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Sudden Decoherence by Resonant Particle Excitation for Testing Gravity-Induced Entanglement

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Aiming to explore quantum gravity, low-energy experiments have been proposed to test whether Newtonian gravity can generate quantum entanglement or not. However, the weakness of gravity hinders experimental realization. In this talk, we propose a novel optimal method to probe gravity-induced entanglement. We consider the gravitational interaction between a particle trapped in a shallow potential and a harmonic oscillator. The harmonic oscillator is in a quantum superposition of two frequencies and only one of these states can excite the trapped particle via resonance. Once the excited particle is detected, the quantum state of the oscillator is collapsed, which can be observed as the sudden disappearance of the superposition of oscillator frequencies. Thus, the sudden decoherence, which is only triggered by particle detection, can be a smoking gun evidence of gravity-induced entanglement. Since the probability of particle excitation increases linearly with time, the total probability is multiplied by repeating experiments. We will also discuss experimental implementations using optomechanics. This talk is based on arXiv: 2501.18147.

Primary author: KAKU, Youka (Kobe University)

Presenter: KAKU, Youka (Kobe University)

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