Amplification and generation bounds of gravity-induced entanglement

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The unification of gravity and quantum mechanics remains incomplete, and the possibility that gravity is fundamentally classical has not yet been ruled out. In recent years, gravity-induced entanglement in the low-energy Newtonian regime has attracted considerable attention as a possible sigature of the quantum nature of gravity. Since such entanglement cannot be generated by a purely classical gravitational interaction, its observation could provide evidence that gravity follows quantum mechanics.

In this work, we discuss both the amplification of gravity-induced entanglement and a universal bound governing its generation [1]. Several schemes have been proposed to enhanced gravity-induced entanglement, including approaches based on mediator systems and unstable potentials. Here, we propose an amplification method using a pulsed optomechanical system. In the pulsed regime, the quantum state of a mechanical oscillator can be swapped with that of an optical mode, allowing one to prepare the mechanical oscillator in a highly nonclassical state. we show that using such a state can amplify the amount of gravity-induced entanglement.

While this method increases the amount of entanglement, the condition for entanglement generation is determined by the competition between thermal noise and the gravitational interaction, and no example exceeding this bound has been found. We therefore demonstrate that this bound is universal for the initial two-mode Gaussian states and Fock states. We also clarify the same universal bound holds for non-Gaussian dynamics and even in the presence of a mediator [2].

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[1] D. Miki, L. Alfred, Y. Chen, arXiv:2605.26240

[2] L. Alfred, D. Miki, Y. Chen, arXiv:2605.26215