

# LORENTZIAN WORMHOLES FROM EINSTEIN TO HAWKING AIP SERIES IN COMPUTATIONAL AND APPLIED MATHEMATICAL PHYSICS

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*Lorentzian Wormholes* - Matt Visser 1995

Drawing on pivotal work by Einstein, Wheeler, Thorne, Hawking, and others, Matt Visser charts the development and current state of Lorentzian wormhole physics. Dr. Visser shows that by pushing established physical theories to their limits, it is possible to deduce the true physics of such exotica as wormholes and time travel. The physical framework he uses is derived from one of the major research frontiers of modern theoretical physics: quantum gravity the intersection of classical Einstein gravity and quantum field theory. About the Author Matt Visser is Research Assistant Professor at Washington University, St. Louis. He has lectured in the United States and abroad on topics including wormhole physics, time travel, and the chronology protection conjecture. He has conducted postdoctoral research at both the University of Southern California and at Los Alamos National Laboratory.

*Time in Physics* - Renato Renner 2017-11-20

One of the most important questions concerning the foundations of physics, especially since the discovery of relativity and quantum theory, is the nature and role of time. In this book we bring together researchers from different areas of physics, mathematics, computer science and philosophy to discuss the role time plays in physics. There have been few books on this topic to date, and two of the key aims of the workshop and this book are to encourage more researchers to explore this area, and to pique students' interest in the different roles time plays in physics.

*Relativity on Curved Manifolds* - F. de Felice 1992-03-27

General relativity is now essential to the understanding of modern physics, but the power of the theory cannot

be exploited fully without a detailed knowledge of its mathematical structure. This book aims to implement this structure, and then to develop those applications that have been central to the growth of the theory.

*Newton's Principia revisited* - Michael Schmiechen 2009

PROBLEM. The treatise is devoted to the reconstruction of our 'instinctive beliefs' in classical mechanics and to present them 'as much isolated and as free from irrelevant additions as possible'. The same motivation has driven many authors since the publication of Newton's Principia. IMPORTANCE. Classical mechanics will remain the basic reference and tool for mechanics on terrestrial and planetary scale as well as the proto-theory of relativistic and quantum mechanics. But it can only serve its purpose if it is not considered as obsolete, but if its foundations and implications are understood and made 'absolutely' clear. METHOD. Based on the 'instinctive belief' that the foundations of classical mechanics cannot be found and reconstructed within mechanics itself but only 'outside', classical mechanics is 'understood' by embedding it into an adequate theory of knowledge and adequate proto- and meta-theories in terms of the 'language of dynamics'. Evidence is produced that available philosophical expositions are not adequate for the purpose at hand. Mechanics is treated as part of physics, not of mathematics. Not sophisticated mathematical artifacts, necessary for solving specific problems, but the intellectually satisfactory foundation of mechanics in general is subject and purpose of the exercise. The goal is reached using axiomatic systems as models. SCOPE. Following an account of the unsatisfactory state of affairs the treatise covers the epistemological foundations, abstract proto-mechanics, i. e. the theories of time and space, meta-mechanics, i. e. the theories of state space models and of quantities proper, and, as an instance of the latter, abstract elementary mechanics, the theory of translational motions of

'small' solid bodies in three-dimensional Euclidean space, including classical general relativity. Subsequently the theory of classical kinematics is developed as basis for interpreted proto-mechanics and interpreted elementary mechanics. As an amus

**Advanced General Relativity** - John Stewart 1993-11-26

A self-contained introduction to advanced general relativity.

*Das Schweizer Buch* - 1997

*Lectures on General Relativity* - A. Papapetrou 2012-12-06

This book is an elaboration of lecture notes for the graduate course on General Relativity given by the author at Boston University in the spring semester of 1972. It is an introduction to the subject only, as the time available for the course was limited. The author of an introduction to General Relativity is faced from the beginning with the difficult task of choosing which material to include. A general criterion assisting in this choice is provided by the didactic character of the book: Those chapters have to be included in priority, which will be most useful to the reader in enabling him to understand the methods used in General Relativity, the results obtained so far and possibly the problems still to be solved. This criterion is not sufficient to ensure a unique choice. General Relativity has developed to such a degree, that it is impossible to include in an introductory textbook of a reasonable length even a very condensed treatment of all important problems which have been discussed until now and the author is obliged to decide, in a more or less subjective manner, which of the more recent developments to omit. The following lines indicate by means of some examples the kind of choice made in this book.

**Quantum Gravity** - Bertfried Fauser 2007-02-15

This book provides the reader with an overview of the different mathematical attempts to quantize gravity written by leading experts in this field. Also discussed are the possible experimental bounds on quantum gravity effects. The contributions have been strictly refereed and are written in an accessible style. The present volume emerged from the 2nd Blaubeuren Workshop "Mathematical and Physical Aspects of Quantum Gravity".

The Eleventh Marcel Grossmann Meeting -

**The British National Bibliography** - Arthur James Wells 2001

**Books in Print** - 1991

*The General Theory of Relativity* - Anadijiban Das 2012-06-26

The General Theory of Relativity: A Mathematical Exposition will serve readers as a modern mathematical introduction to the general theory of relativity. Throughout the book, examples, worked-out problems, and exercises (with hints and solutions) are furnished. Topics in this book include, but are not limited to: tensor analysis the special theory of relativity the general theory of relativity and Einstein's field equations spherically symmetric solutions and experimental confirmations static and stationary space-time domains black holes cosmological models algebraic classifications and the Newman-Penrose equations the coupled Einstein-Maxwell-Klein-Gordon equations appendices covering mathematical supplements and special topics Mathematical rigor, yet very clear presentation of the topics make this book a unique text for both university students and research scholars. Anadijiban Das has taught courses on Relativity Theory at The University College of Dublin, Ireland, Jadavpur University, India, Carnegie-Mellon University, USA, and Simon Fraser University, Canada. His major areas of research include, among diverse topics, the mathematical aspects of general relativity theory. Andrew DeBenedictis has taught courses in Theoretical Physics at Simon Fraser University, Canada, and is also a member of The Pacific Institute for the Mathematical Sciences. His research interests include quantum gravity, classical gravity, and semi-classical gravity.

*Mathematical Reviews* - 1996

Artificial Black Holes - Mario Novello 2002-10-04

Physicists are pondering on the possibility of simulating black holes in the laboratory by means of various "analog models". These analog models, typically based on condensed matter physics, can be used to help us understand general relativity (Einstein's gravity); conversely, abstract techniques developed in general relativity can sometimes be used to help us understand certain aspects of condensed matter physics. This book contains 13 chapters – written by experts in general relativity, particle physics, and condensed matter physics – that explore various aspects of this two-way traffic.

**The Eleventh Marcel Grossmann Meeting** - Hagen Kleinert 2008

The Marcel Grossman Meetings are three-yearly forums that meet to discuss recent advances in gravitation, general relativity and relativistic field theories, emphasizing their mathematical foundations, physical predictions and experimental tests. These meetings aim to facilitate the exchange of ideas among scientists, to deepen our understanding of space-time structures, and to review the status of ongoing experiments and observations testing Einstein's theory of gravitation either from ground or space-based experiments. Since the first meeting in 1975 in Trieste, Italy, which was established by Remo Ruffini and Abdus Salam, the range of

topics presented at these meetings has gradually widened to accommodate issues of major scientific interest, and attendance has grown to attract more than 900 participants from over 80 countries. This proceedings volume of the eleventh meeting in the series, held in Berlin in 2006, highlights and records the developments and applications of Einstein's theory in diverse areas ranging from fundamental field theories to particle physics, astrophysics and cosmology, made possible by unprecedented technological developments in experimental and observational techniques from space, ground and underground observatories. It provides a broad sampling of the current work in the field, especially relativistic astrophysics, including many reviews by leading figures in the research community

Wormholes, Warp Drives and Energy Conditions - Francisco S. N. Lobo 2017-05-16

Top researchers in the field of gravitation present the state-of-the-art topics outlined in this book, ranging from the stability of rotating wormholes solutions supported by ghost scalar fields, modified gravity applied to wormholes, the study of novel semi-classical and nonlinear energy conditions, to the applications of quantum effects and the superluminal version of the warp drive in modified spacetime. Based on Einstein's field equations, this cutting-edge research area explores the more far-fetched theoretical outcomes of General Relativity and relates them to quantum field theory. This includes quantum energy inequalities, flux energy conditions, and wormhole curvature, and sheds light on not just the theoretical physics but also on the possible applications to warp drives and time travel. This book extensively explores the physical properties and characteristics of these 'exotic spacetimes,' describing in detail the general relativistic geometries that generate closed timelike curves.

**Statistical Physics** - Kip S. Thorne 2021-06-15

"Kip Thorne and Roger Blandford's monumental Modern Classical Physics is now available in five stand-alone volumes that make ideal textbooks for individual graduate or advanced undergraduate courses on statistical physics; optics; elasticity and fluid dynamics; plasma physics; and relativity and cosmology. Each volume teaches the fundamental concepts, emphasizes modern, real-world applications, and gives students a physical and intuitive understanding of the subject. Statistical Physics is an essential introduction that is different from others on the subject because of its unique approach, which is coordinate-independent and geometric; embraces and elucidates the close quantum-classical connection and the relativistic and Newtonian domains; and demonstrates the power of statistical techniques--particularly statistical mechanics--by presenting applications not only to the usual kinds of things, such as gases, liquids, solids, and magnetic materials, but also to a much wider range of phenomena, including black holes, the universe, information and communication, and signal processing amid noise. Includes many exercise problems Features color figures,

suggestions for further reading, extensive cross-references, and a detailed index Optional "Track 2" sections make this an ideal book for a one-quarter, half-semester, or full-semester course An online illustration package is available to professors The five volumes, which are available individually as paperbacks and ebooks, are Statistical Physics; Optics; Elasticity and Fluid Dynamics; Plasma Physics; and Relativity and Cosmology." --Amazon.com.

**Progress in Mathematical Relativity, Gravitation and Cosmology** - Alfonso García-Parrado 2013-11-26

This book contains contributions from the Spanish Relativity Meeting, ERE 2012, held in Guimarães, Portugal, September 2012. It features more than 70 papers on a range of topics in general relativity and gravitation, from mathematical cosmology, numerical relativity and black holes to string theory and quantum gravity.

Under the title "Progress in Mathematical Relativity, Gravitation and Cosmology," ERE 2012 was attended by an exceptional international list of over a hundred participants from the five continents and over forty countries. ERE is organized every year by one of the Spanish or Portuguese groups working in this area and is supported by the Spanish Society of Gravitation and Relativity (SEGRE). This book will be of interest to researchers in mathematics and physics.

**The Cognitive-Theoretic Model of the Universe: A New Kind of Reality Theory** - Christopher Michael Langan 2002-06-01

Paperback version of the 2002 paper published in the journal Progress in Information, Complexity, and Design (PCID). ABSTRACT Inasmuch as science is observational or perceptual in nature, the goal of providing a scientific model and mechanism for the evolution of complex systems ultimately requires a supporting theory of reality of which perception itself is the model (or theory-to-universe mapping). Where information is the abstract currency of perception, such a theory must incorporate the theory of information while extending the information concept to incorporate reflexive self-processing in order to achieve an intrinsic (self-contained) description of reality. This extension is associated with a limiting formulation of model theory identifying mental and physical reality, resulting in a reflexively self-generating, self-modeling theory of reality identical to its universe on the syntactic level. By the nature of its derivation, this theory, the Cognitive Theoretic Model of the Universe or CTMU, can be regarded as a supertautological reality-theoretic extension of logic. Uniting the theory of reality with an advanced form of computational language theory, the CTMU describes reality as a Self Configuring Self-Processing Language or SCSPL, a reflexive intrinsic language characterized not only by self-reference and recursive self-definition, but full self-configuration and self-execution (reflexive read-write functionality). SCSPL reality embodies a dual-aspect monism consisting of infocognition, self-transducing information residing in self-recognizing SCSPL elements called syntactic operators. The CTMU identifies itself

with the structure of these operators and thus with the distributive syntax of its self-modeling SCSPL universe, including the reflexive grammar by which the universe refines itself from unbound telesis or UBT, a primordial realm of infocognitive potential free of informational constraint. Under the guidance of a limiting (intrinsic) form of anthropic principle called the Telic Principle, SCSPL evolves by telic recursion, jointly configuring syntax and state while maximizing a generalized self-selection parameter and adjusting on the fly to freely-changing internal conditions. SCSPL relates space, time and object by means of conspansive duality and conspansion, an SCSPL-grammatical process featuring an alternation between dual phases of existence associated with design and actualization and related to the familiar wave-particle duality of quantum mechanics. By distributing the design phase of reality over the actualization phase, conspansive spacetime also provides a distributed mechanism for Intelligent Design, adjoining to the restrictive principle of natural selection a basic means of generating information and complexity. Addressing physical evolution on not only the biological but cosmic level, the CTMU addresses the most evident deficiencies and paradoxes associated with conventional discrete and continuum models of reality, including temporal directionality and accelerating cosmic expansion, while preserving virtually all of the major benefits of current scientific and mathematical paradigms.

#### **Nonlocal Gravity - Bahram Mashhoon 2017**

Relativity theory assumes locality, without accounting for the observer's past history. This work introduces nonlocality, or history dependence, into relativity theory. Inertia and gravitation are deeply tied, suggesting gravity may be nonlocal. The gravitational memory of past events must then be taken into account

#### Relativity and Scientific Computing - Friedrich W Hehl 2012-12-06

For this set of lectures we assumed that the reader has a reasonable back ground in physics and some knowledge of general relativity, the modern theory of gravity in macrophysics, and cosmology. Computer methods are present ed by leading experts in the three main domains: in numerics, in computer algebra, and in visualization. The idea was that each of these subdisciplines is introduced by an extended set of main lectures and that each is conceived as being of comparable 'importance. Therefore we believe that the book represents a good introduction into scientific I computing for any student who wants to specialize in relativity, gravitation, and/or astrophysics. We took great care to select lecturers who teach in a comprehensible way and who are, at the same time, at the research front of their respective field. In numerics we had the privilege of having a lecturer from the National Center for Supercomputing Applications (NCSA, Champaign, IL, USA) and some from other leading institutions of the world; visualization was taught by a visualization expert from Boeing; and in com puter algebra we took recourse to practitioners of different computer algebra systems as applied to classical general relativity up to quantum gravity and differential geometry.

#### *100 Years of Relativity - Abhay Ashtekar 2005*

Thanks to Einstein's relativity theories, our notions of space and time underwent profound revisions about a 100 years ago. The resulting interplay between geometry and physics has dominated all of fundamental physics since then. This volume contains contributions from leading researchers, worldwide, who have thought deeply about the nature and consequences of this interplay. The articles take a long-range view of the subject and distill the most important advances in broad terms, making them easily accessible to non-specialists. The first part is devoted to a summary of how relativity theories were born (J Stachel). The second part discusses the most dramatic ramifications of general relativity, such as black holes (P Chrusciel and R Price), space-time singularities (H Nicolai and A Rendall), gravitational waves (P Laguna and P Saulson), the large scale structure of the cosmos (T Padmanabhan); experimental status of this theory (C Will) as well as its practical application to the GPS system (N Ashby). The last part looks beyond Einstein and provides glimpses into what is in store for us in the 21st century. Contributions here include summaries of radical changes in the notions of space and time that are emerging from quantum field theory in curved space-times (Ford), string theory (T Banks), loop quantum gravity (A Ashtekar), quantum cosmology (M Bojowald), discrete approaches (Dowker, Gambini and Pullin) and twistor theory (R Penrose).

#### *Quantum Mechanics of Fundamental Systems: The Quest for Beauty and Simplicity - Marc Henneaux* 2009-04-20

This article is dedicated to Claudio Bunster on the occasion of his 60th birthday. It is a great honor to take this opportunity to express my gratitude to him, who in my opinion has been the greatest national physicist ever, for his wise guidance and intrepid support through the years. As a Chilean, I can further tell that Claudio's contributions have been well far beyond theoretical physics, helping our country to be ready to face future challenges through science. Gravity in diverse dimensions is a subject in which Claudio has done major c- tributions, encouraging in many ways the following work, that is being made along different fronts in collaboration with my colleagues Diego Correa, Gustavo Dotti, Julio Oliva and David Tempo.

Thepursuitforwormholesolutions,whicharehandlesinthespacetime topology, it is as old as General Relativity and it has appeared in theoretical physics within different subjects, ranging from the attempt of describing physics as pure geometry, as in the Einstein-Rosen bridge model of a particle [1], to the concept of "charge withoutcharge"[2],aswell asindifferentissuesconcerningthe Euclideanapproach to quantum gravity (see, e.g., [3]). More recently, the systematic study of this kind of objects was pushed forward by the works of Morris, Thorne and Yurtsever [4,5].

#### The British Chess Magazine; Volume 16 - Anonymous 2018-10-18

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**Geometric Mechanics** - Waldyr Muniz Oliva 2004-10-25

Geometric Mechanics here means mechanics on a pseudo-riemannian manifold and the main goal is the study of some mechanical models and concepts, with emphasis on the intrinsic and geometric aspects arising in classical problems. The first seven chapters are written in the spirit of Newtonian Mechanics while the last two ones as well as two of the four appendices describe the foundations and some aspects of Special and General Relativity. All the material has a coordinate free presentation but, for the sake of motivation, many examples and exercises are included in order to exhibit the desirable flavor of physical applications.

**Advanced Concepts in Particle and Field Theory** - Tristan Hübsch 2023-01-31

This 2015 advanced textbook, now OA, provides students with a unified understanding of all matter at a fundamental level.

**Singular General Relativity** - Ovidiu Cristinel Stoica 2015-04-21

This Thesis deals with recent progress regarding singularities in General Relativity. Singularities are predicted by the theory, but raise difficult problems, because they make the usual equations to be plagued with infinities and to break down. To resolve some of these problems, extensions of differential geometry and of Einstein's equation to singularities were needed, and were constructed by the author. This generalization works easily at the Big-Bang singularity, which gained by this a description in terms of finite quantities which have both geometric and physical meaning. Moreover, a large class of Big-Bang singularities which are not necessarily homogeneous or isotropic is presented. In addition, these singularities satisfy the Weyl curvature hypothesis, emitted by Penrose to explain the arrow of time. The black hole singularities apparently are more difficult to deal with, but by applying a special procedure they turn out as well to admit a description in terms of finite quantities. In addition, these singularities exhibit a (geo)metric dimensional reduction, which might act as a regulator for the quantum fields, including for quantum gravity, in the high-energy limit. This opens the

perspective of perturbative quantum gravity without modifying General Relativity.

**Heun's Differential Equations** - F. M. Arscott 1995

Heun's equation is a second-order differential equation which crops up in a variety of forms in a wide range of problems in applied mathematics. These include integral equations of potential theory, wave propagation, electrostatic oscillation, and Schrodinger's equation. This volume brings together important research work for the first time, providing an important resource for all those interested in this mathematical topic. Both the current theory and the main areas of application are surveyed, and includes contributions from authoritative researchers.

**Relativistic Quantum Information** - Fabrizio Tamburini 2020-10-12

Relativistic quantum information is one of the most exciting fields of physics today. Not only does it open possibilities for new forms of computing but it also calls into question the peaceful coexistence between classical space-time and quantum physics with scenarios that reopen the relationships between locality and nonlocality in the foundational structure of physics. Curated by two international experts Ignazio Licata and Fabrizio Tamburini, this volume hosts a selection of particularly significant essays for the new territories, and is dedicated to the 60th anniversary of Prof. Ignazio Licata.

**Quantum Analogues: From Phase Transitions to Black Holes and Cosmology** - William Unruh 2007-04-14

Recently, analogies between laboratory physics (e.g. quantum optics and condensed matter) and gravitational/cosmological phenomena such as black holes have attracted an increasing interest. This book contains a series of selected lectures devoted to this new and rapidly developing field. Various analogies connecting (apparently) different areas in physics are presented in order to bridge the gap between them and to provide an alternative point of view.

**Impossibility** - John D. Barrow 1999

Astronomer John Barrow takes an intriguing look at the limits of science, who argues that there are things that are ultimately unknowable, undoable, or unreachable.

**Mass and Motion in General Relativity** - Luc Blanchet 2011-01-19

From the infinitesimal scale of particle physics to the cosmic scale of the universe, research is concerned with the nature of mass. While there have been spectacular advances in physics during the past century, mass still remains a mysterious entity at the forefront of current research. Our current perspective on gravitation has arisen over millennia, through the contemplation of falling apples, lift thought experiments and notions of stars spiraling into black holes. In this volume, the world's leading scientists offer a multifaceted approach to mass by giving a concise and introductory presentation based on insights from their respective fields of research on

gravity. The main theme is mass and its motion within general relativity and other theories of gravity, particularly for compact bodies. Within this framework, all articles are tied together coherently, covering post-Newtonian and related methods as well as the self-force approach to the analysis of motion in curved space-time, closing with an overview of the historical development and a snapshot on the actual state of the art. All contributions reflect the fundamental role of mass in physics, from issues related to Newton's laws, to the effect of self-force and radiation reaction within theories of gravitation, to the role of the Higgs boson in modern physics. High-precision measurements are described in detail, modified theories of gravity reproducing experimental data are investigated as alternatives to dark matter, and the fundamental problem of reconciling any theory of gravity with the physics of quantum fields is addressed. Auxiliary chapters set the framework for theoretical contributions within the broader context of experimental physics. The book is based upon the lectures of the CNRS School on Mass held in Orléans, France, in June 2008. All contributions have been anonymously refereed and, with the cooperation of the authors, revised by the editors to ensure overall consistency.

*Lectures on Astrophysics* - Steven Weinberg 2019-12-12

Lectures on Astrophysics provides an account of classic and contemporary aspects of astrophysics, with an emphasis on analytic calculations and physical understanding. It introduces fundamental topics in astrophysics, including the properties of single and binary stars, the phenomena associated with interstellar matter, and the structure of galaxies. Nobel Laureate Steven Weinberg combines exceptional physical insight with his gift for clear exposition to cover exciting recent developments and new results. Emphasizing theoretical results, and explaining their derivation and application, this book provides an invaluable resource for physics and astronomy students and researchers.

*Quo Vadis Quantum Mechanics?* - Avshalom C. Elitzur 2006-03-30

Each contribution is an article in itself, and great effort has been made by the authors to be lucid and not too technical. A few brief highlights of the round-table discussions are given between the chapters. Topics include: Quantum non-locality, the measurement problem, quantum insights into relativity, cosmology and thermodynamics, and possible bearings of quantum mechanics to biology and consciousness. Authors include Yakir Aharonov and Anton Zeilinger, plus Nobel laureates Anthony J. Leggett (2003) and Gerardus 't Hooft (1999). Foreword written by Sir Roger Penrose, best-selling author (*The Emperor's New Mind*) and world-renowned mathematical physicist.

**Space Technology and Applications International Forum – STAIF 2008** - Mohamed S. El-Genk 2008-01-31

As the British, French and Spanish Atlantic empires were torn apart in the Age of Revolution, Portugal

steadily pursued reforms to tie its American, African and European territories more closely together.

Eventually, after a period of revival and prosperity, the Luso-Brazilian world also succumbed to revolution, which ultimately resulted in Brazil's independence from Portugal. The first of its kind in the English language to examine the Portuguese Atlantic World in the period from 1750 to 1850, this book reveals that despite formal separation, the links and relationships that survived the demise of empire entwined the historical trajectories of Portugal and Brazil even more deeply. From constitutionalism to economic policy to the problem of slavery, Portuguese and Brazilian statesmen and political writers laboured under the long shadow of empire as they sought to begin anew and forge stable post-imperial orders on both sides of the Atlantic.

*Black Holes: A Laboratory for Testing Strong Gravity* - Cosimo Bambi 2017-06-01

This textbook introduces the current astrophysical observations of black holes, and discusses the leading techniques to study the strong gravity region around these objects with electromagnetic radiation. More importantly, it provides the basic tools for writing an astrophysical code and testing the Kerr paradigm. Astrophysical black holes are an ideal laboratory for testing strong gravity. According to general relativity, the spacetime geometry around these objects should be well described by the Kerr solution. The electromagnetic radiation emitted by the gas in the inner part of the accretion disk can probe the metric of the strong gravity region and test the Kerr black hole hypothesis. With exercises and examples in each chapter, as well as calculations and analytical details in the appendix, the book is especially useful to the beginners or graduate students who are familiar with general relativity while they do not have any background in astronomy or astrophysics.

**Genius At Play** - Siobhan Roberts 2015-07-14

Monografie over de Britse wiskundige (1937).

*Multiple Messengers and Challenges in Astroparticle Physics* - Roberto Aloisio 2018-02-27

This book, designed as a tool for young researchers and graduate students, reviews the main open problems and research lines in various fields of astroparticle physics: cosmic rays, gamma rays, neutrinos, cosmology, and gravitational physics. The opening section discusses cosmic rays of both galactic and extragalactic origin, examining experimental results, theoretical models, and possible future developments. The basics of gamma-ray astronomy are then described, including the detection methods and techniques. Galactic and extragalactic aspects of the field are addressed in the light of recent discoveries with space-borne and ground-based detectors. The review of neutrinos outlines the status of the investigations of neutrino radiation and brings together relevant formulae, estimations, and background information. Three complementary issues in cosmology are examined: observable predictions of inflation in the early universe, effects of dark

energy/modified gravity in the large-scale structure of the universe, and neutrinos in cosmology and large-scale structures. The closing section on gravitational physics reviews issues relating to quantum gravity, atomic precision tests, space-based experiments, the strong field regime, gravitational waves, multi-messengers, and alternative theories of gravity.

**Black Holes** - Kip S. Thorne 1986-01-01

A pedagogical introduction to the physics of black holes. The membrane paradigm represents the four-dimensional spacetime of the black hole's "event horizon" as a two-dimensional membrane in three-dimensional space, allowing the reader to understand and compute the behavior of black holes in complex astrophysical environments.

**American Book Publishing Record** - 1995