Modern Canonical Quantum General Relativity

THOMAS THIEMANN

Modern Canonical Quantum General Relativity Cambridge Monographs On Mathematical Physics

Ali Akil,Cosimo Bambi

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Modern Canonical Quantum General Relativity Thomas Thiemann,2008-11-13 Modern physics rests on two fundamental building blocks general relativity and quantum theory General relativity is a geometric interpretation of gravity while quantum theory governs the microscopic behaviour of matter Since matter is described by quantum theory which in turn couples to geometry we need a quantum theory of gravity In order to construct quantum gravity one must reformulate quantum theory on a background independent way Modern Canonical Quantum General Relativity provides a complete treatise of the canonical quantisation of general relativity The focus is on detailing the conceptual and mathematical framework on describing physical applications and on summarising the status of this programme in its most popular incarnation called loop quantum gravity Mathematical concepts and their relevance to physics are provided within this book which therefore can be read by graduate students with basic knowledge of quantum field theory or general relativity

Quantum Mathematical Physics Felix Finster,Johannes Kleiner,Christian Röken,Jürgen Tolksdorf,2016-02-24 Quantum physics has been highly successful for more than 90 years Nevertheless a rigorous construction of interacting quantum field theory is still missing Moreover it is still unclear how to combine quantum physics and general relativity in a unified physical theory Attacking these challenging problems of contemporary physics requires highly advanced mathematical methods as well as radically new physical concepts This book presents different physical ideas and mathematical approaches in this direction It contains a carefully selected cross section of lectures which took place in autumn 2014 at the sixth conference Quantum Mathematical Physics A Bridge between Mathematics and Physics in Regensburg Germany In the tradition of the other proceedings covering this series of conferences a special feature of this book is the exposition of a wide variety of approaches with the intention to facilitate a comparison The book is mainly addressed to mathematicians and physicists who are interested in fundamental questions of mathematical physics It allows the reader to obtain a broad and up to date overview of a fascinating active research area   **General Relativity, Cosmology and Astrophysics** Jiří Bičák,Tomáš Ledvinka,2014-06-12 The articles included in this Volume represent a broad and highly qualified view on the present state of general relativity quantum gravity and their cosmological and astrophysical implications As such it may serve as a valuable source of knowledge and inspiration for experts in these fields as well as an advanced source of information for young researchers The occasion to gather together so many leading experts in the field was to celebrate the centenary of Einstein s stay in Prague in 1911 1912 It was in fact during his stay in Prague that Einstein started in earnest to develop his ideas about general relativity that fully developed in his paper in 1915 Approaching soon the centenary of his famous paper this volume offers a precious overview of the path done by the scientific community in this intriguing and vibrant field in the last century defining the challenges of the next 100 years The content is divided into four broad parts i Gravity and Prague ii Classical General Relativity iii Cosmology and Quantum Gravity and iv Numerical Relativity and Relativistic Astrophysics   Springer

Handbook of Spacetime Abhay Ashtekar,Vesselin Petkov,2014-09-01 The Springer Handbook of Spacetime is dedicated to the ground breaking paradigm shifts embodied in the two relativity theories and describes in detail the profound reshaping of physical sciences they ushered in It includes in a single volume chapters on foundations on the underlying mathematics on physical and astrophysical implications experimental evidence and cosmological predictions as well as chapters on efforts to unify general relativity and quantum physics The Handbook can be used as a desk reference by researchers in a wide variety of fields not only by specialists in relativity but also by researchers in related areas that either grew out of or are deeply influenced by the two relativity theories cosmology astronomy and astrophysics high energy physics quantum field theory mathematics and philosophy of science It should also serve as a valuable resource for graduate students and young researchers entering these areas and for instructors who teach courseson these subjects The Handbook is divided into six parts Part A Introduction to Spacetime Structure Part B Foundational Issues Part C Spacetime Structure and Mathematics Part D Confronting Relativity theories with observations Part E General relativity and the universe Part F Spacetime beyond Einstein   **Discrete Causal Theory** Benjamin F. Dribus,2017-04-26 This book evaluates and suggests potentially critical improvements to causal set theory one of the best motivated approaches to the outstanding problems of fundamental physics Spacetime structure is of central importance to physics beyond general relativity and the standard model The causal metric hypothesis treats causal relations as the basis of this structure The book develops the consequences of this hypothesis under the assumption of a fundamental scale with smooth spacetime geometry viewed as emergent This approach resembles causal set theory but differs in important ways for example the relative viewpoint emphasizing relations between pairs of events and relationships between pairs of histories is central The book culminates in a dynamical law for quantum spacetime derived via generalized path summation   **Quantum Potential: Physics, Geometry and Algebra** Ignazio Licata,Davide Fiscaletti,2013-11-19 Recently the interest in Bohm realist interpretation of quantum mechanics has grown The important advantage of this approach lies in the possibility to introduce non locality ab initio and not as an unexpected host In this book the authors give a detailed analysis of quantum potential the non locality term and its role in quantum cosmology and information The different approaches to the quantum potential are analysed starting from the original attempt to introduce a realism of particles trajectories influenced by de Broglie s pilot wave to the recent dynamic interpretation provided by Goldstein Durr Tumulka and Zangh and the geometrodynamic picture with suggestion about quantum gravity Finally we focus on the algebraic reading of Hiley and Birkbeck school that analyse the meaning of the non local structure of the world bringing important consequences for the space time and information concepts   **The Quantization of Gravity** Claus Gerhardt,2024-11-05 A unified quantum theory incorporating the four fundamental forces of nature is one of the major open problems in physics The Standard Model combines electro magnetism the strong force and the weak force but ignores gravity The quantization of gravity is therefore a necessary first step to achieve a unified quantum theory In this monograph

a canonical quantization of gravity has been achieved by quantizing a geometric evolution equation resulting in a hyperbolic equation in a fiber bundle where the base space represents a Cauchy hypersurface of the quantized spacetime and the fibers the Riemannian metrics in the base space The hyperbolic operator a second order partial differential operator acts both in the fibers as well as in the base space In this second edition new results are presented which allow the solutions of the hyperbolic equation to be expressed as products of spatial and temporal eigenfunctions of self adjoint operators These eigenfunctions form complete bases in appropriate Hilbert spaces The eigenfunctions depending on the fiber elements are a subset of the Fourier kernel of the symmetric space SL n R SO n where n is the dimension of the base space they represent the elementary gravitons corresponding to the degrees of freedom in choosing the entries of Riemannian metrics with determinants equal to one These are all the degrees of freedom available because of the coordinate system invariance For any smooth Riemannian metric there exists an atlas such that in each chart the determinant of the metric is equal to one In the important case n 3 the Standard Model could also be incorporated such that one can speak of a unified quantization of all four fundamental forces of nature *Beyond Spacetime* Nick Huggett,Keizo Matsubara,Christian Wüthrich,2020-05-14 A collection of essays discussing the philosophy and foundations of quantum gravity Written by leading philosophers and physicists in the field chapters cover the important conceptual questions in the search for a quantum theory of gravity and the current state of understanding among philosophers and physicists *New Ideas Concerning Black Holes and the Universe* Eugene Tatum,2020 The ideas presented in this book are new scientific theories based largely upon a spate of very recent astronomical observations These theories include a cosmological model that appears to be superior in many respects to the inflationary concordance model proposed thermal stability criteria for a generic quantum black hole theoretical constraints concerning black hole binary graviton emissions theoretical effects of abelian vortices on space time and a proposed solution to the mystery of the observed asymmetry between universal matter and antimatter The new ideas presented in this book have been selected in order to inspire others that regardless of the impending limits of observation the scientific creative process will continue <u>Modified Gravity and Cosmology</u> Emmanuel N. Saridakis,Ruth Lazkoz,Vincenzo Salzano,Paulo Vargas Moniz,Salvatore Capozziello,Jose Beltrán Jiménez,Mariafelicia De Laurentis,Gonzalo J. Olmo,2021-12-10 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 CDM 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 **Wilson Lines in Quantum Field Theory** Igor Olegovich Cherednikov,Tom Mertens,Frederik Van der Veken,2019-12-02 The objective of this book is to get the reader acquainted with theoretical and mathematical foundations of the concept of Wilson loops in the context of modern quantum fi eld theory It offers an introduction to calculations with Wilson lines and shows the recent development of the subject in different important areas of research within the historical context *The Black Hole Information Paradox* Ali Akil,Cosimo Bambi,2025-09-30 This book reviews a few different derivations of the Hawking radiation most main solutions to the paradox proposed in the literature and some analog laboratory experiments A black hole is an object whose gravity is so strong that nothing not even light can escape its grasp However applying quantum field theory on a black hole background Stephen Hawking showed that black holes are not completely black In fact they seem to emit a form of radiation that was named the Hawking radiation The Hawking radiation appears to be thermal and in a quantum state that is independent of the initial state that formed the black hole instead it solely depends on the black hole s total mass spin and electric charge A problem arises when we consider an initial system that collapses forms a black hole and eventually the black hole evaporates completely through Hawking radiation Since Hawking radiation depends solely on the black hole s total mass spin and electric charge it implies that numerous distinct initial states could all lead to the same final state Consequently the intricate details of the initial state seem to be lost which contradicts the unitarity of evolution of closed systems a fundamental principle of quantum mechanics The unitarity principle implies that closed systems evolve in a reversible manner such that knowing a system s final state and the way it evolved one can always determine its initial state The many to one evolution of the black hole initial state to radiation evolution is in a clear contradiction with this principle This is the black hole information paradox The black hole information paradox was found in the 1970s by Stephen Hawking Over the past 50 years it has attracted a lot of interest in the theoretical physics community and is still an active research field Chapters are written by leading experts in the field **Approaches to Quantum Gravity** Daniele Oriti,2009-03-05 The theory of quantum gravity promises a revolutionary new understanding of gravity and spacetime valid from microscopic to cosmological distances Research in this field involves an exciting blend of rigorous mathematics and bold speculations foundational questions and technical issues Containing contributions from leading researchers in this field this book presents the

fundamental issues involved in the construction of a quantum theory of gravity and building up a quantum picture of space and time It introduces the most current approaches to this problem and reviews their main achievements Each part ends in questions and answers in which the contributors explore the merits and problems of the various approaches This book provides a complete overview of this field from the frontiers of theoretical physics research for graduate students and researchers **String-Math 2015** Si Li,Bong H. Lian, Wei Song,Shing-Tung Yau,2017-11-28 This volume contains the proceedings of the conference String Math 2015 which was held from December 31 2015 January 4 2016 at Tsinghua Sanya International Mathematics Forum in Sanya China Two of the main themes of this volume are frontier research on Calabi Yau manifolds and mirror symmetry and the development of non perturbative methods in supersymmetric gauge theories The articles present state of the art developments in these topics String theory is a broad subject which has profound connections with broad branches of modern mathematics In the last decades the prosperous interaction built upon the joint efforts from both mathematicians and physicists has given rise to marvelous deep results in supersymmetric gauge theory topological string M theory and duality on the physics side as well as in algebraic geometry differential geometry algebraic topology representation theory and number theory on the mathematics side **Conversations on Quantum Gravity** Jácome Armas,2021-08-26 Leading theorists share their important insights into the ongoing quest of theoretical physics to find a quantum theory of gravity *The Foundations of Spacetime Physics* Antonio Vassallo,2022-09-30 This book provides an up to date overview of the foundations of spacetime physics It features original essays written by world class experts in the physics and philosophy of spacetime The foundational questions regarding the origin and nature of spacetime are branching into new and exciting directions These questions are not restricted to the quantum gravity program but also arise in the context of a well established theory like general relativity Against the background of these quick and diverse developments this volume features a broad range of perspectives on spacetime Part I focuses on the nature of spacetime in non quantum theories such as Newtonian mechanics and relativity Part II explores some intriguing conceptual implications of developing a quantum theory of spacetime The Foundations of Spacetime Physics is an essential resource for scholars and advanced students working in philosophy of physics philosophy of science and scientific metaphysics **Combinatorial Physics** Adrian Tanasa,2021 The goal of the book is to use combinatorial techniques to solve fundamental physics problems and vice versa to use theoretical physics techniques to solve combinatorial problems **Quantum Information and Foundations** Giacomo Mauro D'Ariano,Paolo Perinotti,2020-03-23 Quantum information has dramatically changed information science and technology looking at the quantum nature of the information carrier as a resource for building new information protocols designing radically new communication and computation algorithms and ultra sensitive measurements in metrology with a wealth of applications From a fundamental perspective this new discipline has led us to regard quantum theory itself as a special theory of information and has opened routes for exploring solutions to the tension with general relativity based for

example on the holographic principle on non causal variations of the theory or else on the powerful algorithm of the quantum cellular automaton which has revealed new routes for exploring quantum fields theory both as a new microscopic mechanism on the fundamental side and as a tool for efficient physical quantum simulations for practical purposes In this golden age of foundations an astonishing number of new ideas frameworks and results spawned by the quantum information theory experience have revolutionized the way we think about the subject with a new research community emerging worldwide including scientists from computer science and mathematics   Relativity and Gravitation Jiří Bičák,Tomáš Ledvinka,2014-06-06 In early April 1911 Albert Einstein arrived in Prague to become full professor of theoretical physics at the German part of Charles University It was there for the first time that he concentrated primarily on the problem of gravitation Before he left Prague in July 1912 he had submitted the paper Relativit t und Gravitation Erwiderung auf eine Bemerkung von M Abraham in which he remarkably anticipated what a future theory of gravity should look like At the occasion of the Einstein in Prague centenary an international meeting was organized under a title inspired by Einstein s last paper from the Prague period Relativity and Gravitation 100 Years after Einstein in Prague The main topics of the conference included classical relativity numerical relativity relativistic astrophysics and cosmology quantum gravity experimental aspects of gravitation and conceptual and historical issues The conference attracted over 200 scientists from 31 countries among them a number of leading experts in the field of general relativity and its applications This volume includes abstracts of the plenary talks and full texts of contributed talks and articles based on the posters presented at the conference These describe primarily original results of the authors Full texts of the plenary talks are included in the volume General Relativity Cosmology and Astrophysics Perspectives 100 Years after Einstein in Prague eds J Bi k and T Ledvinka published also by Springer Verlag   *Exploring the Early Universe with Gravitational Waves* Laura Bianca Bethke,2015-05-20 This work investigates gravitational wave production in the early universe and identifies potentially observable features thereby paving the way for future gravitational wave experiments It focuses on gravitational wave production in two scenarios inflation in a model inspired by loop quantum gravity and preheating at the end of inflation In the first part it is demonstrated that gravitational waves spectrum differs from the result obtained using ordinary general relativity with potentially observable consequences that could yield insights into quantum gravity In the second part it is shown that the cosmic gravitational wave background is anisotropic at a level that could be detected by future experiments Gravitational waves promise to be an rich source of information on the early universe To them the universe has been transparent from its earliest moments so they can give us an unobstructed view of the Big Bang and a means to probe the fundamental laws of nature at very high energies

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FJ44-72-080: Engine - 2nd ... FJ44 SERVICE BULLETIN Jan 17, 2017 — This service bulletin gives instructions to replace the installed fuel flow to oil cooler tube assembly (P/N 50450). F. Approval: This service ... Fan Balance Williams International FJ44-1A/1AP(5/16wts) All procedures for Fan Balance and all adjustments should be made in accordance with the Aircraft Maintenance Manual. ... FJ44 Vibration Sensor Mount (Item 7). 9 ... 25.2 Nuclear Transformations Flashcards Study with Quizlet and memorize flashcards containing terms like Band of stability, Positron, Half-life and more. Nuclear Chemistry Chapter 25 (25.2, 25.3, 25.4) Worksheet ... Pearson Chemistry; Nuclear Chemistry Chapter 25 (25.2, 25.3, 25.4) Worksheet Answers. ... Chapter 25.2-Nuclear Transformations vocabulary and key concepts. 9 ... Nuclear Chemistry 2. The three types of nuclear radiation are radiation, radiation, and radiation. 25.2 Nuclear Transformations. 25.2 Nuclear Transformations Carbon-14 emits beta radiation and decays with a half-life ($t_{1/2}$) of 5730 years. Assume you start with a mass of 2.00×10^{12} g of carbon-14. a. How long is ... ECON101 - Ch.25 Section Review Answers For the electronic transition from $n = 3$ to $n = 5$ in the hydrogen atom. a) Calculatethe energy. b) Calculate the wavelength (in nm). Chapter 25 Nuclear Chemistry 25.2 Nuclear Transformations Sep 5, 2017 — Nuclear Chemistry Targets: 1.I CAN Utilize appropriate scientific vocabulary to explain scientific concepts. 2.I CAN Distinguish between fission ... Matter and Change • Chapter 25 When a radioactive nucleus gives off a gamma ray, its atomic number increases by. 12. The three types of radiation were first identified by Ernest Rutherford. Nuclear Chemistry - Lake Central High School Jul 12, 2015 — What is the change in atomic number after the alpha decay?It decreases by 2.b. ... answer the following questions.Nuclear ... 25.2 Nuclear Transformations | Lecture notes Chemistry These nuclei decay by turning a neutron into a pro- ton to emit a beta particle (an electron) from the nucleus. This process is known as beta emission. It ... 60 s - 1 min SECTION 25.2 NUCLEAR TRANSFORMATIONS. 1. Write a nuclear equation for the following radioactive processes. a. alpha decay of francium-208 208 Fr→ b ... chapter 15 air, weather, and climate Students need to know the basic composition of the atmosphere. They should know that the atmosphere is mostly nitrogen, approximately 78%. In. 015 Air Weather and Climate Chapter 15: Air, Weather, and Climate. Student ... seasonal changes in air temperature and humidity. E. movement of tectonic plates. 29. Due to the influence ... Air Pollution, Climate Change, and Ozone Depletion Chapter 15. Air Pollution,. Climate. Change, and. Ozone. Depletion. Page 2. © 2019 ... Weather, Climate, and Change. • Weather: short-term changes in atmospheric. AP Environmental Science Chapter 15 Air, Weather, and ... Study with Quizlet and memorize flashcards containing terms like Is Antarctica Melting?, The Atmosphere and Climate, Weather and more. Chapter 15: Weather and Climate A measure of how close the air is to dew point is . 59. The day-to-day change in temperature and precipitation makes up an area's . 60. Gases in the atmosphere ... A World of Weather: Chapter 15 Introduction We can see and feel weather: the day-long rain, the cold slap of Arctic air, the gusty afternoon winds, or the sudden snow squall. Climate, in contrast, is ... Weather and Climate Chapter 15 Flashcards Study with Quizlet and memorize flashcards containing terms like climate, climatic normal, Koeppen system and more. Chapter 15 Air, Weather,

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