GR 2: Quantum Gravity I

Zeit: Montag 11:00–12:20 Raum: VMP6 HS A

Hauptvortrag GR 2.1 Mo 11:00 VMP6 HS A

Dynamics of Loop Quantum Gravity — •Kristina Giesel — Institute for Quantum Gravity, FAU Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen

Loop quantum gravity is a candidate for a theory of quantum gravity, which takes general relativity as its classical starting point. The quantum theory is obtained by applying canonical quantization to general relativity. For this purpose, the techniques known from quantum field theory need to be generalized. As a consequence, loop quantum gravity is based on a quantum field theory, which is in many aspects different from the quantum field theory, that is used to formulate the Standard Model of particle physics. The dynamics of the quantum theory is described by the so called quantum Einstein equations, the quantum analog of Einstein's equations. After a brief introduction to the ideas and concepts of loop quantum gravity, we will discuss the current status of the dynamics, particularly the role of gauge invariance in this context and also present further research directions currently addressed in loop quantum gravity.

GR 2.2 Mo 11:40 VMP6 HS A

Semiclassical perturbation theory in Loop Quantum Gravity — •David Winnekens and Kristina Giesel — University of Erlangen-Nürnberg, Institute for Quantum Gravity, Theoretical Physics III, Staudtstr. 7, 91058 Erlangen

The volume operator plays a pivotal role in the quantum dynamics of Loop Quantum Gravity, yet its full spectrum is unknown. This also affects a semiclassical analysis of the theory since that requires computing semiclassical expectation values of dynamical operators, which themselves involve the volume operator. Within the context of Algebraic Quantum Gravity [1] – a model formulated in the framework of Loop Quantum Gravity –, a formalism called semiclassical perturbation theory was developed, which allows calculating these semiclassical expectation values perturbatively as a power series in $\hbar$.

This talk presents an application of this formalism to the operator of the inverse scale factor, which is an important ingredient for the dynamics of quantum cosmological models. In [2], a semiclassical analysis of this operator has been performed via substituting SU(2) by $U(1)^3$. In this case, the volume operator simplifies drastically. With the work presented in this talk, the analysis of [2] can be generalized to the full SU(2)-case.

[1] Algebraic Quantum Gravity (AQG) III. Semiclassical Perturbation Theory, K. Giesel, T. Thiemann, Class.Quant.Grav.24:2565-2588, 2007 [2] On (Cosmological) Singularity Avoidance in Loop Quantum Gravity, J. Brunnemann, T. Thiemann, Class.Quant.Grav.23:1395-1428, 2006

GR 2.3 Mo 12:00 VMP6 HS A

A physical Hamiltonian obtained from four Klein-Gordon Fields — Kristina Giesel and •Almut Oelmann — Institute for Quantum Gravity, FAU Erlangen-Nürnberg

In Loop Quantum Gravity (LQG) we do not have a true Hamiltonian which describes the dynamics of General Relativity. Instead one obtains from the Einstein-Hilbert action a sum of constraints, called the Diffeomorphism and the Hamiltonian constraint. They represent spatial and temporal diffeomorphisms which are the gauge transformations of General Relativity. In order to obtain Dirac observables which are real physical (gauge invariant) quantities one introduces additional matter fields as reference fields. A special Dirac observable is the physical Hamiltonian. It describes the physical evolution (dynamics) of the considered system. A well known approach to obtain Dirac observables that are invariant under spatial and temporal diffeomorphisms is the so called relational formalism combined with the so called Brown-Kuchar mechanism, where four dust fields are used as reference fields. Here we consider the model of the gravitational field coupled to four Klein-Gordon reference fields and derive the physical Hamiltonian of this model. We compare this model to the Brown-Kuchar dust model and discuss the differences and similarities of the two models with a particular focus on the reduced phase space quantization of this model in the context of Loop Quantum Gravity.