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Title: Causal Dynamical Triangulations: Lattice quantum gravity reloaded

Abstract:
Lattice methods are a powerful tool to investigate quantum field theories beyond perturbation theory, as demonstrated by the impressive successes of lattice QCD. Due to the dynamical character of spacetime in gravity, putting the quantum-gravitational path integral on the lattice faces formidable obstacles, which for a long time were thought to be insurmountable. Key to overcoming them is the use of dynamical lattices, while also making sure that the Lorentzian character of spacetime is built in from the outset. Both features are realized by the use of causal dynamical triangulations (CDT), a methodology that also allows us to obtain evidence for the presence of a nontrivial UV fixed point.

Lattice quantum gravity 2.0 based on CDT is well-tested and operational, using state-of-the-art Monte Carlo simulations. It has opened a computational window near the Planck scale, where numerical experiments can be performed, giving for the first time quantitative information on the spectra of geometric observables characterizing quantum gravity nonperturbatively, with unexpected results. Remarkably, the path integral produces a quantum spacetime with some large-scale properties matching those of a de Sitter universe, as well as genuine quantum gravity signatures. These results shed light on long-standing conceptual issues and give rise to a concrete roadmap for how we may connect fundamental quantum gravity to early-universe cosmology.