GR 6: Quantum Gravity and Quantum Cosmology

Time: Tuesday 14:00–15:20 Location: H 2013

GR 6.1 Tue 14:00 H 2013

Probing the limits of classical gravity with trapped macroscopic quantum systems — •André Grossardt — Dipartimento di Fisica, Università degli Studi di Trieste, Italy

Whether gravity is quantised - and therefore correctly described by perturbative quantum gravity in the low-energy regime - is still subject to experimental tests. Here I discuss the most naive alternative, a theory in which the classical Einstein's equations are fundamental even at the microscopic level, and the gravitational field is sourced by the expectation value of energy-momentum - also known as "semiclassical gravity". In its non-relativistic limit, such a theory leads to the nonlinear Schrödinger-Newton equation, for which prospects for experimental tests will be discussed, particularly with trapped crystalline nanospheres.

GR 6.2 Tue 14:20 H 2013

Quantum-gravitational effects on scalar and tensor perturbations during inflation — David Brizuela[1,2], Claus Kiefer[2], and •Manuel Krämer[3,2] — [1]Fisika Teorikoa eta Zientziaren Historia Saila, UPV/EHU, 644 P.K., 48080 Bilbao, Spain — [2]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany — [3]Instytut Fizyki, Uniwersytet Szczeciński, ul. Wielkopolska 15, 70-451 Szczecin, Poland

We calculate corrections originating from canonical quantum gravity to the power spectra of gauge-invariant scalar and tensor perturbations during inflation. This is done by performing a semiclassical Born–Oppenheimer type of approximation to the Wheeler–DeWitt equation, from which we obtain a Schrödinger equation with a quantum-gravitational correction term. We perform our calculation both for a de Sitter universe as well as for a generic slow-roll model. The quantum-gravitational correction term leads to a modification of the power spectra on the largest scales, which is too small to be measurable, and we find a correction to the tensor-to-scalar ratio at the second order in the slow-roll parameters. We also compare these findings with results that were obtained in this context using just scalar-field perturbations in a non-gauge-invariant way.

GR 6.3 Tue 14:40 H 2013

Symmetry reductions in loop quantum gravity based on classical gauge fixings — •Norbert Bodendorfer, Jerzy Lewandowski, and Jedrzej Swiezewski — University of Warsaw, Poland

We discuss a new strategy to perform a symmetry reduction in loop quantum gravity based on classically gauge fixing the spatial diffeomorphism constraint. Symmetry reductions can then be performed by demanding the vanishing of certain classical phase space functions, which translates into implementing (some part of) spatial diffeomorphism invariance on the reduced phase space, thus solving the spatial diffeomorphism constraint "twice". We illustrate how this process works for reductions to spherical symmetry and Bianchi I cosmological models.

GR 6.4 Tue 15:00 H 2013

Quantum Geometrodynamics of Conformal Gravity — •Branislav Nikolic — Institute for Theoretical Physics, Cologne, Germany

In order to study the role of conformal symmetry (symmetry under local Weyl rescaling) at the level of quantum gravity, a toy model of conformally invariant gravitational action described with squared Weyl tensor (Weyl tensor action) is canonically quantized. An analog to the Wheeler-DeWitt equation has been proposed, leading to the formulation of quantum geometrodynamics of conformally invariant gravity. From this, the semiclassical expansion in terms of coupling constant is performed and it has been shown that in the highest order one obtains the Hamilton-Jacobi equation corresponding to the Weyl tensor action, while in the next order one obtains a functional Schroedinger equation, analogously to the case of quantum geometrodynamics of General Relativity. Furthermore, the conformal action is extended to the more physically justified action containing additional Einstein-Hilbert term, that breaks the conformal invariance. Upon performing the semiclassical expansion of the corresponding Wheeler-DeWitt equation with respect to the relative couplings of the two terms, it has been shown that the Einstein-Hamilton-Jacobi equation emerges as a classical limit of the theory. Moreover, the problem of time is discussed at the level of both actions. This opens the door to the formulation of quantum geometrodynamics of the higher derivative gravity theories.