GR 13: Quantum Gravity and Quantum Cosmology I

Time: Thursday 13:45–15:15 Location: KH 02.012

GR 13.1 Thu 13:45 KH 02.012

Measurement of the Casimir force during free fall — •Sascha Kulas — International University of Applied Sciences (IU), Schiffgraben 49-51, 30175 Hannover, Germany

The Casimir effect is an attractive interaction between two uncharged and perfectly conducting plates held a short distance apart. Its force still has a lot of unknown aspects. Here, this force is measured in a tuning fork experiment during free fall and compared with a measurement on ground. It seems like the Casimir force is strongly suppressed during free fall. This is a hint that the Casimir force does not have its origin in the Van der Waals force, which would not change in weightlessness. In the next step, drop tower experiments have to proof the results. In addition, a physical toy model is introduced, that explains these experimental results and further effects concerning gravity and quantum mechanics.

GR 13.2 Thu 14:00 KH 02.012

Gravitational collapse in effective loop quantum gravity and the formation of shell-crossing singularities — Francesco Fazzini[1], Kristina Giesel[1], Hongguang Liu[2], and •Eric Rullit[1] — [1]Institute for Quantum Gravity, Friedrich-Alexander-Universität, Erlangen-Nürnberg, Germany — [2]Institute for Theoretical Sciences, Westlake University, Hangzhou, China

In this talk the investigation of the gravitational dust collapse within the framework of effective loop quantum gravity will be addressed, with a special focus on the properties and the formation of shell-crossing singularities in these models. The specific effective model that will be discussed in this talk is based on a cosmological Hamiltonian derived from full LQG by Dapor and Liegener using coherent state techniques, which governs the FLRW-type time evolution of each radial shell in the collapsing dust sphere. This model is characterized by an asymmetric bounce as its central feature where the classical singularity is resolved due to leading-order quantum corrections encoded in the effective description. The investigation of the resulting effective dynamics will be presented in detail and differences and similarities compared to other existing models will be discussed. In a broader context, the question of the existence of shell-crossing singularities is investigated beyond the specific model, including also non-bouncing scenarios such as regular black hole models of Bardeen and Hayward.

GR 13.3 Thu 14:15 KH 02.012

The perturbative Ricci flow — Robert Harlander[1], Yannick Kluth[2], Jonas Kohnen[1], and •Henry Werthenbach[1] — [1]TTK, RWTH Aachen University, 52056 Aachen, Germany — [2]Department of Physics, University of Toronto, Toronto, ON M5S 1A7, Canada

One candidate for a quantum theory of gravity is the Asymptotic Safety conjecture, which postulates the existence of a non-trivial fixed point for the gravitational couplings. We investigate the search for such a fixed point within the framework of perturbation theory.

For this, we employ the Ricci flow as the central tool, pursuing a perturbative scheme analogous to the gradient flow formalism in QCD. In QCD, the gradient flow was introduced to bridge the gap between lattice simulations and perturbative calculations, allowing for a definition of a renormalisation scheme that is accessible in both settings. Applied to gravity the gradient flow is known as 'Ricci flow'. The core idea is to utilize this framework to compute the beta function of the gravitational coupling by explicitly defining it within the Ricci flow scheme.

In this talk, I will first provide a brief introduction to the gradient flow formalism. I will then present the first steps towards constructing a perturbative implementation of the Ricci flow and the definition of Newton's coupling in this scheme.

GR 13.4 Thu 14:30 KH 02.012

Gravitational induced decoherence and the role of reference frames: a quantum mechanical toy model — •Ashay Sathe[1] and Kristina Giesel[2] — [1]Friedrich-Alexander-Universität, Erlangen-Nürnberg, Deutschland — [2]Friedrich-Alexander-Universität, Erlangen-Nürnberg, Deutschland

In this talk, we investigate a quantum mechanical toy model of gravitationally induced decoherence, with particular emphasis on the role of reference frames in the description of open quantum systems. We analyse two complementary choices of reference frames: a classical reference frame and a quantum reference frame. For each choice, the master equation governing the effective dynamics is derived. We then compare the resulting models and discuss both their common features and their conceptual and dynamical differences.

GR 13.5 Thu 14:45 KH 02.012

Area Metric actions and equations on an AdS background — •Mario Flory[1], Aranya Bhattacharya[1,2], Lavish Chawla[1,3], and Mateusz Kulig[1] — [1]Jagiellonian University, Cracow, Poland — [2]University of Bristol, Bristol, UK — [3]Friedrich-Schiller-Universität, Jena, Germany

Following the talk by A. Bhattacharya, we study Lagrangians governing linearised area metric fluctuations on an Anti-de Sitter (AdS) background. Our aim is to identify actions whose equations of motion respect the requirements imposed by the holographic principle, with particular emphasis on the allowed boundary behaviour of the solutions. We demonstrate that rewriting area metric fluctuations in terms of Lanczos-like potentials yields a notably elegant model. Interesting parallels with conformal (i.e., Weyl-squared) gravity naturally arise and will be discussed.

GR 13.6 Thu 15:00 KH 02.012

Exploring physical states of loop quantum gravity using neural networks — •Waleed Sherif and Hanno Sahlmann — Institute for Quantum Gravity, Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Staudtstraße 7, 91058, Erlangen, Germany

Loop quantum gravity (LQG) is a canonical approach to the quantisation of general relativity that aims to preserve background independence. The dynamics of the theory is encoded in a set of constraints, among which the Hamiltonian constraint plays a central role. Constructing and analysing general physical states that satisfy this constraint has long remained one of the central open challenges in LQG.

In this talk, we show that this problem can be approached using modern deep learning techniques, specifically neural network quantum states (NQS). We demonstrate that these methods make it possible to construct approximate physical states in simplified models of LQG for the first time in a way that is both flexible and scalable. Using a range of models in Euclidean LQG, we illustrate how this approach enables large-scale numerical investigations of the theory's quantum dynamics, allowing for the systematic characterisation of physical states and exploring the impact of different operator orderings, regularisation choices and more.