cauchy Problem
Yvonne Choquet-Bruhat and James W. York, Jr.

5. The Positive Mass Conjecture
Dieter R. Brill and Pong Soo Jang

6. The Hamiltonian Structure of Space–Time
Claudio Teitelboim

7. The Phase Space Formulation of General Relativity and Approaches Toward Its Canonical Quantization
Peter G. Bergmann and Arthur Komar

8. Quantum Fields in Curved Space
P. C. W. Davies

9. Fiber Bundles, Gauge Fields, and Gravitation
Andrzej Trautman

10. Gravity, Groups, and Gauges
Yuval Ne'eman

11. Gravitation and the Poincaré Gauge Field Theory with Quadratic Lagrangian
Friedrich W. Hehl, Jürgen Nitsch, and Paul Von der Heyde

12. From Gravity to Supergravity
S. Deser

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13. The Theory of Separability of the Hamilton–Jacobi Equation and Its Applications to General Relativity
Sergio Benenti and Mauro Francaviglia

14. Local Isometric Embedding of Riemannian Manifolds and Einstein's Theory of Gravitation
Hubert F. Goenner

15. Invariant Transformations, Conservation Laws, and Energy–Momentum
Joshua N. Goldberg

16. A Review of Algebraic Computing in General Relativity
R. A. d'Inverno

17. High-Frequency Gravitational Waves, Two-Timing, and Averaged Lagrangians
A. H. Taub

18. Supergravity: An Odyssey through Space–Time and Superspace
S. Ferrara and P. van Nieuwenhuizen

Contents

1. Asymptotically Flat Space-Times

E. T. Newman and K. P. Tod

1. Introduction 1
2. The Definition of Asymptotic Flatness and the NU Tetrad 4
   2.1. The Definition of $\mathscr{I}$ 4
   2.2. The Coordinate and Tetrad System 5
3. The Spin Coefficient Formalism 9
4. Asymptotic Solutions of the Spin Coefficient Equations 13
5. The Bondi-Metzner-Sachs Group 17
6. Applications of the Formalism 20
   6.1. Exact Solutions 20
   6.2. Perturbation Calculations 21
   6.3. Cone Space and $\mathscr{H}$ Space 21
   Appendix A: The Spin Coefficients Equations 24
      A.1. The Einstein-Maxwell Equations 24
      A.2. The Einstein-Yang-Mills Equations 27
   Appendix B: Solutions 29
      B.1. Asymptotically Flat Einstein-Maxwell Fields 29
      B.2. The Robinson-Trautman Solutions 31
      B.3. Twisting Algebraically Special Solutions 32
   References 34

2. Asymptotic Structure of the Gravitational Field at Spatial Infinity

Abhay Ashtekar

1. Introduction 37
2. Minkowski Space-Time 40
   2.1. Isometries 40
   2.2. Physical Fields: An Example 42
   2.3. Physical Fields: General Structure 43
3. The Basic Definitions 46
   3.1. Preliminaries 46
   3.2. Asymptotic Conditions 47
4. Asymptotic Symmetries 50
5. Asymptotic Fields 54
6. Conserved Quantities 57
   6.1. The ADM 4-Momentum 58
   6.2. The Angular Momentum 59

7. Other Approaches 61
7.1. Geroch's Version of the ADM Approach 62
7.2. The Sommers Approach 63
8. Discussion 65
Appendix: Open Issues and Possible Extensions 67
References 68

3. Angular Momentum in General Relativity

Jeffrey Winicour

1. Introduction 71
2. Angular Momentum of Asymptotically Flat Space-Times 72
2.1. Null Infinity 74
2.2. Spatial Infinity 77
3. Radiative Complications 80
4. Sources 84
4.1. Kinematic Preliminaries 85
4.2. Exact Exteriors 86
4.3. Exact Interiors 87
4.4. Global Solutions 88
4.5. General Features 90
5. Conclusion 93
References 93

4. Singularities and Horizons—A Review Article

F. J. Tipler, C. J. S. Clarke, and G. F. R. Ellis

1. Introduction 97
2. The Early Work on Singularities 98
3. Beginnings of a New Approach 111
3.1. Timelike and Null Curves 112
3.2. Causal Relations 116
3.3. Technical Advances 123
4. The Existence and Nature of Singularities 129
4.1. The Occurrence of Singularities 131
4.2. The Definition of Singularities 139
4.3. The Nature of Singular Space-Times 141
5. The Study of Singularities since 1970 147
5.1. Weakening the Conditions of the Classical Theorems 147
5.2. The Definition of Boundary Structure 152
5.3. Types of Singularity 155
5.4. The Nature of Physical Singularities 162
6. Unsolved Problems 167
6.1. Strong Cosmic Censorship 167
6.2. Weak Cosmic Censorship 176
6.3. Quantum Mechanics and Singularities 189
References 190

5. Complex Variables in Relativity

Edward J. Flaherty, Jr.

1. Introduction 207
2. Complex Substitutions 207
3. Null Tetrads and the Schwarzschild-to-Kerr Transformation 211
4. Mathematical Digression 221
5. Holomorphic Functions and H-Spaces 227
6. Conclusion 236
References 237

6. Complex General Relativity, $\mathcal{H}$ and $\mathcal{H}\mathcal{H}$ Spaces—A Survey of One Approach

C. P. Boyer, J. D. Finley, III, and J. F. Plebański

1. Introduction 241
2. Preliminaries 244
3. Basic Properties of $\mathcal{H}$ Spaces 250
4. Explicit Solutions and Symmetries of $\mathcal{H}$ Spaces 254
4.1. Explicit Examples of $\mathcal{H}$ Spaces 254
4.2. Symmetries of $\mathcal{H}$ Spaces 258
4.3. Further Comments on $\mathcal{H}$ Spaces 262
5. Null String Foliations and $\mathcal{H}\mathcal{H}$ Spaces 263
5.1. The Geometry of Null Foliations 264
5.2. Nonexpanding $\mathcal{H}\mathcal{H}$ Spaces 267
5.3. Expanding $\mathcal{H}\mathcal{H}$ Spaces 270
5.4. $\mathcal{H}\mathcal{H}$ Spaces with Two Sets of Null Strings 274
6. Further Properties of $\mathcal{H}\mathcal{H}$ Spaces 275
6.1. Explicit Solutions for $\mathcal{H}\mathcal{H}$ Spaces 275
6.2. Symmetries in Nonexpanding $\mathcal{H}\mathcal{H}$ Spaces 277
6.3. Electrovac $\mathcal{H}\mathcal{H}$ Spaces 278
7. Conclusions and Further Comments 278
References 279

7. Twistors for Flat and Curved Space–Time

R. Penrose and R. S. Ward

1. Introduction 283
2. Twistor Theory in Flat Space–Time 284
2.1. Twistor Algebra and Geometry 284
2.2. Massless Free Fields 298
3. Twistors in Curved Space–Time 308
4. The Nonlinear Gravitation Construction 311
4.1. Half-Flat Spaces and Curved Twistor Space 311
4.2. Examples 315
4.3. Massless Fields on a Half-Flat Background 318
5. Hypersurface Twistors 321
5.1. CR Structure and Hypersurface Twistors 321
5.2. Twistors Relative to a Null Hypersurface 322
References 328

8. Cosmology

E. P. T. Liang and R. K. Sachs

1. Einstein and the Universe 329
1.1. Introduction 329
1.2. Historical Comments 330
2. Spatially Homogeneous, Isotropic Cosmological Models 332
2.1. Pressure Zero Newtonian Models 332
2.2. Is the Universe Open or Closed? 335
2.3. $k = 0$ Relativistic Models 337
2.4. The Standard Hot Big Bang Model 340
3. Some Recent Developments 342
3.1. The Distribution of Galaxies 342
3.2. Gravitational Instability 345
3.3. The Distribution of Radio Sources, QSO's, and Intergalactic Matter 347
3.4. The Microwave Background 348
3.5. Nucleosynthesis in the Early Universe 351
4. Some Current Problems 353
References 355

9. Gravitational Collapse to the Black Hole State

J. C. Miller and D. W. Sciama

1. Introduction 359
2. Black Hole Formation by Gravitational Collapse of Ordinary Stars 360
3. Spherical Collapse 365
4. Nonspherical Collapse 376
5. Collapse of Rotating Configurations 379
6. Gravitational Radiation from Gravitational Collapse 385
7. Conclusion 388
References 388

10. Gravitational Waves and Their Interaction with Matter and Fields

L. P. Grishchuk and A. G. Polnarev

1. Introduction 393
2. Test Particles and Photons in the Field of a Gravitational Wave 395
2.1. Description of the Motion of a Free Particle in a Locally Inertial Frame 395
2.2. Systematic Change of Energy and the Mean Trajectory of a Moving Particle 399
3. Detection of Gravitational Waves 402
3.1. Mechanical Oscillator 403
3.2. Quantum Theory of Mechanical Oscillator 406
3.3. Electromagnetic Detectors of Gravitational Waves 409
3.4. Rotating Two-Body Systems as Detectors of Gravitational Waves 413
4. The Interaction of Gravitational Waves with Electromagnetic Field, Matter, and Curvature 416
4.1. Mutual Conversion of Gravitational and Electromagnetic Waves 417
4.2. Interaction of Gravitational Waves with Matter 419
4.3. Interaction of Gravitational Waves with Background Curvature 427
References 430

11. The Search for Gravitational Radiation

J. Weber

1. Introduction 435
2. Interaction of a Gravitational Wave with Coupled Masses 436
3. Interaction of an Elastic Solid with Gravitational Waves 441
4. The Free-Mass Gravitational Radiation Antenna 442
5. Comparison of an Elastic Solid with Direct Method of Measuring Curvature ... 443
6. Instrumentation of an Elastic Solid Gravitational Radiation Antenna 443
7. Piezoelectric Crystal Instrumentation 444
8. Antenna Directivity Pattern 446
9. Sensitivity of a Gravitational Radiation Antenna 447
10. Fluctuations 448
11. Short-Pulse Algorithm 449
12. Antenna Coupling and Quality Factor 452
13. Early Search for Gravitational Radiation at Kilohertz Frequencies 452
14. Errors, Correction of Errors, Controversy, and Computer Results 456
15. Summary of the 1973–1974 Maryland–Argonne Observations 458
16. Sensitivity Measurements and Calibration 460
17. Development of Maryland Low-Temperature Gravitational Radiation Antennas 461
18. Normal Modes of the Earth and the Moon 461
19. Comments on the Observations 462
20. Electronics Noise Temperature, Quantum Limitations, and Long-Term Outlook . 463
References 465

12. Experimental Tests of the General Theory of Relativity

Irwin I. Shapiro

1. Introduction 469
2. Principle of Equivalence for Massive Bodies 469
3. Clock Comparisons 472
4. Light Deflection 474
5. Signal Retardation 477
6. Precession of Perihelia 481
7. Time Variation of the Gravitational "Constant" 483
8. The Lense–Thirring Effect 485
9. Conclusions 487
References 488

13. Progress in Relativistic Thermodynamics and Electrodynamics of Continuous Media

W. Israel and J. M. Stewart

1. Introduction 491
2. Quasistationary and Transient Thermodynamics 493
3. Thermodynamics of a Polarized Medium 495
3.1. The Electromagnetic Field 496
3.2. The Medium 496
3.3. Equilibrium 497

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