Gravitoelectromagnetism A Brief Review

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The Measurement of Gravitomagnetism Nova Publishers
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.
Relativistic Physics in Rotating Reference Frames Bentham Science Publishers
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.
Quantum Theory and Symmetries Peeter Joot
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.

Proceedings of the XXIII Spanish Relativity Meeting on Reference Frames and Gravitomagnetism Nova Publishers

Spacetime physics -- Physics in flat spacetime -- The mathematics of curved spacetime -- Einstein's geometric theory of gravity -- Relativistic stars -- The universe -- Gravitational collapse and black holes -- Gravitational waves -- Experimental tests of general relativity -- Frontiers

Progress in Physics, vol. 3/2009 World Scientific

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.

Inertia and Gravitation ScholarlyEditions

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.

How Can Physics Underlie the Mind? Oxford University Press

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.

Selected Essays in Honour of Jürgen Ehlers Infinite Study

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.

From Quantum to Cosmos IOP Publishing Limited

Relativity Reexamined examines relativity from a new angle and with an unconventional perspective. Topics covered range from quantum theory and relativity to gravitation and relativity quantized atomic clocks, as well as special relativity Doppler effect and spherical symmetry. A distinction is also made between mathematical coordinates and physical frames of reference. This book is comprised of eight chapters and begins by considering the development of scientific theories in general, citing examples to show how scientists' viewpoints have progressively changed. Some of the problems that have emerged, and which even Albert Einstein was unable to foresee, are highlighted. The first chapter reviews the historical sequence of events that led to quantum theory and relativity, while the second chapter focuses on some problems about restricted relativity, paying particular attention to the meaning of potential energy and the importance of field theory in relativistic theories. The following chapters analyze a variety of experimental evidences that challenge many basic assumptions in theoretical physics, focusing on the fundamental importance of the Mössbauer effect and of atomic clocks; the link between gravitation and relativity; classical problems of theoretical mechanics; and special relativity Doppler effect. A gravistatic problem with spherical symmetry is also described. This monograph will be of interest to physicists and students of physics.

Fundamental Physics Research in Space The Measurement of GravitomagnetismA Challenging Enterprise

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.

Relativity Reexamined Springer Nature

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:

Reference Frames and Gravitomagnetism World Scientific

This book introduces the general theory of relativity and includes applications to cosmology. The book provides a thorough introduction to tensor calculus and curved manifolds. After the necessary mathematical tools are introduced, the authors offer a thorough presentation of the theory of relativity. Also included are some advanced topics not previously covered by textbooks, including Kaluza-Klein theory, Israel's formalism and branes. Anisotropic cosmological models are also included. The book contains a large number of new exercises and examples, each with separate headings. The reader will benefit from an updated introduction to general relativity including the most recent developments in cosmology.

A Challenging Enterprise World Scientific

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.

The Journal on Advanced Studies in Theoretical and Experimental Physics, including Related Themes from Mathematics Cambridge University Press

The Measurement of GravitomagnetismA Challenging EnterpriseNova Publishers

Exploration of Relativistic Gravity in Space Infinite Study

This book provides an authoritative overview of the developments in gravitomagnetism which have taken place in the last few years. In particular, experiments for measuring the Lense-Thirring effect with satellites orbiting the Earth are reviewed, and an updated list of references on

gravitomagnetism is included. The book also presents diverse research in general relativity and cosmology. It will be of interest to graduate students and researchers in cosmology, astrophysics, astronomy, relativity and applied mathematics. Contents:Spacetime Splitting Techniques and Gravitoelectromagnetism in General Relativity (D Bini & R T Jantzen)Black Hole Astrophysics: Gravitomagnetism and Non Keplerian Orbits (F de Felice)Gravitoelectromagnetism (B Mashhoon)Properties of Bel Currents (R Lazkoz et al.)On Cyclically Symmetrical Spacetimes (A Barnes)Scalar Field Cosmologies (J Carot & M M Collinge)Ideas Gas Stephani Universes (B Coll & J J Ferrando)Comments on Purely Electric Weyl Tensors (J J Ferrando & J A Sáez)Advance of Mercury Perihelion Explained by Cogravity (C J de Matos & M Tajmar)The Intrinsic Structure of the Petrov Classification (J M Pozo & J M Parra)and other papers Readership: Graduate students and researchers in physics, astronomy and applied mathematics. Keywords:

One Hundred Years Of General Relativity: From Genesis And Empirical Foundations To Gravitational Waves, Cosmology And Quantum Gravity - Volume 1 World Scientific

This classic text and reference monograph applies modern differential geometry to general relativity. A brief mathematical introduction to gravitational curvature, it emphasizes the subject's geometric essence and stresses the global aspects of cosmology. Suitable for independent study as well as for courses in differential geometry, relativity, and cosmology. 1979 edition.

Exploring physics with Geometric Algebra Springer Nature

General Relativity Research Trends

Einstein’s Field Equations and Their Physical Implications Nova Publishers

Einstein's theory of general relativity is a theory of gravity and, as in the earlier Newtonian theory, much can be learnt about the character of gravitation and its effects by investigating particular idealised examples. This book describes the basic solutions of Einstein's equations with a particular emphasis on what they mean, both geometrically and physically. Concepts such as big bang and big crunch-types of singularities, different kinds of horizons and gravitational waves, are described in the context of the particular space-times in which they naturally arise. These notions are initially introduced using the most simple and symmetric cases. Various important coordinate forms of each solution are presented, thus enabling the global structure of the corresponding space-time and its other properties to be analysed. The book is an invaluable resource both for graduate students and academic researchers working in gravitational physics.

Fundamentals of Astronomy Cambridge University Press

Space-time in a vacuum has generally been viewed as a transparent and ubiquitous empty continuum within which physical events take place. However quantum field theory and quantum electrodynamics views the vacuum as the sum total of all zero-point fluctuations of the vacuum electromagnetic field, arising from the continuous creation and annihilation of virtual particle pairs. It is this latter more contemporary view that is, for the first time, more fully explored in text form with Physics of the Zero Point Field. The scope of applications in this book range from the Casimir effect, the variation in zero-point energy at the boundaries of a region observable in nano-scale devices, to ideas for a proposed inertial drive as first described by Puthoff.

Gravity, Magnetic and Electromagnetic Gradiometry CRC Press

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