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back to namelist

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Gravitational Cat State*

We investigate the nature of a gravitational two-state system (G2S) in the simplest setup in Newtonian gravity. In a quantum description of matter a single motionless massive particle can in principle be in a superposition state of two spatially-separated locations. This superposition state in gravity, or gravitational cat state, would lead to fluctuations in the Newtonian force exerted on a nearby test particle. The central quantity of importance for this inquiry is the energy density correlation. This corresponds to the noise kernel in stochastic gravity theory, evaluated in the weak field nonrelativistic limit. In this limit, quantum fluctuations of the stress energy tensor manifest as the fluctuations of the Newtonian force. We describe the properties of such a G2S system and present two ways of measuring the cat state for the Newtonian force, one by way of a classical probe, the other a quantum harmonic oscillator. Our findings include: (i) mass density fluctuations persist even in single particle systems, and they are of the same order of magnitude as the mean; (ii) a classical probe generically records a non-Markovian fluctuating force; (iii) a quantum probe interacting with the G2S system may undergo Rabi oscillations in a strong coupling regime. This simple prototypical gravitational quantum system could provide a robust testing ground to compare predictions from alternative quantum theories, since the results reported here are based on standard quantum mechanics and classical gravity.

*Based on Charis Anastopoulos, Bei-Lok Hu, “Probing a Gravitational Cat State”, Class. Quant. Grav. (2015) [arXiv:1504.03103]

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