Toward Experimental Signatures of Semiclassical Gravity

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Testing the quantum nature of gravity in the laboratory has recently become an active field of research. In this talk, I will discuss two theoretical aspects of this research program.

It has been argued that since Newtonian gravity can be incorporated as a term in the Schroedinger equation, its quantumness does not necessarily require the quantization of the gravitational field. In connection to this, Danielson, Satischandran and Wald considered a series of thought experiments, in which the transfer of quantum information via Newtonian gravity can be viewed as information transfer by gravitons. In the most exciting thought experiment, they showed that gravitating static quantum systems near a Killing horizon will undergo quantum decoherence via soft-graviton emission across the horizon. I will discuss how this effect can also be understood as a form of the Unruh effect.

Another aspect of the research program is to explore "classical" theories of gravity, namely whether a classical field theory can be constructed to describe the effect of gravitational interaction between quantum systems, in a way that recovers the phenomenology of classical gravity. I will describe a "causal-conditional formulation" of semiclassical gravity, which is a causality-preserving extension of the nonlinear Schroedinger-Newton theory. I will make connections between this theory and other semiclassical gravity theories (e.g., by Kafri, Taylor and Milburn and by Oppenheim), as well as the Diosi-Penrose and CSL collapse models.

This work was supported by the Simons Foundation (Award Number 568762).