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Analyzing quantum gravity spillover in the semiclassical regime

The uneasiness associated with the notion of a quantum state of a universe presents challenges not only on the interpretational front but on the phenomenological front as well. A reductionist approach that somewhat circumvents this issue is to consider sharply peaked states on the classical trajectory and introducing a quantum-corrected spacetime arising from a quantum gravity model. This procedure assumes that the expectation value of the metric variable for these states effectively captures the relevant quantum gravity subtleties in the semiclassical regime. We investigate the viability of this assumption and look for the signatures of ordering ambiguity in the case of a flat-FLRW universe with perfect fluid. A generalized ordering scheme for the Hamiltonian is considered, and the implication of different ordering choices on the observables is investigated. We first check the consistency of this quantum-corrected geometry by comparing the geometric quantities calculated for this metric with their expectation values. In the limit of sharply peaked states, the expectation value of the geometric quantities matches their semiclassical counterparts. Furthermore, we check the dependence of the expectation value of the observables on the ordering of the Hamiltonian. We demonstrate that the operator ordering ambiguity leaves no imprint on the states sharply peaked on the classical trajectory, leading to a consistent semiclassical picture for a quantum-corrected spacetime. Therefore, a reductionist viewpoint on the quantum nature of the universe leads to an ambiguity-free quantum theory.

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