Probing a Gravitational Cat State: Experimental Possibilities

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The notion of "gravitational cat states" has long been confined to abstract theoretical discussions, on account of the immense difficulty of experimentally detecting them. In this talk, we will review the description of gravitational cat states in the framework of canonical quantum theory (CQT) combined with the weak-field limit of general relativity (CQT+GR) [1], and then outline a recently proposed experimental scheme to detect the (CQT+GR predicted) quantum jumps of a gravitational cat state [2]. This scheme involves a magnetically trapped superconducting microsphere coupled to a qubit circuit [3] to form the gravitational cat state, and a trampoline micro-resonator to act as a macroscopic force probe [4]. It will be shown that, under plausible assumptions, the microsphere-probe gravitational force is less than ten orders of magnitude away from the peak force sensitivity of the resonator, and that anticipated technological improvements [5] make it conceivable that the force magnitude could fall within measurable range in the next (or next-next) generation of state-of-the-art experiments.

We will also highlight how the proposed scheme could empirically address open foundational questions on the relation between gravity and quantum measurement, such as: Does it make physical sense to treat the gravitational field as a quantum operator that undergoes discontinuous jumps upon measurement? If gravitational coupling of a cat state to a macroscopic force probe yields a quantum measurement, why doesn't gravitational coupling of a cat state to the Earth (for example) act as a quantum measurement? Does the description of gravitational cat states within alternative quantum theories [6, 7, 8] entail different predictions for the proposed scheme than CQT+GR?

(Based on joint work with Bei-Lok Hu at UMD and Charis Anastopoulos at U. Patras.)

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