Gravitoelectromagnetism A Brief Review

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The Fundamental Nature and Structure of Space-Time Springer Nature
Providing a broad overview of foundational concepts, this second edition of Fundamentals of Astronomy covers topics ranging from spherical astronomy to reference systems, and celestial mechanics to astronomical photometry and spectroscopy. It expounds arguments of classical astronomy that provided the foundation for modern astrometry, whilst presenting the latest results of the very-long-baseline interferometry (VLBI) radio technique, optical interferometers and satellites such as Hipparcos and GAIA, and recent resolutions of the IAU and IERS regarding precession, forced and free nutation, and Earth figure and rotation. Concepts of general relativity are explored, such as the advance of Mercury’s perihelion, light deflection and black holes, in addition to the physical properties, orbits, and ephemerides of planets, comets and asteroids with an extension to visual binary stars orbital reconstruction. Extrasolar planets are also discussed, with reference to radial velocity and transits measurements by ground and space telescopes. Basic concepts of astronomical photometry, spectroscopy and polarimetry are given, including the influence of the terrestrial atmosphere. Classical works, such as Hipparchus, are mentioned in order to provide a flavor of the historical development of the field. It is an ideal textbook for undergraduate and graduate students studying astronomy, astrophysics, mathematics, and engineering. Supplementary and explanatory notes provide readers with references to additional material published in other literature and scientific journals, whilst solved and unsolved exercises allow students to review their understanding of the material. Features: Provides an introductory vision of arguments from spherical astronomy to celestial mechanics to astronomical photometry and spectroscopy Presents the information at an introductory level without sacrificing scientific rigor Fully updated throughout with the latest results in the field
Exploring physics with Geometric Algebra Nova Publishers
Contents:Tests of Underlying Principles in Gravitational Physics and Their Theoretical RationaleFrameworks for Testing Gravitational Theories, Present Status of Theory Testing and Future ProspectsRotational Effects in General Relativity, Frame-Dragging and the Geodetic EffectExperiments and Theory of Gravitational RadiationAdvanced Technologies: Clocks, Drag-Free and Cryogenics in SpaceClassical GravityConsiderations in Spacecraft Design, Program Management and the Use of Columbus Space Station Readership: Physicists interested in relativity and astrophysicists. keywords:
Relativistic Gravitational Experiments in Space ScholarlyEditions
This is an exploratory collection of notes containing worked examples of a number of applications of Geometric Algebra (GA), also known as Clifford Algebra. This writing is focused on undergraduate level physics concepts, with a target audience of somebody with an undergraduate engineering background (i.e. me at the time of writing.) These notes are more journal than book. You'll find lots of duplication, since I reworked some topics from scratch a number of times. In many places I was attempting to learn both the basic physics concepts as well as playing with how to express many of those concepts using GA formalisms. The page count proves that I did a very poor job of weeding out all the duplication. These notes are (dis)organized into the following chapters * Basics and Geometry. This chapter covers a hodge-podge collection of topics, including GA forms for

traditional vector identities, Quaterions, Cauchy equations, Legendre polynomials, wedge product representation of a plane, bivector and trivector geometry, torque and more. A couple attempts at producing an introduction to GA concepts are included (none of which I was ever happy with.) * Projection. Here the concept of reciprocal frame vectors, using GA and traditional matrix formalisms is developed. Projection, rejection and Moore-Penrose (generalized inverse) operations are discussed. * Rotation. GA Rotors, Euler angles, spherical coordinates, blade exponentials, rotation generators, and infinitesimal rotations are all examined from a GA point of view. * Calculus. Here GA equivalents for a number of vector calculus relations are developed, spherical and hyperspherical volume parameterizations are derived, some questions about the structure of divergence and curl are examined, and tangent planes and normals in 3 and 4 dimensions are examined. Wrapping up this chapter is a complete GA formulation of the general Stokes theorem for curvilinear coordinates in Euclidean or non-Euclidean spaces is developed. * General Physics. This chapter introduces a bivector form of angular momentum (instead of a cross product), examines the components of radial velocity and acceleration, kinetic energy, symplectic structure, Newton's method, and a center of mass problem for a toroidal segment. * Relativity. This is a fairly incoherent chapter, including an attempt to develop the Lorentz transformation by requiring wave equation invariance, Lorentz transformation of the four-vector (STA) gradient, and a look at the relativistic doppler equation. * Electrodynamics. The GA formulation of Maxwell's equation (singular in GA) is developed here. Various basic topics of electrodynamics are examined using the GA toolbox, including the Biot-Savart law, the covariant form for Maxwell's equation (Space Time Algebra, or STA), four vectors and potentials, gauge invariance, TEM waves, and some Lienard-Wiechert problems. * Lorentz Force. Here the GA form of the Lorentz force equation and its relation to the usual vectorial representation is explored. This includes some application of boosts to the force equation to examine how it transforms under observe dependent conditions. * Electrodynamic stress energy. This chapter explores concepts of electrodynamic energy and momentum density and the GA representation of the Poynting vector and the stress-energy tensors. * Quantum Mechanics. This chapter includes a look at the Dirac Lagrangian, and how this can be cast into GA form. Properties of the Pauli and Dirac bases are explored, and how various matrix operations map onto their GA equivalents. A bivector form for the angular momentum operator is examined. A multivector form for the first few spherical harmonic eigenfunctions is developed. A multivector factorization of the three and four dimensional Laplacian and the angular momentum operators are derived. * Fourier treatments. Solutions to various PDE equations are attempted using Fourier series and transforms. Much of this chapter was exploring Fourier solutions to the GA form of Maxwell's equation, but a few other non-geometric algebra Fourier problems were also tackled.

With Modern Applications in Cosmology World Scientific

Progress in Physics has been created for publications on advanced studies in theoretical and experimental physics, including related themes from mathematics.

Progress in Physics, vol. 3/2009 CRC Press

This book presents a generalization of transforms from the frames co-moving with an accelerated particle for uniform circular or linear motion into an inertial frame of reference. The solutions presented here will be of great interest for real-time applications because earth-bound laboratories are inertial only in approximation. The motivation behind this is that real life applications include accelerating and rotating frames with arbitrary orientations more often than the idealized case of inertial frames. The book is divided into three main sections: the first deals with the theory of dynamics, while the second section deals with the application of theory to the derivation of the relativistic fictitious forces (Coriolis, centrifugal and Euler) occurring in a rotating frame and D'Alembert for a linearly accelerated frame. The third section deals with the Thomas Wigner effect. This is the first book on the subject and it will be of great interest for physics students, physics professors, and engineers.

Exact Space-Times in Einstein's General Relativity The Measurement of GravitomagnetismA Challenging Enterprise

This text provides a quantitative introduction to general relativity for advanced undergraduate and graduate students.

Issues in General Physics Research: 2011 Edition Cambridge University Press

This volume presents leading-edge research in physics from researchers around the world.

Fundamentals of Astronomy Infinite Study

Physics underlies all complexity, including our own existence: how is this possible? How can our own lives emerge from interactions of electrons, protons, and neutrons? This book considers the interaction of physical and non-physical causation in complex systems such as living beings, and in particular in the human brain, relating this to the emergence of higher levels of complexity with real causal powers. In particular it explores the idea of top-down causation, which is the key effect allowing the emergence of true complexity and also enables the causal efficacy of non-physical entities, including the value of money, social conventions, and ethical choices.

Theory and Experiment IOP Publishing Limited

This book is intended to give an updated overview on the state-of-the art of the theoretical and experimental efforts aimed to detect the elusive Lense-Thirring effect in the gravitational field of the Earth. The reader, after a robust introduction to the historical (Chapter 2) and theoretical (Chapters 3-5) aspects of the subject, will get acquainted with the subtleties required to design suitable observables which are able to sufficiently enhance the signal-to-noise ratio. Moreover, he/she should be able to follow autonomously the exciting developments which, hopefully, will take place in the near future if and when reliable few percent tests of this prediction of general relativity should become available. In an Earth-space based experiment with artificial satellites a good compromise between the need of reducing the impact of the systematic errors of gravitational origin and of non-gravitational origin must be obtained; this is not an easy task because such requirements are often in conflict one with each other. Consequently, a great attention is paid to elucidate many classical perturbing effects which, if not carefully modelled and accounted for in the data analysis, may alias the recovery of the gravitomagnetic signature. Indeed, we are dealing with a fundamental test of general relativity which must be honest, robust and based on solid error analysis. A critical and detailed discussion of the latest test with the LAGEOS satellites is included. The book will also be useful for better understanding the interplay among various geodetic, geophysical, general relativistic, astronomical and matter-wave interferometric effects which occurs in the weak-field and slow-motion approximation and which will become increasingly important in the near future thanks to the improvements in the accuracy of the orbital reconstruction process.

Exploration of Relativistic Gravity in Space Nova Publishers

Even if the subject is a long-standing one, this is the first monograph on this field. On the one hand, this book is intended to give a rather wide review on this field, both in a historical and pedagogical perspective; on the other hand, it aims at critically re-examining and discussing the most controversial issues. For instance, according to some authors the celebrated Sagnac effect is a disproval of the theory of relativity applied to rotating frames; according to others, it is an astonishing experimental evidence of the relativistic theory. In order to give the reader a deeper insight into this research field, the contributing authors discuss their opinions on the main subjects in an enthralling virtual round table: in this way, the reader can get a direct comparison of the various viewpoints on the most controversial and interesting topics. This is particularly expedient, since the differences in the various approaches are often based upon subtleties that can be understood only by a direct comparison of the underlying hypotheses.

Thermal Quantum Field Theory Springer

Progress in Physics has been created for publications on advanced studies in theoretical and experimental physics, including related themes from mathematics.

The Measurement of Gravitomagnetism Bentham Science Publishers

Einstein's standard and battle-tested geometric theory of gravity--spacetime tells mass how to move and mass tells spacetime how to curve--is expounded in this book by Ignazio Ciufolini and John Wheeler. They give special attention to the theory's observational checks and to two of its consequences: the predicted existence of gravitomagnetism and the origin of inertia (local inertial frames) in Einstein's general relativity: inertia here arises from mass there. The authors explain the modern understanding of the link between gravitation and inertia in Einstein's theory, from the origin of inertia in some cosmological models of the universe, to the interpretation of the initial value formulation of Einstein's standard geometrodynamics; and from the devices and the methods used to determine the local inertial frames of reference, to the experiments used to detect and measure the "dragging of inertial frames of reference." In this book, Ciufolini and Wheeler emphasize present, past, and proposed tests of gravitational interaction, metric theories, and general relativity. They describe the numerous confirmations of the foundations of geometrodynamics and some proposed experiments, including space missions, to test some of its fundamental predictions--in particular gravitomagnetic field or "dragging of inertial frames" and gravitational waves.

Nonlocal Gravity World Scientific

For readers of Sean Carroll, Brian Greene, Katie Mack, and anyone who wants to know what theoretical physicists actually do. This Way to the Universe is a celebration of the astounding, ongoing scientific investigations that have revealed the nature of reality at its smallest, at its largest, and at the scale of our daily lives. The enigmas that Professor Michael Dine discusses are like landmarks on a fantastic journey to the edge of the universe. Asked where to find out about the Big Bang, Dark Matter, the Higgs boson particle—the long cutting edge of physics right now—Dine had no single book he could recommend. This is his accessible, authoritative, and up-to-date answer. Comprehensible to anyone with a high-school level education, with almost no equations, there is no better author to take you on this amazing odyssey. Dine is widely recognized as having made profound contributions to our understanding of matter, time, the Big Bang, and even what might have come before it. This Way to the Universe touches on many emotional, critical points in his extraordinary carreer while presenting mind-bending physics like his answer to the Dark Matter and Dark Energy mysteries as well as the ideas that explain why our universe consists of something rather than nothing. People assume String Theory can never be tested, but Dine intrepidly explores exactly how the theory might be tested experimentally, as well as the pitfalls of falling in love with math. This book reflects a lifetime pursuing the deepest mysteries of reality, by one of the most humble and warmly engaging voices you will ever read.

General Relativity Research Trends Oxford University Press

With a focus on modified gravity this book presents a review of the recent developments in the fields of gravity and cosmology, presenting the state of the art, high-lighting the open problems, and outlining the directions of future research. General Relativity and the ΛCDM framework are currently the standard lore and constitute the concordance paradigm of cosmology. Nevertheless, long-standing open theoretical issues, as well as possible new observational ones arising from the explosive development of cosmology in the last two decades, offer the motivation and lead a large amount of research to be devoted in constructing various extensions and modifications. In this review all extended theories and scenarios are first examined under the light of theoretical consistency, and are then applied in various geometrical backgrounds, such as the cosmological and the spherical symmetric ones. Their predictions at both the background and perturbation levels, and concerning cosmology at early, intermediate and late times, are then confronted with the huge amount of observational data that astrophysics and cosmology has been able to offer in the last two decades. Theories, scenarios and models that successfully and efficiently pass the above steps are classified as viable and are candidates for the description of Nature, allowing readers to get a clear overview of the state of the art and where the field of modified gravity is likely to go. This work was performed in the framework of the COST European Action “Cosmology and Astrophysics Network for Theoretical Advances and Training Actions” - CANTATA.

Fundamentals of Astronomy Princeton University Press

Relativity theory is based on a postulate of locality, which means that the past history of the observer is not directly taken into account. This book argues that the past history should be taken into account. In this way, nonlocality---in the sense of history dependence---is introduced into relativity theory. The deep connection between inertia and gravitation suggests that gravity could be nonlocal, and in nonlocal gravity the fading gravitational memory of past events must then be taken into account. Along this line of thought, a classical nonlocal generalization of Einstein's theory of gravitation has recently been developed. A significant consequence of this theory is that the nonlocal aspect of gravity appears to simulate dark matter. According to nonlocal gravity theory, what astronomers attribute to dark matter should instead be due to the nonlocality of gravitation. Nonlocality dominates on the scale of galaxies and beyond. Memory fades with time; therefore, the nonlocal aspect of gravity becomes weaker as the universe expands. The implications of nonlocal gravity are explored in this book for gravitational lensing, gravitational radiation, the gravitational physics of the Solar System and the internal dynamics of nearby galaxies, as well as clusters of galaxies. This approach is extended to nonlocal Newtonian cosmology, where the attraction of gravity fades with the expansion of the universe. Thus far, scientists have only compared some of the consequences of nonlocal gravity with astronomical observations.

Selected Essays in Honour of Jürgen Ehlers Springer Science & Business Media
Space-based laboratory research in fundamental physics is an emerging research discipline that offers great discovery potential and at the same time could drive the development of technological advances which are likely to be important to scientists and technologists in many other different research fields. The articles in this review volume have been contributed by participants of the international workshop "From Quantum to Cosmos : Fundamental Physics Research in Space" held at the Airlie Center in Warrenton, Virginia, USA, on May 21-24, 2006. This unique volume discusses the advances in our understanding of fundamental physics that are anticipated in the near future, and evaluates the discovery potential of a number of recently proposed space-based gravitational experiments. Specific research areas covered include various tests of general relativity and alternative theories, search of physics beyond the Standard Model, investigations of possible violations of the equivalence principle, search for new hypothetical long- and short-range forces, variations of fundamental constants, tests of Lorentz invariance and attempts at unification of the fundamental interactions. The book also encompasses experiments aimed at the discovery of novel phenomena, including dark matter candidates, and studies of dark energy.
The Journal on Advanced Studies in Theoretical and Experimental Physics, including Related Themes from Mathematics Cambridge Scholars Publishing
This book focuses on the phenomena of inertia and gravitation, one objective being to shed some new light on the basic laws of gravitational interaction and the fundamental nature and structures of spacetime. Chapter 1 is devoted to an extensive, partly new analysis of the law of inertia. The underlying mathematical and geometrical structure of Newtonian spacetime is presented from a four-dimensional point of view, and some historical difficulties and controversies - in particular the concepts of free particles and straight lines - are critically analyzed, while connections to projective geometry are also explored. The relativistic extensions of the law of gravitation and its intriguing consequences are studied in Chapter 2. This is achieved, following the works of Weyl, Ehlers, Pirani and Schild, by adopting a point of view of the combined conformal and projective structure of spacetime. Specifically, Mach’s fundamental critique of Newton’s concepts of ‘absolute space’ and ‘absolute time’ was a decisive motivation for Einstein’s development of general relativity, and his equivalence principle provided a new perspective on inertia. In Chapter 3 the very special mathematical structure of Einstein’s field equations is analyzed, and some of their remarkable physical predictions are presented. By analyzing different types of dragging phenomena, Chapter 4 reviews to what extent the equivalence principle is realized in general relativity - a question intimately connected to the ‘new force’ of gravitomagnetism, which was theoretically predicted by Einstein and Thirring but which was only recently experimentally confirmed and is thus of current interest.
Progress in Physics, vol. 3/2008 CRC Press
Many new tests of gravity and, in particular, of Einstein's general relativity theory will be carried out in the near future: The Lense--Thirring effect and the equivalence principle will be tested in space; moreover, gravitational waves will be detected, and new atomic interferometers and clocks will be built for measurements in gravitational and inertial fields. New high-precision devices have made these experiments feasible. They will contribute to a better understanding of gravitational physics. Both experimental developments and the theoretical concepts are collected in this volume. Exhaustive reviews give an overall insight into the subject of experimental gravitation.
This Way to the Universe Princeton University Press
Providing a broad overview of foundational concepts, Fundamentals of Astronomy covers topics ranging from spherical astronomy to celestial mechanics, closing with two chapters that discuss elements of astronomical photometry and spectroscopy. Supplementary and explanatory notes at the end of each chapter provide references to material published in scientific journals, and solved and unsolved exercises allow students to review their understanding of the material. Broad in coverage, the book presents arguments from classical astronomy, such as spherical astronomy, that form the foundation for future work in the field. Features
The Journal on Advanced Studies in Theoretical and Experimental Physics, including Related Themes from Mathematics Springer Science & Business Media
Gradiometry is a multidisciplinary area that combines theoretical and applied physics, ultra-low noise electronics, precision engineering, and advanced signal processing. Applications include the search for oil, gas, and mineral resources, GPS-free navigation, defence, space missions, and medical research. This book provides readers with a comprehensive and updated overview of the history, applications, and current developments in relation to some of the most advanced technologies in the 21st Century, especially regarding future challenges in natural resource exploration in the changing energy supply environment and a post COVID world. This new edition incorporates the most important new directions bringing fresh ideas into the field, including quantum or quantum-enabled sensing and miniaturization of the operational environment in which gradiometers should function. Key Features Reviews all sensor technologies for gravity gradiometry. The first book to include a breakdown of quantum sensing for gravity gradiometry. Includes applications in natural resource exploration, defence industry, archaeology, environmental science, GPS free navigation and medical research. Reviews current themes and direction of research, as well as industrial landscape and applications. Interdisciplinary readership - for technologists developing systems and practitioners using systems in the field.

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