Contribution ID: **130** Type: **Talk in the parallel session**

Loop Quantum Gravity on Dynamical Lattice and Improved Cosmological Effective Dynamics with Inflaton

Thursday, 8 July 2021 19:00 (15 minutes)

In the framework of reduced phase space Loop Quantum Gravity (LQG), we propose a new approach in coherent state path integral formulation which allows the spatial cubic lattice (graph) to change dynamically in the physical time evolution. The equations of motion of the path integral derive the effective dynamics of cosmology from the full LQG, when we focus on solutions with homogeneous and isotropic symmetry. The resulting cosmological effective dynamics with the dynamical lattice improves the effective dynamics obtained from the path integral with fixed spatial lattice: The improved effective dynamics recovers the FLRW cosmology at low energy density and resolves the big-bang singularity with a bounce. The critical density ρ_c at the bounce is Planckian $\rho_c \sim \Delta^{-1}$ where Δ is a Planckian area serving as certain UV cut-off of the effective theory. The effective dynamics gives the unsymmetric bounce and has the de-Sitter (dS) spacetime in the past of the bounce. The cosmological constant Λ_{eff} of the dS spacetime is emergent from the quantum effect $\Lambda_{eff} \sim \Delta^{-1}$. These results are qualitatively similar to the properties of $\bar{\mu}$-scheme Loop Quantum Cosmology (LQC). Moreover, we generalize the path integral formulation of the full LQG by taking into account the coupling with an additional real scalar field, which drives the slow-roll inflation of the effective cosmological dynamics. In addition, we discuss the cosmological perturbation theory on the dynamical lattice in full LQG, and the relation to the Mukhanov-Sasaki equation.

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Session Classification: Loop Quantum Gravity: Cosmology and Black Holes

Track Classification: Quantum Gravity: Loop quantum gravity: cosmology and black holes