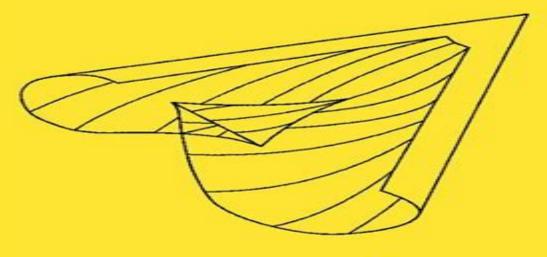Volker Perlick

Ray Optics, Fermat's Principle, and Applications to General Relativity

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Ray Optics Fermats Principle And Applications To General Relativity

Anatoliy Malyarenko

Ray Optics Fermats Principle And Applications To General Relativity:

Ray Optics, Fermat's Principle, and Applications to General Relativity Volker Perlick,2003-07-01 This book is about the mathematical theory of light propagation in media on general relativistic spacetimes The first part discusses the transition from Maxwell s equations to ray optics The second part establishes a general mathematical framework for treating ray optics as a theory in its own right making extensive use of the Hamiltonian formalism This part also includes a detailed discussion of variational principles i e various versions of Fermat s principle for light rays in general relativistic media Some applications e g to gravitational lensing are worked out The reader is assumed to have some basic knowledge of general relativity and some familiarity with differential geometry Some of the results are published here for the first time e g a general relativistic version of Fermat s principle for light rays in a medium that has to satisfy some regularity condition only

Einstein's Field Equations and Their Physical Implications Bernd G. Schmidt,2008-01-11 This book serves two purposes The authors present important aspects of modern research on the mathematical structure of Einstein s field equations and they show how to extract their physical content from them by mathematically exact methods The essays are devoted to exact solutions and to the Cauchy problem of the field equations as well as to post Newtonian approximations that have direct physical implications Further topics concern quantum gravity and optics in gravitational fields The book addresses researchers in relativity and differential geometry but can also be used as additional reading material for graduate students **Singularity Theory and Gravitational Lensing** Arlie O. Petters,Harold Levine,Joachim Wambsganss,2012-12-06 Astronomers do not do experiments They observe the universe primarily through detect ing light emitted by stars and other luminous objects Since this light must travel through space to reach us variations in the metric of space affects the appearance of astronomical objects These variations lead to dramatic changes in the shape and brightness of astronom ical sources Because these variations are sensitive to mass rather than to light observations of gravitational lensing enable astronomers to probe the mass distribution of the universe With gravitational lensing observations astronomers are addressing many of the most important scientific questions in astronomy and physics What is the universe made of Most of the energy and mass in the universe is not in the form of luminous objects Stars account for less than 1 % of the energy density of the universe Perhaps as much as another 3% of the energy density of the universe is in the form of warm gas that fills the space between galaxies The remaining 96% of the energy density is in some yet unidentified form Roughly one third of this energy density of the universe is dark matter matter that clusters gravitationally but does not emit light Most cosmologists suspect that this dark matter is composed of weakly interacting subatomic particles However most of the energy density of the universe appears to be in an even stranger form energy associated with empty space **Null Curves and Hypersurfaces of Semi-Riemannian Manifolds** Krishan L. Duggal,Dae Ho Jin,2007 This is a first textbook that is entirely focused on the up to date developments of null curves with their applications to science and engineering It

fills an important gap in a second level course in differential geometry as well as being essential for a core undergraduate course on Riemannian curves and surfaces The sequence of chapters is arranged to provide in depth understanding of a chapter and stimulate further interest in the next The book comprises a large variety of solved examples and rigorous exercises that range from elementary to higher levels This unique volume is self contained and unified in presenting A systematic account of all possible null curves their Frenet equations unique null Cartan curves in Lorentzian manifolds and their practical problems in science and engineering The geometric and physical significance of null geodesics mechanical systems involving curvature of null curves simple variation problems and the interrelation of null curves with hypersurfaces

Sixteenth Marcel Grossmann Meeting, The: On Recent Developments In Theoretical And Experimental General Relativity, Astrophysics, And Relativistic Field Theories - Proceedings Of The Mg16 Meeting On General Relativity (In 4 Volumes) Remo Ruffini,Gregory Vereshchagin,2022-12-15 The proceedings of MG16 give a broad view of all aspects of gravitational physics and astrophysics from mathematical issues to recent observations and experiments The scientific program of the meeting included 46 plenary presentations 3 public lectures 5 round tables and 81 parallel sessions arranged during the intense six day online meeting All talks were recorded and are available on the ICRANet YouTube channel at the following link www icranet org video_mg16 These proceedings are a representative sample of the very many contributions made at the meeting They contain 383 papers among which 14 come from the plenary sessions The material represented in these proceedings cover the following topics accretion active galactic nuclei alternative theories of gravity black holes theory observations and experiments binaries boson stars cosmic microwave background cosmic strings dark energy and large scale structure dark matter education exact solutions early universe fundamental interactions and stellar evolution fast transients gravitational waves high energy physics history of relativity neutron stars precision tests quantum gravity strong fields and white dwarf all of them represented by a large number of contributions The online e proceedings are published in an open access format

Special Relativity Jürgen Ehlers,Claus Lämmerzahl,2006-09-11 After a century of successes physicists still feel the need to probe the limits of the validity of theories based on special relativity Canonical approaches to quantum gravity non commutative geometry string theory and unification scenarios predict tiny violations of Lorentz invariance at high energies The present book based on a recent seminar devoted to such frontier problems contains reviews of the foundations of special relativity and the implications of Poincar invariance as well as comprehensive accounts of experimental results and proposed tests The book addresses besides researchers in the field everyone interested in the conceptual and empirical foundations of our knowledge about space time and matter *An Introduction to Biomedical Optics* Robert Splinter,Brett A. Hooper,2006-12-13 Many universities now offer a course in biomedical optics but lack a textbook specifically addressing the topic Intended to fill this gap An Introduction to Biomedical Optics is the first comprehensive introductory text describing both diagnostic and therapeutic optical methods in medicine It provides the fundamental background needed for grad

Fourteenth Marcel Grossmann Meeting, The: On Recent Developments In Theoretical And Experimental General Relativity, Astrophysics, And Relativistic Field Theories - Proceedings Of The Mg14 Meeting On General Relativity (In 4 Parts) Massimo Bianchi,Robert T Jantzen,Remo Ruffini,2017-10-13 The four volumes of the proceedings of MG14 give a broad view of all aspects of gravitational physics and astrophysics from mathematical issues to recent observations and experiments The scientific program of the meeting included 35 morning plenary talks over 6 days 6 evening popular talks and 100 parallel sessions on 84 topics over 4 afternoons Volume A contains plenary and review talks ranging from the mathematical foundations of classical and quantum gravitational theories including recent developments in string theory to precision tests of general relativity including progress towards the detection of gravitational waves and from supernova cosmology to relativistic astrophysics including topics such as gamma ray bursts black hole physics both in our galaxy and in active galactic nuclei in other galaxies and neutron star pulsar and white dwarf astrophysics The remaining volumes include parallel sessions which touch on dark matter neutrinos X ray sources astrophysical black holes neutron stars white dwarfs binary systems radiative transfer accretion disks quasars gamma ray bursts supernovas alternative gravitational theories perturbations of collapsed objects analog models black hole thermodynamics numerical relativity gravitational lensing large scale structure observational cosmology early universe models and cosmic microwave background anisotropies inhomogeneous cosmology inflation global structure singularities chaos Einstein Maxwell systems wormholes exact solutions of Einstein s equations gravitational waves gravitational wave detectors and data analysis precision gravitational measurements quantum gravity and loop quantum gravity quantum cosmology strings and branes self gravitating systems gamma ray astronomy cosmic rays and the history of general relativity *Thirteenth Marcel Grossmann Meeting, The: On Recent Developments In Theoretical And Experimental General Relativity, Astrophysics And Relativistic Field Theories - Proceedings Of The Mg13 Meeting On General Relativity (In 3 Volumes)* Remo Ruffini,Kjell Rosquist,Robert T Jantzen,2015-01-26 The Marcel Grossmann Meetings seek to further the development of the foundations and applications of Einstein s general relativity by promoting theoretical understanding in the relevant fields of physics mathematics astronomy and astrophysics and to direct future technological observational and experimental efforts The meetings discuss recent developments in classical and quantum aspects of gravity and in cosmology and relativistic astrophysics with major emphasis on mathematical foundations and physical predictions having the main objective of gathering scientists from diverse backgrounds for deepening our understanding of spacetime structure and reviewing the current state of the art in the theory observations and experiments pertinent to relativistic gravitation The range of topics is broad going from the more abstract classical theory quantum gravity branes and strings to more concrete relativistic astrophysics observations and modeling The three volumes of the proceedings of MG13 give a broad view of all aspects of gravitational physics and astrophysics from mathematical issues to recent observations and experiments The scientific program of the meeting included 33 morning

plenary talks during 6 days and 75 parallel sessions over 4 afternoons Volume A contains plenary and review talks ranging from the mathematical foundations of classical and quantum gravitational theories including recent developments in string brane theories to precision tests of general relativity including progress towards the detection of gravitational waves and from supernova cosmology to relativistic astrophysics including such topics as gamma ray bursts black hole physics both in our galaxy and in active galactic nuclei in other galaxies and neutron star and pulsar astrophysics Volumes B and C include parallel sessions which touch on dark matter neutrinos X ray sources astrophysical black holes neutron stars binary systems radiative transfer accretion disks quasors gamma ray bursts supernovas alternative gravitational theories perturbations of collapsed objects analog models black hole thermodynamics numerical relativity gravitational lensing large scale structure observational cosmology early universe models and cosmic microwave background anisotropies inhomogeneous cosmology inflation global structure singularities chaos Einstein Maxwell systems wormholes exact solutions of Einstein s equations gravitational waves gravitational wave detectors and data analysis precision gravitational measurements quantum gravity and loop quantum gravity quantum cosmology strings and branes self gravitating systems gamma ray astronomy and cosmic rays and the history of general relativity   *Analytical and Numerical Approaches to Mathematical Relativity* Jörg Frauendiener,Domenico J. W. Giulini,Volker Perlick,2006-03-28 General relativity ranks among the most accurately tested fundamental theories in all of physics Deficiencies in mathematical and conceptual understanding still exist hampering further progress This book collects surveys by experts in mathematical relativity writing about the current status of and problems in their fields There are four contributions for each of the following mathematical areas differential geometry and differential topology analytical methods and differential equations and numerical methods   *The Ninth Marcel Grossmann Meeting* Robert T. Jantzen,Remo Ruffini,V. G. Gurzadyan,2002   **Ninth Marcel Grossmann Meeting, The: On Recent Developments In Theoretical And Experimental General Relativity, Gravitation & Relativistic Field Theories (In 3 Volumes) - Procs Of The Mgix Mm Meeting** Vahe G Gurzadyan,Robert T Jantzen,Remo Ruffini,2002-12-12 In 1975 the Marcel Grossmann Meetings were established by Remo Ruffini and Abdus Salam to provide a forum for discussion of recent advances in gravitation general relativity and relativistic field theories In these meetings which are held once every three years every aspect of research is emphasized mathematical foundations physical predictions and numerical and experimental investigations The major objective of these meetings is to facilitate exchange among scientists so as to deepen our understanding of the structure of space time and to review the status of both the ground based and the space based experiments aimed at testing the theory of gravitation The Marcel Grossmann Meetings have grown under the guidance of an International Organizing Committee and a large International Coordinating Committee The first two meetings MG1 and MG2 were held in Trieste 1975 1979 A most memorable MG3 1982 was held in Shanghai and represented the first truly international scientific meeting in China after the so called Cultural Revolution Three years later MG4 was held in Rome

1985 It was at MG4 that astroparticle physics was born MGIXMM was organized by the International Organizing Committee composed of D Blair Y Choquet Bruhat D Christodoulou T Damour J Ehlers F Everitt Fang Li Zhi S Hawking Y Ne eman R Ruffini chair H Sato R Sunyaev and S Weinberg Essential to the organization was an International Coordinating Committee of 135 members from scientific institutions of 54 countries MGIXMM was attended by 997 scientists of 69 nationalities It took place on 2 8 July 2000 at the University of Rome Italy The scientific programs included 60 plenary and review talks as well as talks in 88 parallel sessions The three volumes of the proceedings of MGIXMM present a rather authoritative view of relativistic astrophysics which is becoming one of the priorities in scientific endeavour The papers appearing in these volumes cover all aspects of gravitation from mathematical issues to recent observations and experiments Their intention is to give a complete picture of our current understanding of gravitational theory at the turn of the millennium The Marcel Grossmann Individual Awards for this meeting were presented to Cecille and Bryce DeWitt Riccardo Giacconi and Roger Penrose while the Institutional Award went to the Solvay Institute accepted on behalf of the Institute by Jacques Solvay and Ilya Prigogine The acceptance speeches are also included in the proceedings   *Probabilistic Models of Cosmic Backgrounds* Anatoliy Malyarenko,2024-06-30 Combining research methods from various areas of mathematics and physics Probabilistic Models of Cosmic Backgrounds describes the isotropic random sections of certain fiber bundles and their applications to creating rigorous mathematical models of both discovered and hypothetical cosmic backgrounds Previously scattered and hard to find mathematical and physical theories have been assembled from numerous textbooks monographs and research papers and explained from different or even unexpected points of view This consists of both classical and newly discovered results necessary for understanding a sophisticated problem of modelling cosmic backgrounds The book contains a comprehensive description of mathematical and physical aspects of cosmic backgrounds with a clear focus on examples and explicit calculations Its reader will bridge the gap of misunderstanding between the specialists in various theoretical and applied areas who speak different scientific languages The audience of the book consists of scholars students and professional researchers A scholar will find basic material for starting their own research A student will use the book as supplementary material for various courses and modules A professional mathematician will find a description of several physical phenomena at the rigorous mathematical level A professional physicist will discover mathematical foundations for well known physical theories   *Turbulence and Magnetic Fields in Astrophysics* Edith Falgarone,Thierry Passot,2003-03-11 This book contains review articles of most of the topics addressed at the conf ence on Simulations of Magnetohydrodynamic turbulence in astrophysics recent achievements and perspectives which took place from July 2 to 6 2001 at the Institut Henri Poincar e in Paris We made the choice to publish these lectures in a tutorial form so that they can be read by a broad audience As a result this book does not give an exhaustive view of all the subjects addressed during the conference The main objective of this workshop which gathered about 90 scientists from di erent elds was to present and confront recent results

on the topic of t bulence in magnetized astrophysical environments A second objective was to discuss the latest generation of numerical codes such as those using adaptive mesh re nement AMR techniques During a plenary discussion at the end of the workshop discussions were held on several topics often at the heart of vivid controversies Topics included the timescale for the dissipation of magneto hydrodynamical MHD turbulence the role of boundary conditions the characteristics of imbalanced turbulence the validity of the polytropic approach to Alfv en waves support within interst lar clouds the source of turbulence inside clouds devoid of stellar activity the timescale for star formation the Alfv en Mach number of interstellar gas motions the formation process for helical elds in the interstellar medium The impact of small upon large scales was also discussed **Modified and Quantum Gravity** Christian Pfeifer,Claus Lämmerzahl,2023-09-30 This book discusses theoretical predictions and their comparison with experiments of extended and modified classical and quantum theories of gravity The goal is to provide a readable access and broad overview over different approaches to the topic to graduate and PhD students as well as to young researchers The book presents both theoretical and experimental insights and is structured in three parts The first addresses the theoretical models beyond special and general relativity such as string theory Poincare gauge theory and teleparallelism as well as Finsler gravity In turn the second part is focused on the observational effects that these models generate accounting for tests and comparisons which can be made on all possible scales from the universe as a whole via binary systems stars black holes satellite experiments down to laboratory experiments at micrometer and smaller scales The last part of this book is dedicated to quantum systems and gravity showing tests of classical gravity with quantum systems and coupling of quantum matter and gravity *Exact Solutions and Scalar Fields in Gravity* Alfredo Macías,Jorge L. Cervantes-Cota,Claus Lämmerzahl,2001-08-31 Here quantum and cosmological effects which arise from both gravity theories in four and higher dimensions and from metric affine theories are investigated Part Three is devoted to cosmological and inflationary scenarios Local effects such as the influence of scalar fields in protogalactic interactions numerical studies of the collapse of molecular cores as well as the inverse inflationary problem and the blue eigenvalue spectrum of it are considered Moreover the role of scalar fields as dark matter and quantum cosmology in the Bergman Wagoner and Gowdy theories together with the relation of the conformal symmetry and deflationary gas universe are likewise presented The last part of the book includes some mixed topics which are still in the experimental stage General Relativity Norbert Straumann,2013-11-11 The foundations are thoroughly developed together with the required mathematical background from differential geometry developed in Part III The author also discusses the tests of general relativity in detail including binary pulsars with much space is devoted to the study of compact objects especially to neutron stars and to the basic laws of black hole physics This well structured text and reference enables readers to easily navigate through the various sections as best matches their backgrounds and perspectives whether mathematical physical or astronomical Very applications oriented the text includes very recent results such as the supermassive black hole in our galaxy and first double pulsar system

American Journal of Physics ,2007 **Gravitational Lensing and Optical Geometry** Marcus C.Werner,2020-12-08 The year 2019 saw the centenary of Eddington s eclipse expeditions and the corroboration of Einstein s general relativity by gravitational lensing To mark the occasion a Special Issue of Universe has been dedicated to the theoretical aspects of strong gravitational lensing The articles assembled in this volume contain original research and reviews and apply a variety of mathematical techniques that have been developed to study this effect both in 3 space and in spacetime These include Mathematical properties of the standard thin lens approximation in particular caustics Optical geometry the Gauss Bonnet method and related approaches Lensing in the spacetime of general relativity and modified theories black hole shadows

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