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Quantum effect unique to gravity based on the weak equivalence principle

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The construction of a quantum gravity theory remains a challenge. One of the difficulties stems from the lack of sufficient experimental evidence. As a first step toward the quantum gravity experiment, Bose et al. proposed a low-energy experiment to test if Newtonian gravity can generate quantum entanglement or not. However, they assumed that only gravity is mediating in the system, and their proposals fail when other quantum interactions come into play.
To overcome this issue, we explore an alternative experimental setup that can distinguish gravity-induced entanglement and entanglement resulting from other interactions. Specifically, we investigate an interference experiment of a quantum clock particle that feels a weak gravitational field as well as Coulomb potential. As a result, we find that the interference does not recohere only when gravity induces entanglement, while other cases exhibit periodic decoherence and recoherence. Furthermore, we discuss the deep connection between our experimental setup and the weak equivalence principle.
This talk is based on the collaborated work with Y. Nambu, S. Maeda and Y. Osawa, published in Phys.Rev.D 106 (2022) 12, 126005.

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