GR 4: Quantum Gravity

Time: Tuesday 17:00–18:20 Location: ZEU/0260

GR 4.1 Tue 17:00 ZEU/0260

Quantum gravitational redshift — •David Edward Bruschi — Institute for Quantum Computing Analytics (PGI-12), Forschungszentrum Jülich, Germany

General relativity and quantum mechanics are the two frameworks through which we understand Nature. To date, they have remained valid to great extent in their respective domains. Regardless of the myriad of attempts to find a unified theory that can describe all of observable phenomena, the quest for unification continues.

One avenue for investigating the overlap of general relativity and quantum mechanics that is less ambitious but can still provide potentially observable and measurable predictions is that of quantum field theory in curved spacetime viewed through the lens of quantum information. In recent years, a great deal of attention has been given to this approach, which has provided novel and intriguing insights into phenomena that can be tested in the laboratory.

We present an investigation in the quantum nature of the gravitational redshift, seeking to understand which are the expected quantum dynamics that lead to the effective classical observable effect. We discuss the classical regime and show that more intriguing aspects are expected. We conclude discussing potential for detection in space-based experiments.

GR 4.2 Tue 17:20 ZEU/0260

A Rigorous Neutrino Oscillation Formula in Curved Spacetime — •Dominik Hellmann — TU Dortmund, 44227 Dortmund, Germany

In the light of upcoming experiments searching to detect neutrino signals from astrophysical sources, the question for a rigorously derived neutrino oscillation formula in curved spacetime from first principles seems to be well motivated.

Based on the theoretical foundations of quantum field theory in curved spacetime (cQFT), we generalize the well known external wave packet approach to neutrino oscillations from flat to curved spacetime.

In this framework, external particles are represented by wave packets, while the neutrino is described by its Feynman propagator and PMNS matrix elements. In addition to that, we incorporate nontrivial cQFT effects like the non-uniqueness of the vacuum and show how these modify the oscillation behavior. Finally, we derive the conditions under which a neutrino oscillation probability is well defined and show how it is calculated from cQFT amplitudes.

GR 4.3 Tue 17:40 ZEU/0260

Proton Stability and Quantum Gravity: Towards an asymptotically safe perspective — Astrid Eichhorn and •Shouryya Ray — CP3 Origins, Institut for Fysik, Kemi og Farmaci, Syddansk Universitet, Campusvej 55, 5230 Odense M, Denmark

The observed long lifetime ($\gtrsim 10^{34}$ yrs) of the proton can pose serious constraints on UV completions of the Standard Model. In those that include quantum gravity, fluctuations of the spacetime metric are often argued to break all effective global symmetries; baryon number conservation, which prevents proton decay, being one of them. Here, I shall present our computations concerning the proton lifetime within asymptotically safe quantum gravity. Time permitting, I shall speculate on how asymptotically safe metric fluctuations may in fact reconcile a significantly reduced quantum gravity scale with proton stability, and thereby possibly also stabilize the proton in certain GUT scenarios afflicted by excessive proton decay.

GR 4.4 Tue 18:00 ZEU/0260

Asymptotically nonlocal gravity — •Jens Boos and Christopher D Carone — William & Mary, Williamsburg, VA, USA

Asymptotically nonlocal field theories interpolate between Lee-Wick theories with multiple propagator poles, and ghost-free nonlocal theories. Previous work on asymptotically nonlocal scalar, Abelian, and non-Abelian gauge theories has demonstrated the existence of an emergent regulator scale that is hierarchically smaller than the lightest Lee-Wick partner, in a limit where the Lee-Wick spectrum becomes dense and decoupled. We generalize this construction to linearized gravity, and demonstrate the emergent regulator scale in three examples: by studying the resolution of the singularity (i) at the origin in the classical solution for the metric of a point particle, and (ii) in the nonrelativistic gravitational potential computed via a one-graviton exchange amplitude; (iii) we also show how this derived scale regulates the one-loop graviton contribution to the self energy of a real scalar field. We comment briefly on the generalization of our approach to the full, nonlinear theory of gravity.