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Detecting post-Newtonian classical and quantum gravity via atom clock interferometry

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Understanding physical phenomena at the intersection of quantum mechanics and general relativity remains one of the major challenges in modern physics. Among various approaches, experimental tests have been proposed to investigate the dynamics of quantum systems in curved spacetime and to examine the quantum nature of gravity in the low-energy regime. However, most previous studies have considered only Newtonian gravity, leaving the post-Newtonian regime largely unexplored. In this study, we propose an experimental test to investigate how post-Newtonian gravity affects quantum systems and to examine its quantum nature. Specifically, we design and analyze two types of experiments: one using a quantum clock interferometry setup to detect the gravitational field generated by a rotating mass, and another leveraging this effect to generate gravity-mediated entanglement. Although the proposed experiments are extremely challenging to implement, they are inherently suited for probing post-Newtonian gravity. Due to the symmetry of the configuration, the setup is insensitive to the Newtonian gravitational contribution while sensitive to the frame-dragging effect. Moreover, assuming the validity of quantum equivalence principle, our approach provides a potential means not only to test the quantum nature of gravity but also to explore the quantum nature of spacetime itself.

Working Group

WG3 - Low-energy gravitational effects in quantum systems

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