# GR 10: Quantum Gravity and Quantum Cosmology 1

Time: Wednesday 16:30–18:30 Location: H-HS IX

GR 10.1 Wed 16:30 H-HS IX

**On the construction of diffeomorphism-invariant observables** — •Leonardo Chataignier — Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Cologne, Germany

We describe a method of construction of diffeomorphism-invariant operators (Dirac observables or "evolving constants of motion") from the knowledge of the eigenstates of the gauge generator in time-reparametrisation invariant mechanical systems. These invariant operators evolve unitarily with respect to an arbitrarily chosen time variable. We emphasise that the dynamics is relational, both in the classical and quantum theories. We conclude with some remarks about possible phenomenological applications of this framework, such as singularity avoidance in quantum cosmology.

Ref.: L.C., "On the Construction of Quantum Dirac Observables and the Emergence of WKB Time", arXiv:1910.02998 [gr-qc].

GR 10.2 Wed 16:45 H-HS IX

**Cosmological Decoherence from Thermal Gravitons** — Ning Bao[1,2], •Aidan Chatwin-Davies[3], Jason Pollack[4], and Grant Remmen[1] — [1]University of California, Berkeley, USA — [2]Brookhaven National Lab, NY, USA — [3]KU Leuven, Belgium — [4]University of British Columbia, Canada

Coupling a coherent superposition of stress-energy to a bath of gravitons of course causes the superposition to decohere. While the decoherence rate may be very small in everyday configurations, such gravitational interactions can nevertheless have an appreciable effect over the course of cosmic history in the presence of a positive cosmological constant, which sources a thermal bath of gravitons. I will discuss some recent work which studies the effects of gravitationally-driven decoherence on tunneling processes associated with false vacuum decays, commenting on the consequences of these effects, as well as on further applications and observability.

GR 10.3 Wed 17:00 H-HS IX

**Quantum cosmology of Starobinsky inflation revisited** — Mariam Bouhmadi-López[1,2] and •Manuel Krämer[3] — [1]Department of Theoretical Physics, University of the Basque Country UPV/EHU, Bilbao, Spain — [2]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain — [3]Institute for Theoretical Physics, KU Leuven, Belgium

We study the canonical quantization of a cosmological model of Starobinsky inflation. We solve the resulting Wheeler–DeWitt equation in the Einstein frame formulation using a Born–Oppenheimer approximation and compare our findings to the quantization in the Jordan frame. We then discuss the implications for the question of whether Jordan and Einstein frame are equivalent at the quantum level.

GR 10.4 Wed 17:15 H-HS IX

**Towards a quantum Oppenheimer-Snyder model** — •Tim Schmitz — Institut für Theoretische Physik, Universität zu Köln, Germany

We present a consistent canonical formulation of the flat Oppenheimer-Snyder model, including the Schwarzschild exterior. The switching between comoving and stationary observer is realized by promoting the coordinate transformation between dust proper time and Schwarzschild-Killing time to a canonical one. This leads to two different forms of the Hamiltonian constraint, both (almost) deparameterizable with regard to one of these times. A preliminary quantization of these constraints reveals a consistent picture for both observers: the singularity is avoided by a bounce.

GR 10.5 Wed 17:30 H-HS IX

**Towards a classical correspondence of wave packets in quantum cosmology** — Chen Lan[1], •Yi-Fan Wang[2], and Yan-Gang Miao[1] — [1]School of Physics, Nankai University, Tianjin 300071, China — [2]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, D-50937 Köln, Germany

In Wheeler–DeWitt quantum cosmology, a classical universe can emerge from a realistic wave function at a suitable scale. It has been argued that such wave functions are strongly peaked around classical solutions; in other words, the ridgeline of a physical wave packet corresponds to a classical solution.

We give quantitative descriptions of the ridge-line of a wave packet. With explicit examples of wave packets, it is shown that ridgelines can deviate from classical trajectories at classical scales. Possible interpretations are discussed.

GR 10.6 Wed 17:45 H-HS IX

**Quantum Corrected Black Holes from String T-Duality** — •Piero Nicolini[1,2], Euro Spallucci[3], and Michael Wondrak[1,2] — [1]Goethe Universität, Frankfurt — [2]Frankfurt Institute for Advanced Studies — [3]University of Trieste

After recalling the relation between the T-duality and the path integral duality, we present an exact static, neutral black hole solution emerging from the stringy modifications of Newton's potential. The spacetime is singularity free and formally equivalent to the Bardeen metric, apart from the presence of a string dependent ultraviolet regulator. Some considerations about the thermodynamics will be offered as a conclusion.

GR 10.7 Wed 18:00 H-HS IX

**Primordial black holes in a dimensionally reduced universe** — •Athanasios Tzikas[1], Piero Nicolini[2], Jonas Mureika[3], and Bernard Carr[4] — [1]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [2]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [3]Loyola Marymount University, Los Angeles, USA — [4]Queen Mary University of London, London, UK

We investigate the spontaneous creation of primordial black holes in a lower-dimensional expanding early universe. We use the no-boundary proposal to construct instanton solutions for both the background and a black hole nucleated inside this background. The resulting creation rate could lead to a significant population of primordial black holes during the lower dimensional phase. We also consider the subsequent evaporation of these dimensionally reduced black holes and find that their temperature increases with mass, whereas it decreases with mass for 4-dimensional black holes. This means that they could leave stable sub-Planckian relics, which might in principle provide the dark matter.

GR 10.8 Wed 18:15 H-HS IX

**Dirac's Way to Quantum Gravity** — •Alexander Unzicker — Pestalozzi-Gymnasium München

It is shown that Dirac's Large Number Hypotheses are equivalent to a numerical coincidence regarding Planck's constant, the speed of light and the mass and radius of the proton. Though this observation goes back to Finkelnburg (1947), the proton radius puzzle (Pohl, 2010) has augmented its possible relevance. As it happened with many other fundamental problems, a numerical coincidence may be the key to the quantum gravity conundrum.