



Quantum Gravity

Claus Kiefer



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Quantum Gravity Carlo Rovelli, 2004-11-15 Publisher Description *Covariant Loop Quantum Gravity* Carlo Rovelli, Francesca Vidotto, 2015 A comprehensible introduction to the most fascinating research in theoretical physics advanced quantum gravity Ideal for researchers and graduate students Quantum Gravity Claus Kiefer, 2012-04-05 Quantum theory and Einstein's theory of relativity are at the centre of modern theoretical physics yet the consistent unification of both theories is still elusive This book offers an up to date introduction into the attempts to construct a unified theory of quantum gravity **Quantum Gravity** Domenico J. W. Giulini, Claus Kiefer, Claus Lämmerzahl, 2003-09-16 The relation between quantum theory and the theory of gravitation remains one of the most outstanding unresolved issues of modern physics According to general expectation general relativity as well as quantum field theory in a fixed background spacetime cannot be fundamentally correct Hence there should exist a broader theory comprising both in appropriate limits i.e. quantum gravity This book gives readers a comprehensive introduction accessible to interested non experts to the main issues surrounding the search for quantum gravity These issues relate to fundamental questions concerning the various formalisms of quantization specific questions concerning concrete processes like gravitational collapse or black hole evaporation and the all important question concerning the possibility of experimental tests of quantum gravity effects

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 **Quantum Gravity** Claus Kiefer, 2007-02-22 The search for a quantum theory of the gravitational field is one of the great open problems in theoretical physics This book presents a self contained discussion of the concepts methods and applications that can be expected in such a theory The two main approaches to its construction the direct quantisation of Einstein's general theory of relativity and string theory are covered Whereas the first attempts to construct a viable theory for the gravitational field alone string theory assumes that a quantum theory of gravity will be achieved only through a unification of all the interactions However both employ the general method of quantization of constrained systems which is described together with illustrative examples relevant for quantum gravity There is a detailed presentation of the main approaches employed in quantum general relativity path integral quantization the background field method and canonical quantum gravity in the metric connection

and loop formulations The discussion of string theory centres around its quantum gravitational aspects and the comparison with quantum general relativity Physical applications discussed at length include the quantization of black holes quantum cosmology the indications of a discrete structure of spacetime and the origin of irreversibility The second edition will add some sections on topical issues These include loop quantum cosmology dynamical triangulation renormalization group approach primordial black holes and information loss problem for black holes The second edition will also contain some pedagogical extensions This book will be of interest to researchers and students working in relativity and gravitation cosmology quantum field theory and related topics It will also be of interest to mathematicians and philosophers of science

The Meaning of Quantum Gravity Horst-Heino Borzeszkowski, H.J. Treder, 2012-12-06 In discussing the question of whether General Relativity Theory really needs to be quantized a simply negative answer cannot be accepted of course Such an answer is not satisfying because first Einstein's gravitational equations connect gravity and non gravitational matter and because second it can be taken for granted that non gravitational matter has an atomic or quantum structure such that its energy momentum tensor standing on the right hand side of Einstein's equations is formed out of quantum operators These two facts make it impossible to read the left hand side of Einstein's equations as an ordinary classical function This does not necessarily mean however that we must draw the conclusion that General Relativity Theory similar to electrodynamics could or should be quantized in a rigorous manner and that this quantization has similar consequences to quantum electrodynamics In other words when for reasons of consistency quantization is tried then one has to ask whether and where the quantization procedure has a physical meaning i.e. whether there exist measurable effects of quantum gravity In accordance with these questions we are mainly dealing with the discussion of the principles of quantized General Relativity Theory and with the estimation of quantum effects including the question of their measurability This analysis proves that it is impossible to distinguish between classical and quantum General Relativity Theory for the extreme case of Planck's orders of magnitude In other words there does not exist a physically meaningful rigorous quantization conception for Einstein's theory

Quantum Gravity War Norbert Schwarzer, 2024-04-16 Imagine a civilization with a technology so powerful that a single push of the wrong button could destroy this very entire civilization As the consideration of future warfare requires the inclusion of a unified physics we have to deal with complex concepts of Quantum Theory and General Theory of Relativity The two have to be brought together before we are able to deal with the matter of future warfare technology in a satisfactory manner That such a Theory of Everything or Theory of Quantum Gravity in principle already exists and had been already derived by the great German mathematician David Hilbert When digging deeper and looking for applications of the new theory we realized that many of the new possibilities could also lead to quite disastrous utilizations in military It is futile to hope that mankind would not recognize this potential and restrain itself from its exploitation Thus we thought we better make this knowledge public and hope for some kind of global understanding perhaps guaranteeing the non usage of certain

technologies It might only be a weak hope but in observing history and realizing how little we gained by keeping crucial knowledge restricted to some thereby often only even more provoking the development of the most horrific weapons one could imagine at the time we simply see no better way This book does not provide blueprints ready to start the developments of new quantum gravity weaponry and strategies but it draws the line that would suffice to awake the right forces and trigger the best developments before the bad guys get the gist

Lectures on Quantum Gravity Andres Gomberoff, Donald Marolf, 2005-05-13 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

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

Quantum Space J. E. Baggott, 2018 The greatest challenge for physics is to combine its two most successful theories general relativity and quantum mechanics The resulting quantum theory of gravity would explain the universe across all scales Much has been said about the approach based on string theory Here Jim Baggott describes its powerful rival Loop Quantum Gravity

Quantum Field Theory II Edouard B. Manoukian, 2016-09-26 This book takes a pedagogical approach to explaining quantum gravity supersymmetry and string theory in a coherent way It is aimed at graduate students and researchers in quantum field theory and high energy physics The first part of the book introduces quantum gravity without requiring previous knowledge of general relativity GR The necessary geometrical aspects are derived afresh leading to explicit general Lagrangians for gravity including that of general relativity The quantum aspect of gravitation as described by the graviton is introduced and perturbative quantum GR is discussed The Schwinger DeWitt formalism is developed to compute the one loop contribution to the theory and renormalizability aspects of the perturbative theory are also discussed This follows by introducing only the very basics of a non perturbative background independent formulation of quantum gravity referred to as loop quantum gravity which gives rise to a quantization of space In the second part the author introduces supersymmetry and its consequences The generation of superfields is represented in detail Supersymmetric generalizations of Maxwell's Theory as well as of Yang Mills field theory and of the standard model

are worked out Spontaneous symmetry breaking improvement of the divergence problem in supersymmetric field theory and its role in the hierarchy problem are covered The unification of the fundamental constants in a supersymmetric version of the standard model are then studied Geometrical aspects necessary to study supergravity are developed culminating in the derivation of its full action The third part introduces string theory and the analysis of the spectra of the mass squared operator associated with the oscillating strings The properties of the underlying fields associated with massless particles encountered in string theory are studied in some detail Elements of compactification duality and D branes are given as well of the generation of vertices and interactions of strings In the final sections the author shows how to recover GR and the Yang Mills field Theory from string theory

Foundations of Quantum Gravity James Lindesay, 2013-05-16 Explores how quantum coherence can be consistently incorporated into Einstein's theory of gravitation for researchers in the foundations of physics

Reality Is Not What It Seems Carlo Rovelli, 2016-10-06 The physicist transforming how we see the universe Financial Times An utter joy Adam Rutherford Do space and time truly exist What is reality made of Can we understand its deep texture Scientist Carlo Rovelli has spent his whole life exploring these questions and pushing the boundaries of what we know In this mind expanding book he shows how our understanding of reality has changed throughout centuries from Democritus to loop quantum gravity Taking us on a wondrous journey he invites us to imagine a whole new world where black holes are waiting to explode spacetime is made up of grains and infinity does not exist a vast universe still largely undiscovered A hugely engaging book Rovelli is a charming thought provoking tour guide Manjit Kumar Prospect Translated by Simon Carnell and Erica Segre

Random Surfaces and Quantum Gravity Orlando Alvarez, Enzo Marinari, Paul Windey, 2013-03-09 The Cargèse Workshop Random Surfaces and Quantum Gravity was held from May 27 to June 2 1990 Little was known about string theory in the non perturbative regime before October 1989 when non perturbative equations for the string partition functions were found by using methods based on the random triangulations of surfaces This set of methods provides a description of non critical string theory or equivalently of the coupling of matter fields to quantum gravity in two dimensions The Cargèse meeting was very successful in that it provided the first opportunity to gather most of the active workers in the field for a full week of lectures and extensive informal discussions about these exciting new developments The main results were reviewed recent advances were explained new results and conjectures which appear for the first time in these proceedings were presented and discussed Among the most important topics discussed at the workshop were The relation of KdV theory to loop equations and the Virasoro algebra new results in Liouville field theory effective 1+1 dimensional theory for 2D quantum gravity coupled to $c=1$ matter and its fermionization proposal for a new geometrical interpretation of the string equation and possible definition of quantum Riemann surfaces discussion of the string equation for the multi matrix models links with topological field theories of gravity issues in using target space supersymmetry to define good theories definition of the partition function via analytic continuation new models of random

surfaces *The Structural Foundations of Quantum Gravity* Dean Rickles, Steven French, Juha T. Saatsi, 2006-11-16 What is spacetime General relativity and quantum field theory answer this question in different ways This collection of essays looks at the problem of uniting these two fundamental theories of our world focusing on the nature of space and time within this quantum framework Three Roads To Quantum Gravity Lee Smolin, 2008-03-18 It would be hard to imagine a better guide to this difficult subject Scientific American In Three Roads to Quantum Gravity Lee Smolin provides an accessible overview of the attempts to build a final theory of everything He explains in simple terms what scientists are talking about when they say the world is made from exotic entities such as loops strings and black holes and tells the fascinating stories behind these discoveries the rivalries epiphanies and intrigues he witnessed firsthand Provocative original and unsettling The New York Review of Books An excellent writer a creative thinker Nature **Quantum Gravity and the Functional**

Renormalization Group Martin Reuter, Frank Saueressig, 2019-01-03 During the past two decades the gravitational asymptotic safety scenario has undergone a major transition from an exotic possibility to a serious contender for a realistic theory of quantum gravity It aims at a mathematically consistent quantum description of the gravitational interaction and the geometry of spacetime within the realm of quantum field theory which keeps its predictive power at the highest energies This volume provides a self contained pedagogical introduction to asymptotic safety and introduces the functional renormalization group techniques used in its investigation along with the requisite computational techniques The foundational chapters are followed by an accessible summary of the results obtained so far It is the first detailed exposition of asymptotic safety providing a unique introduction to quantum gravity and it assumes no previous familiarity with the renormalization group It serves as an important resource for both practising researchers and graduate students entering this maturing field

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 **Quantum Gravity in a Laboratory?** Nick Huggett, Niels Linnemann, Mike D. Schneider, 2023-08-03 The characteristic Planck energy scale of quantum gravity makes experimental access to the relevant physics apparently impossible Nevertheless low energy experiments linking gravity and the quantum have been undertaken the Page and Geilker quantum Cavendish experiment and the Colella Overhauser Werner neutron interferometry experiment for instance However neither probes states in which gravity remains in a coherent quantum superposition unlike it is claimed recent proposals In essence if two initially unentangled subsystems interacting solely via gravity become entangled then theorems of quantum mechanics show that gravity cannot be a classical subsystem There are formidable challenges to such an experiment but remarkably tabletop technology into the gravity of very small bodies has advanced to the point that such an experiment might be feasible in the near future This Element explains the proposal and what it aims to show highlighting the important ways in which its interpretation is theory laden

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