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100 Years of Chr

onogeometrodynamics: The Status of the Einstein's Theory of Gravitation in Its Centennial Year Cambridge University Press The theory of quantum fields on curved spacetimes has attracted great attention since the discovery, by

Stephen Hawking, of black-hole evaporation. It remains an important subject for the understanding of such contemporary topics as inflationary cosmology, quantum gravity and superstring theory. This book provides, for mathematicians, an introduction to this field of physics in a language and from a viewpoint which such a reader should find congenial. Physicists should also gain from reading this book a sound grasp of various aspects of the theory, some of which have not been particularly emphasised in the existing review literature. The topics covered include normal-mode expansions for a general elliptic operator, Fock space, the Casimir effect, the 'Klein' paradox, particle definition and particle creation in expanding universes, asymptotic expansion of Green's functions and heat kernels, and renormalisation of the stress tensor. The style is pedagogic rather than formal; some knowledge of general relativity and differential geometry is assumed, but the author does supply background material on functional analysis and quantum field theory as required. The book arose from a course taught to graduate students and could be used for self-study or for advanced courses in relativity and quantum field theory.

Unity from Duality: Gravity, Gauge Theory and Strings

Springer

This book tells the

story of how, over the past century, dedicated observers and pioneering scientists achieved our current understanding of the universe. It was in antiquity that humankind first attempted to explain the universe often with the help of myths and legends. This book, however, focuses on the time when cosmology finally became a true science. As the reader will learn, this was a slow process, extending over a large part of the 20th century and involving many astronomers, cosmologists and theoretical physicists. The book explains how empirical astronomical data (e.g., Leavitt, Slipher and Hubble) were reconciled with Einstein's general relativity; a challenge which finally led Friedmann, De Sitter and Lemaître, and eventually Einstein himself, to a consistent understanding of the observational results. The reader will realize the extraordinary implications of these achievements and how deeply they changed our vision of the cosmos: From being small, static, immutable and eternal, it became vast and dynamical - originating from (almost) nothing, and yet now, nearly 14 billion years later, undergoing accelerated expansion. But, as always happens, as well as precious knowledge, new mysteries have also been created where previously absolute certainty had reigned.

Understanding the Quantum World through Mathematical Innovation

ScholarlyEditions

The aim of this book

is to give graduate students an overview of quantum gravity but it also covers related topics from astrophysics. Some well-written contributions can serve as an introduction into basic conceptual concepts like time in quantum gravity or the emergence of a classical world from quantum cosmology. This makes the volume attractive to philosophers of science, too. Other topics are black holes, gravitational waves and non-commutative extensions of physical theories.

Progress in String, Field and Particle Theory Cambridge University Press This book overviews the extensive literature on apparent cosmological and black hole horizons. In theoretical gravity, dynamical situations such as gravitational collapse, black hole evaporation, and black holes interacting with non-trivial environments, as well as the attempts to model gravitational waves occurring in highly dynamical astrophysical processes, require that the concept of event horizon be generalized. Inequivalent notions of horizon abound in the technical literature and are discussed in this manuscript. The book begins with a quick review of basic material in the first one and a half chapters, establishing a unified notation. Chapter 2 reminds the reader of the basic tools used in the analysis of horizons and reviews the various definitions of horizons appearing in the literature. Cosmological horizons are the playground in which one should take baby steps in understanding horizon physics. Chapter 3 analyzes cosmological

horizons, their proposed thermodynamics, and several coordinate systems. The remaining chapters discuss analytical solutions of the field equations of General Relativity, scalar-tensor, and f(R) gravity which exhibit time-varying apparent horizons and horizons which appear and/or disappear in pairs. An extensive bibliography enriches the volume. The intended audience is master and PhD level students and researchers in theoretical physics with knowledge of standard gravity.

Time Complexity, Inferential Uncertainty, and Spacekime Analytics

Springer

This book explains and develops the Dirac equation in the context of general relativistic quantum mechanics in a range of spacetime dimensions. It clarifies the subject by carefully pointing out the various conventions used and explaining how they are related to each other. The prerequisites are familiarity with general relativity and an exposure to the Dirac equation at the level of special relativistic quantum mechanics, but a review of this latter topic is given in the first chapter as a reference and framework for the physical interpretations that follow. Worked examples and exercises with solutions are provided. Appendices include reviews of topics used in the body of the text. This book should benefit researchers and graduate students in general relativity and in condensed matter.

Real and

Complex Singularities Springer
Exploring common themes in modern art, mathematics, and science, including the concept of space, the notion of randomness, and the shape of the cosmos. This is a book about art—and a book about mathematics and physics. In Lumen Naturae (the title refers to a purely immanent, non-supernatural form of enlightenment), mathematical physicist Matilde Marcolli explores common themes in modern art and modern science—the concept of space, the notion of randomness, the shape of the cosmos, and other puzzles of the universe—while mapping convergences with the work of such artists as Paul Cezanne, Mark Rothko, Sol LeWitt, and Lee Krasner. Her account, focusing on questions she has investigated in her own scientific work, is illustrated by more than two hundred color images of artworks by modern and contemporary artists. Thus Marcolli finds in still life paintings broad and deep philosophical reflections on space and time, and connects notions of space in mathematics to works by Paul Klee, Salvador Dal í , and others. She considers the relation of entropy and art and how notions of entropy have been expressed by such artists as Hans Arp and Fernand L é ger; and traces the evolution of

randomness as a mode of artistic expression. She analyzes the relation between graphical illustration and scientific text, and offers her own watercolor-decorated mathematical notebooks. Throughout, she balances discussions of science with explorations of art, using one to inform the other. (She employs some formal notation, which can easily be skipped by general readers.) Marcolli is not simply explaining art to scientists and science to artists; she charts unexpected inter dependencies that illuminate the universe.

String Theory Compactifications American Mathematical Soc.

The amount of new information is constantly increasing, faster than our ability to fully interpret and utilize it to improve human experiences. Addressing this asymmetry requires novel and revolutionary scientific methods and effective human and artificial intelligence interfaces. By lifting the concept of time from a positive real number to a 2D complex time (kime), this book uncovers a connection between artificial intelligence (AI), data science, and quantum mechanics. It proposes a new mathematical foundation for

data science based on raising the 4D spacetime to a higher dimension where longitudinal data (e.g., time-series) are represented as manifolds (e.g., kime-surfaces). This new framework enables the development of innovative data science analytical methods for model-based and model-free scientific inference, derived computed phenotyping, and statistical forecasting. The book provides a tran sdisciplinary bridge and a pragmatic mechanism to translate quantum mechanical principles, such as particles and wavefunctions, into data science concepts, such as datum and in ference-functions. It includes many open mathematical problems that still need to be solved, technological challenges that need to be tackled, and computational statistics algorithms that have to be fully developed and validated. Spacekime analytics provide mechanisms to effectively handle, process, and interpret large, heterogeneous, and continuousl y-tracked digital information from multiple sources. The authors propose computational methods, probability

model-based techniques, and analytical strategies to estimate, approximate, or simulate the complex time phases (kime directions). This allows transforming time-varying data, such as time-series observations, into higher-dimensional manifolds representing complex-valued and kime-indexed surfaces (kime-surfaces). The book includes many illustrations of model-based and model-free spacekime analytic techniques applied to economic forecasting, identification of functional brain activation, and high-dimensional cohort phenotyping. Specific case-study examples include unsupervised clustering using the Michigan Consumer Sentiment Index (MCSI), model-based inference using functional magnetic resonance imaging (fMRI) data, and model-free inference using the UK Biobank data archive. The material includes mathematical, inferential, computational, and philosophical topics such as Heisenberg uncertainty principle and alternative approaches to large sample theory, where a few spacetime observations can be amplified by a series of derived,

estimated, or simulated kime-phases. The authors extend Newton-Leibniz calculus of integration and differentiation to the spacekime manifold and discuss possible solutions to some of the "problems of time". The coverage also includes 5D spacekime formulations of classical 4D spacetime mathematical equations describing natural laws of physics, as well as, statistical articulation of spacekime analytics in a Bayesian inference framework. The steady increase of the volume and complexity of observed and recorded digital information drives the urgent need to develop novel data analytical strategies. Spacekime analytics represents one new data-analytic approach, which provides a mechanism to understand compound phenomena that are observed as multiplex longitudinal processes and computationally tracked by proxy measures. This book may be of interest to academic scholars, graduate students, postdoctoral fellows, artificial intelligence and machine learning engineers, biostatisticians, econometricians, and data analysts. Some of the material

may also resonate with philosophers, futurists, astrophysicists, space industry technicians, biomedical researchers, health practitioners, and the general public.

Proceedings of the XXXV International Winter School on Theoretical Physics Held in Polanica, Poland, 2 – 11 February 1999 Springer Nature

This thesis focuses on the recent firewall controversy surrounding evaporating black holes, and shows that in the best understood example concerning electrically charged black holes with a flat event horizon in anti-de Sitter (AdS) spacetime, the firewall does not arise. The firewall, which surrounds a sufficiently old black hole, threatens to develop into a huge crisis since it could occur even when spacetime curvature is small, which contradicts general relativity. However, the end state for asymptotically flat black holes is ill-understood since their curvature becomes unbounded. This issue is avoided by working with flat charged black holes in AdS. The presence of electrical charge is crucial since black holes inevitably pick up charges throughout their long lifetime. These black holes always evolve toward extremal limit, and are then destroyed by quantum gravitational effects. This happens sooner than the time required to decode Hawking radiation so that the firewall never sets in, as conjectured by Harlow and Hayden. Motivated by the information loss paradox, the

author also investigates the possibility that " monster " configurations might exist, with an arbitrarily large interior bounded by a finite surface area. Investigating such an object in AdS shows that in the best understood case, such an object -- much like a firewall -- cannot exist.

In Quantum and Classical Physics

American Mathematical Soc.

This book contains Thirring's scientific contributions to mathematical physics, statistical physics, general relativity, quantum field theory and elementary particle theory from 1950 onward. The order of the papers within the various sections is chronological and reflects the development of the fields during the second half of this century. In some cases, Thirring returned to problems decades later when the tools for their solution had ripened. Each section contains introductory comments by Thirring, outlining his motivation for the work at that time. Features: A complete proof of the divergence of the renormalized perturbation theory in a relativistic quantum field theory and a proof of the divergence of a similar theory A proof of the

stability of matter An analysis of a dynamical system with negative specific heat A generalization of the dynamical entropy to quantum dynamical systems

De Sitter Projective Relativity Springer

This is a book about physics, written for mathematicians. The readers we have in mind can be roughly described as those who: I. are mathematics graduate students with some knowledge of global differential geometry 2. have had the equivalent of freshman physics, and find popular accounts of astrophysics and cosmology interesting 3. appreciate mathematical elarity, but are willing to accept physical motiva tions for the mathematics in place of mathematical ones 4. are willing to spend time and effort mastering certain technical details, such as those in Section 1. 1. Each book disappoints so me readers. This one will disappoint: 1. physicists who want to use this book as a first course on differential geometry 2. mathematicians who think Lorentzian manifolds are wholly similar to Riemannian ones, or that, given a sufficiently good mathematical back ground, the essentials of a subject !ike cosmology can be learned without so me hard work on boring detaiis 3. those who believe vague

philosophical arguments have more than historical and heuristic significance, that general relativity should somehow be "proved," or that axiomatization of this subject is useful 4. those who want an encyclopedic treatment (the books by Hawking-Ellis [1], Penrose [1], Weinberg [1], and Misner-Thorne-Wheeler [I] go further into the subject than we do; see also the survey article, Sachs-Wu [1]). 5. mathematicians who want to learn quantum physics or unified fieId theory (unfortunateIy, quantum physics texts all seem either to be for physicists, or merely concerned with formaI mathematics).

From Einstein to Black Holes ScholarlyEditions

The contributions to this volume of the famous summer school in Les Houches cover the recent developments in supersymmetric string theory, the gauge theory/string theory correspondence and string duality. The book is a comprehensive introduction to the recent developments in string/M-theory and quantum gravity.

Les Houches Session LXXVI, July 30 - August 31, 2001 Springer

Issues in Astronomy and Astrophysics / 2013 Edition is a ScholarlyEditions™ book that delivers timely,

authoritative, and comprehensive information about Planetary Science. The editors have built Issues in Astronomy and Astrophysics: 2013 Edition on the vast information databases of ScholarlyNews.™ You can expect the information about Planetary Science in this book to be deeper than what you can access anywhere else, as well as consistently reliable, authoritative, informed, and relevant. The content of Issues in Astronomy and Astrophysics: 2013 Edition has been produced by the world ' s leading scientists, engineers, analysts, research institutions, and companies. All of the content is from peer-reviewed sources, and all of it is written, assembled, and edited by the editors at ScholarlyEditions™ and available exclusively from us. You now have a source you can cite with authority, confidence, and credibility. More information is available at http://www.ScholarlyEditions.com/.

Springer Handbook of Spacetime

Birkh ä user

Einstein's Special Relativity (E-SR) is the cornerstone of physics. De Sitter invariant SR (dS/AdS-SR) is a natural extension of E-

SR, hence it relates to the foundation of physics. This book provides a description to dS/AdS-SR in terms of Lagrangian-Hamiltonian formulation associated with spacetime metric of inertial reference frames. One of the outstanding features of the book is as follows: All discussions on SR are in the inertial reference frames. This is a requirement due to the first principle of SR theory. The descriptions on dS/AdS-SR in this book satisfy this principle. For the curved spacetime in dS/AdS-SR theory, it is highly non-trivial. Contents:General IntroductionOverview of Einstein's Special Relativity (E-SR)De Sitter Invariant Special RelativityDe Sitter Invariant General RelativityDynamics of Expansion of the Universe in General RelativityRelativistic Quantum Mechanics for de Sitter Invariant Special RelativityDistant Hydrogen Atom in CosmologyTemporal and Spatial Variation of the Fine Structure ConstantDe Sitter Invariance of Generally Covariant Dirac Equation Readership: Students and professionals who are interested in de Sitter and anti-de Sitter invariant Special

Relativity. Key Features:This is the first book to describe dS/AdS-SR systematically and comprehensivelyThe crucial contributions to dS/AdS-SR due to Lu – Zou – Guo's work (1970's) are interpreted in detail in this book. The conceptions of dS/AdS-SR Mechanics, dS/AdS-SR Quantum Mechanics, dS/AdS-SR General Relativity, and effects of dS/AdS-SR Cosmology are introduced in the book. In the descriptions, many techniques are involvedThe author, Professor Mu-Lin Yan, is an expert in SR, GR, Black Hole Physics, and Particle Physics. He is one of the discoverers of Nieh – Yan topological identity (1982), High genus solution of Yang – Baxter equation of chiral Potts model (1987), and some unusual hadron's states (2005). He also has contributions to the calculations of entropies of black holes, and to the studies of non-perturbative QCDKeywords:De Sitter Invariant Special Relativity;Special Relativity;De Sitter Group

The True Story of Modern Cosmology

Springer Science & Business Media

Scattering resonances generalize bound states/eigenvalues for systems in

which energy can scatter to infinity. A typical resonance has a rate of oscillation (just as a bound state does) and a rate of decay. Although the notion is intrinsically dynamical, an elegant mathematical formulation comes from considering meromorphic continuations of Green's functions. The poles of these meromorphic continuations capture physical information by identifying the rate of oscillation with the real part of a pole and the rate of decay with its imaginary part. An example from mathematics is given by the zeros of the Riemann zeta function: they are, essentially, the resonances of the Laplacian on the modular surface. The Riemann hypothesis then states that the decay rates for the modular surface are all either or . An example from physics is given by quasi-normal modes of black holes which appear in long-time asymptotics of gravitational waves. This book concentrates mostly on the simplest case of scattering by compactly supported potentials but provides pointers to modern literature where more general cases are studied. It also presents a recent approach to the study of resonances on asymptotically hyperbolic manifolds. The last two chapters are devoted to semiclassical methods in the

study of resonances.

Towards Quantum Gravity

Princeton University Press

Southern Illinois University at Carbondale undertook to honor Albert Einstein as scientist and as humanitarian in commemo ration of his lOOth birthday during an "Albert Einstein Centennial Week", February 23 - March 2, 1979. During the course of this week two Symposia were held, entitled "Symmetries in Science" and "Einstein: Humanities Conscience", in addition to cultural and social activities honoring Einstein. This volume presents the Symposium "Symmetries in Science". It reflects the outstanding response that was given to our "Albert Einstein Centennial Week" by the international community of scientists. The motivation to have a celebration honoring Albert Einstein at Southern Illinois University at Carbondale was supplied by Dr. Paul A. Schilpp, the editor of the "Library of Living Philo sophers". Albert Einstein has contributed to this series with his autobiographical notes, a kind of autobiography of his scientific life, in a volume entitled "Einstein: Scient ist-Philosopher", the most popular among all the outstanding volumes of this series. Dr. Paul A. Schilpp's presence at Southern Illinois University at Carbondale

provided a natural link for an Einstein Celebration as a kind of a continuation of the contribution he made to mankind through the Einstein volume of his "Library of Living Philosophers".

Holographic Quantum Matter OUP Oxford

This book, dedicated to Roger Penrose, is a second, mathematically oriented course in general relativity. It contains extensive references and occasional excursions in the history and philosophy of gravity, including a relatively lengthy historical introduction. The book is intended for all students of general relativity of any age and orientation who have a background including at least first courses in special and general relativity, differential geometry, and topology. The material is developed in such a way that through the last two chapters the reader may acquire a taste of the modern mathematical study of black holes initiated by Penrose, Hawking, and others, as further influenced by the initial-value or PDE approach to general relativity. Successful readers might be able to begin reading research papers on black holes, especially in mathematical physics and in the philosophy of physics. The chapters are: Historical introduction, General differential geometry, Metric differential geometry, Curvature, Geodesics and causal structure, The singularity theorems of Hawking and Penrose, The Einstein equations, The 3+1 split of space-time, Black holes

I: Exact solutions, and Black holes II: General theory. These are followed by two appendices containing background on Lie groups, Lie algebras, & constant curvature, and on Formal PDE theory.

Aspects of Quantum Field Theory in Curved Spacetime

Cambridge University Press

The NATO Advanced Study Institute and EC Summer School "Progress in String Field and Particle Theory" was held in Cargse from June 25th till July 11th 2002. The main focus of the school was the recent progress in the very ac tive areas of superstring theory, quantum gravity and the theory of elementary particles. It covered topical problems in domains such as duality between gravity and gaug einteractions, string field theory, tachyon condensation, non-commutative field theory, string cosmology and string phenomenology. The School featured daily introductory lectures and topical seminars. An informal Gong Show session allowed young post-doctoral researchers and senior graduate students to make a concise presentation oftheir current work. The School gave an excellent opportunity to the youngest researchers to establish a close relationship with their seniors and with the lecturers. These proceedings will further serve in fixing the

acquired knowledge, and hopefully, become a useful reference for anyone working in this fascinating do main of physics. Some of the contributions provide an elementary introduction to their subject, while other ones are more geared to the specialist. We are deeply indebted to the NATO Division for Scientific Affairs for funding, and for their constant attention for our meetings, and to the European Commission for a High-Level Scientific Conference grant HPCFCT 2001-00298. *GeLoMa 2016, Málaga, Spain, September 20 – 23* Springer This book consists of 16 surveys on Thurston's work and its later development. The authors are mathematicians who were strongly influenced by Thurston's publications and ideas. The subjects discussed include, among others, knot theory, the topology of 3-manifolds, circle packings, complex projective structures, hyperbolic geometry, Kleinian groups, foliations, mapping class groups, Teichmüller theory, anti-de Sitter geometry, and co-Minkowski geometry. The book is addressed to researchers and students who want to learn about Thurston's wide-ranging mathematical ideas and their impact. At the same time, it is a tribute to Thurston, one of the greatest

geometers of all time, whose work extended over many fields in mathematics and who had a unique way of perceiving forms and patterns, and of communicating and writing mathematics.

Issues in Astronomy and Astrophysics: 2013 Edition

MIT Press

No scientific theory has caused more puzzlement and confusion than quantum theory. Physics is supposed to help us to understand the world, but quantum theory makes it seem a very strange place. This book is about how mathematical innovation can help us gain deeper insight into the structure of the physical world. Chapters by top researchers in the mathematical foundations of physics explore new ideas, especially novel mathematical concepts at the cutting edge of future physics. These creative developments in mathematics may catalyze the advances that enable us to understand our current physical theories, especially quantum theory. The authors bring diverse perspectives, unified only by the attempt to introduce fresh concepts that will open up new vistas in our understanding of future physics.

De Sitter Invariant Special Relativity

Radboud University Press

The 2002 Pan-American Advanced Studies Institute School on Quantum Gravity was held at the Centro de Estudios Cientificos (CECS),Valdivia, Chile, January 4-14, 2002. The

school featured lectures by ten speakers, and was attended by nearly 70 students from over 14 countries. A primary goal was to foster interaction and communication between participants from different cultures, both in the layman ' s sense of the term and in terms of approaches to quantum gravity. We hope that the links formed by students and the school will persist throughout their professional lives, continuing to promote interaction and the essential exchange of ideas that drives research forward.

This volume contains improved and updated versions of the lectures given at the School. It has been prepared both as a reminder for the participants, and so that these pedagogical introductions can be made available to others who were unable to attend. We expect them to serve students of all ages well.