

**N. Straumann**

# **General Relativity**

With Applications  
to Astrophysics



**Springer**

# General Relativity With Applications To Astrophysics Theoretical And Mathematical Physics

**Walter Thirring**



## **General Relativity With Applications To Astrophysics Theoretical And Mathematical Physics:**

**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

General Relativity Norbert Straumann, 2014-03-12 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

**General Relativity: The most beautiful of theories** Carlo Rovelli, 2015-02-17 Generalising Newton's law of gravitation general relativity is one of the pillars of modern physics While applications in the beginning were restricted to isolated effects such as a proper understanding of Mercury's orbit the second half of the twentieth century saw a massive development of applications These include cosmology gravitational waves and even very practical results for satellite based positioning systems as well as different approaches to unite general relativity with another very successful branch of physics quantum theory On the occasion of general relativity's centennial leading scientists in the different branches of gravitational research review the history and recent advances in the main fields of applications of the theory which was referred to by Lev Landau as the most beautiful of the existing physical theories Contributions from Andy C Fabian Anthony L Lasenby Astrophysical black Holes Neil Ashby GNSS and other applications of General Relativity Gene Byrd Arthur Chernin Pekka Teerikorpi Mauri Vaaltonen Observations of general Relativity at strong and weak limits Ignazio Ciufolini General Relativity and dragging of inertial frames Carlo Rovelli The strange world of quantum spacetime

*General Relativity* Norbert Straumann, 2012-10-09 This book provides a completely revised and expanded version of the previous classic edition General Relativity and Relativistic Astrophysics In Part I the foundations of general relativity are thoroughly developed while Part II is devoted to tests of general relativity and many of its applications Binary pulsars our best laboratories for general relativity are studied in considerable detail An introduction to gravitational lensing theory is included as well so as to make the current literature on the subject accessible to readers Considerable attention is devoted to the study of compact objects especially to black holes

This includes a detailed derivation of the Kerr solution Israel's proof of his uniqueness theorem and a derivation of the basic laws of black hole physics Part II ends with Witten's proof of the positive energy theorem which is presented in detail together with the required tools on spin structures and spinor analysis In Part III all of the differential geometric tools required are developed in detail A great deal of effort went into refining and improving the text for the new edition New material has been added including a chapter on cosmology The book addresses undergraduate and graduate students in physics astrophysics and mathematics It utilizes a very well structured approach which should help it continue to be a standard work for a modern treatment of gravitational physics The clear presentation of differential geometry also makes it useful for work on string theory and other fields of physics classical as well as quantum

**Special and General Relativity** Sebastian Boblest, Thomas Müller, Günter Wunner, 2025-12-14 This textbook combines the mathematical foundations of the theory of special and general relativity with numerous applications in physics and astronomy Besides the discussion of classical experiments that impressively confirm the predictions of the theory of relativity a special focus is on cosmology as an important application of general relativity The discussion of the physics of compact stellar objects i.e. white dwarfs neutron stars and black holes and a short section on the formation and evolution of stars complement the presentation The authors put special emphasis on relativistic visualization Two chapters give an overview of various visualization techniques in special and general relativity Examples of relativistic visualization make the predictions of relativity which so blatantly seem to contradict everyday experience more tangible and intelligible The resulting figures and accompanying videos support the understanding of the topics covered in the text The videos are accessible also via the Springer Nature More Media App This edition is the translation and extension of a textbook of the authors written in German It also includes more recent developments in astrophysics and cosmology such as the detection and observation of gravitational waves or the Hubble controversy The book is intended for students of physics and related study courses who would like to get an overview of both the theory of relativity and its areas of application However the interested layperson too will gain a new and deeper insight into relativity and astrophysics

**A First Course in General Relativity** Bernard Schutz, 2009-05-14 Second edition of a widely used textbook providing the first step into general relativity for undergraduate students with minimal mathematical background

**A First Course in General Relativity** Bernard F. Schutz, 1985-01-31 This textbook develops general relativity and its associated mathematics from a minimum of prerequisites leading to a physical understanding of the theory in some depth

*An Introduction to General Relativity and Cosmology* Jerzy Plebanski, Andrzej Krasinski, 2024-05-31 Experts Plebanski and Krasinski provide a thorough introduction to the tools of general relativity and relativistic cosmology Assuming familiarity with advanced calculus classical mechanics electrodynamics and special relativity the text begins with a short course on differential geometry taking a unique top down approach Starting with general manifolds on which only tensors are defined the covariant derivative and affine connection are introduced before moving on to geodesics and curvature Only

then is the metric tensor and the pseudo Riemannian geometry introduced specialising the general results to this case The main text describes relativity as a physical theory with applications to astrophysics and cosmology It takes the reader beyond traditional courses on relativity through in depth descriptions of inhomogeneous cosmological models and the Kerr metric Emphasis is given to complete and clear derivations of the results enabling readers to access research articles published in relativity journals

**The General Theory of Relativity** Farook Rahaman,2021-09-30 Discusses the general theory of relativity Lie derivatives rotating black holes with a focus on basics of cosmology and astrophysics

**Einstein's General Theory of Relativity** Brian P. Dolan,2023-06-29 Einstein's general theory of relativity can be a notoriously difficult subject for students approaching it for the first time with arcane mathematical concepts such as connection coefficients and tensors adorned with a forest of indices This book is an elementary introduction to Einstein's theory and the physics of curved space times that avoids these complications as much as possible Its first half describes the physics of black holes gravitational waves and the expanding Universe without using tensors Only in the second half are Einstein's field equations derived and used to explain the dynamical evolution of the early Universe and the creation of the first elements Each chapter concludes with problem sets and technical mathematical details are given in the appendices This short text is intended for undergraduate physics students who have taken courses in special relativity and advanced mechanics

**Special Relativity in General Frames** Éricourgoulhon,2013-08-20 Special relativity is the basis of many fields in modern physics particle physics quantum field theory high energy astrophysics etc This theory is presented here by adopting a four dimensional point of view from the start An outstanding feature of the book is that it doesn't restrict itself to inertial frames but considers accelerated and rotating observers It is thus possible to treat physical effects such as the Thomas precession or the Sagnac effect in a simple yet precise manner In the final chapters more advanced topics like tensorial fields in spacetime exterior calculus and relativistic hydrodynamics are addressed In the last brief chapter the author gives a preview of gravity and shows where it becomes incompatible with Minkowsky spacetime Well illustrated and enriched by many historical notes this book also presents many applications of special relativity ranging from particle physics accelerators particle collisions quark gluon plasma to astrophysics relativistic jets active galactic nuclei and including practical applications Sagnac gyrometers synchrotron radiation GPS In addition the book provides some mathematical developments such as the detailed analysis of the Lorentz group and its Lie algebra The book is suitable for students in the third year of a physics degree or on a masters course as well as researchers and any reader interested in relativity Thanks to the geometric approach adopted this book should also be beneficial for the study of general relativity A modern presentation of special relativity must put forward its essential structures before illustrating them using concrete applications to specific dynamical problems Such is the challenge so successfully met of the beautiful book by Éricourgoulhon excerpt from the Foreword by Thibault Damour

**General Relativity and Relativistic Astrophysics** Norbert Straumann,2012-12-06 In 1979 I gave graduate courses at the University of

Zurich and lectured in the Troisième Cycle de la Suisse Romande a consortium of four universities in the French speaking part of Switzerland and these lectures were the basis of the Springer Lecture Notes in Physics Volume 150 published in 1981. This text appeared in German because there have been few modern expositions of the general theory of relativity in the mother tongue of its only begetter. Soon after the book appeared W Thirring asked me to prepare an English edition for the Texts and Monographs in Physics. Fortunately E Borie agreed to translate the original German text into English. An excellent collaboration allowed me to revise and add to the contents of the book. I have updated and improved the original text and have added a number of new sections mostly on astrophysical topics. In particular in collaboration with M Camenzind I have included a chapter on spherical and disk accretion onto compact objects. This book divides into three parts. Part I develops the mathematical tools used in the general theory of relativity. Since I wanted to keep this part short but reasonably self contained I have adopted the dry style of most modern mathematical texts. Readers who have never before been confronted with differential geometry will find the exposition too abstract and will miss motivations of the basic concepts and constructions.

*Noether Symmetries in Theories of Gravity* Francesco Bajardi, Salvatore Capozziello, 2022-11-24. This volume summarizes the many alternatives and extensions to Einstein's General Theory of Relativity and shows how symmetry principles can be applied to identify physically viable models. The first part of the book establishes the foundations of classical field theory providing an introduction to symmetry groups and the Noether theorems. A quick overview of general relativity is provided including discussion of its successes and shortcomings then several theories of gravity are presented and their main features are summarized. In the second part the Noether Symmetry Approach is applied to theories of gravity to identify those which contain symmetries. In the third part of the book these selected models are tested through comparison with the latest experiments and observations. This constrains the free parameters in the selected models to fit the current data demonstrating a useful approach that will allow researchers to construct and constrain modified gravity models for further applications.

**Special Relativity in General Frames** Eric Gourgoulhon, 2013-11-27. Special relativity is the basis of many fields in modern physics: particle physics, quantum field theory, high energy astrophysics etc. This theory is presented here by adopting a four dimensional point of view from the start. An outstanding feature of the book is that it doesn't restrict itself to inertial frames but considers accelerated and rotating observers. It is thus possible to treat physical effects such as the Thomas precession or the Sagnac effect in a simple yet precise manner. In the final chapters more advanced topics like tensorial fields in spacetime, exterior calculus and relativistic hydrodynamics are addressed. In the last brief chapter the author gives a preview of gravity and shows where it becomes incompatible with Minkowski spacetime. Well illustrated and enriched by many historical notes, this book also presents many applications of special relativity ranging from particle physics accelerators, particle collisions, quark gluon plasma to astrophysics: relativistic jets, active galactic nuclei and including practical applications: Sagnac gyroscopes, synchrotron radiation, GPS. In addition the book provides some mathematical

developments such as the detailed analysis of the Lorentz group and its Lie algebra The book is suitable for students in the third year of a physics degree or on a masters course as well as researchers and any reader interested in relativity Thanks to the geometric approach adopted this book should also be beneficial for the study of general relativity A modern presentation of special relativity must put forward its essential structures before illustrating them using concrete applications to specific dynamical problems Such is the challenge so successfully met of the beautiful book by ric Gourgoulhon excerpt from the Foreword by Thibault Damour

**Gravity, a Geometrical Course** Pietro Giuseppe Frè, 2012-10-24 Gravity a Geometrical Course presents general relativity GR in a systematic and exhaustive way covering three aspects that are homogenized into a single texture i the mathematical geometrical foundations exposed in a self consistent contemporary formalism ii the main physical astrophysical and cosmological applications updated to the issues of contemporary research and observations with glimpses on supergravity and superstring theory iii the historical development of scientific ideas underlying both the birth of general relativity and its subsequent evolution The book divided in two volumes is a rich resource for graduate students and those who wish to gain a deep knowledge of the subject without an instructor Volume One is dedicated to the development of the theory and basic physical applications It guides the reader from the foundation of special relativity to Einstein field equations illustrating some basic applications in astrophysics A detailed account of the historical and conceptual development of the theory is combined with the presentation of its mathematical foundations Differentiable manifolds fibre bundles differential forms and the theory of connections are covered with a sketchy introduction to homology and cohomology Pseudo Riemannian geometry is presented both in the metric and in the vielbein approach Physical applications include the motions in a Schwarzschild field leading to the classical tests of GR light ray bending and periastron advance discussion of relativistic stellar equilibrium white dwarfs Chandrasekhar mass limit and polytropes An entire chapter is devoted to tests of GR and to the indirect evidence of gravitational wave emission The formal structure of gravitational theory is at all stages compared with that of non gravitational gauge theories as a preparation to its modern extension namely supergravity discussed in the second volume Pietro Fr is Professor of Theoretical Physics at the University of Torino Italy and is currently serving as Scientific Counsellor of the Italian Embassy in Moscow His scientific passion lies in supergravity and all allied topics since the inception of the field in 1976 He was professor at SISSA worked in the USA and at CERN He has taught General Relativity for 15 years He has previously two scientific monographs Supergravity and Superstrings and The N 2 Wonderland He is also the author of a popular science book on cosmology and two novels in Italian

*The Relativistic Boltzmann Equation: Theory and Applications* Carlo Cercignani, Gilberto M. Kremer, 2012-12-06 The aim of this book is to present the theory and applications of the relativistic Boltzmann equation in a self contained manner even for those readers who have no familiarity with special and general relativity Though an attempt is made to present the basic concepts in a complete fashion the style of presentation is chosen to be appealing to readers who want to understand how

kinetic theory is used for explicit calculations The book will be helpful not only as a textbook for an advanced course on relativistic kinetic theory but also as a reference for physicists astrophysicists and applied mathematicians who are interested in the theory and applications of the relativistic Boltzmann equation A Course in Mathematical Physics 1 and 2 Walter Thirring, 2012-12-06 The last decade has seen a considerable renaissance in the realm of classical dynamical systems and many things that may have appeared mathematically overly sophisticated at the time of the first appearance of this textbook have since become the everyday tools of working physicists This new edition is intended to take this development into account I have also tried to make the book more readable and to eradicate errors Since the first edition already contained plenty of material for a one semester course new material was added only when some of the original could be dropped or simplified Even so it was necessary to expand the chapter with the proof of the K A M Theorem to make allowances for the current trend in physics This involved not only the use of more refined mathematical tools but also a reevaluation of the word fundamental What was earlier dismissed as a grubby calculation is now seen as the consequence of a deep principle Even Kepler's laws which determine the radii of the planetary orbits and which used to be passed over in silence as mystical nonsense seem to point the way to a truth unattainable by superficial observation The ratios of the radii of Platonic solids to the radii of inscribed Platonic solids are irrational but satisfy algebraic equations of lower order A Course in Mathematical Physics 2 Walter Thirring, 2014-07-08 In the past decade the language and methods of modern differential geometry have been increasingly used in theoretical physics What seemed extravagant when this book first appeared 12 years ago as lecture notes is now a commonplace This fact has strengthened my belief that today students of theoretical physics have to learn that language and the sooner the better After all they will be the professors of the twenty first century and it would be absurd if they were to teach then the mathematics of the nineteenth century Thus for this new edition I did not change the mathematical language Apart from correcting some mistakes I have only added a section on gauge theories In the last decade it has become evident that these theories describe fundamental interactions and on the classical level their structure is sufficiently clear to qualify them for the minimum amount of knowledge required by a theoretician It is with much regret that I had to refrain from incorporating the interesting developments in Kaluza Klein theories and in cosmology but I felt bound to my promise not to burden the students with theoretical speculations for which there is no experimental evidence I am indebted to many people for suggestions concerning this volume In particular P Aichelburg H Rumpf and H Urbantke have contributed generously to corrections and improvements Finally I would like to thank Dr 1 Dahl Jensen for redoing some of the figures on the computer *Multivariate Calculus and Geometry Concepts* Chirag Verma, 2025-02-20 Multivariate Calculus and Geometry Concepts is a comprehensive textbook designed to provide students researchers and practitioners with a thorough understanding of fundamental concepts techniques and applications in multivariate calculus and geometry Authored by experts we offer a balanced blend of theoretical foundations practical



examples and computational methods making it suitable for both classroom instruction and self study We cover a wide range of topics including partial derivatives gradients line and surface integrals parametric equations polar coordinates conic sections and differential forms Each topic is presented clearly and concisely with detailed explanations and illustrative examples to aid understanding Our emphasis is on developing a conceptual understanding of key concepts and techniques rather than rote memorization of formulas We include numerous figures diagrams and geometric interpretations to help readers visualize abstract mathematical concepts and their real world applications Practical applications of multivariate calculus and geometry are highlighted throughout the book with examples drawn from physics engineering computer graphics and other fields We demonstrate how these concepts are used to solve real world problems and inspire readers to apply their knowledge in diverse areas We discuss computational methods and numerical techniques used in multivariate calculus and geometry such as numerical integration optimization algorithms and finite element methods Programming exercises and computer simulations provide hands on experience with implementing and applying these methods Our supplementary resources include online tutorials solution manuals and interactive simulations offering additional guidance practice problems and opportunities for further exploration and self assessment Multivariate Calculus and Geometry Concepts is suitable for undergraduate and graduate students in mathematics engineering physics computer science and related disciplines It also serves as a valuable reference for researchers educators and professionals seeking a comprehensive overview of multivariate calculus and geometry and its applications in modern science and technology

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

## **General Relativity With Applications To Astrophysics Theoretical And Mathematical Physics** Book Review: Unveiling the Magic of Language

In a digital era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**General Relativity With Applications To Astrophysics Theoretical And Mathematical Physics**," compiled by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound affect our existence. Throughout this critique, we shall delve into the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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