Contribution ID: **35** Type: **talk**

Quantum enhanced correlated interferometry for Planck scale physics

Wednesday, 25 September 2019 15:30 (30 minutes)

Recently, hypothetical faint effects in interferometers connected to non-commutativity of position variables in different directions originating at the Planck scale have been considered, as a possible signature of quantum gravity. In particular, this idea led to the realization of a double 40 m interferometer at Fermilab with state of the art sensitivity in the MHz domain. Although instruments such as optical interferometers represent probably the most sensitive devices currently available, their performance are still limited by shot noise, if operated with classical light. Quantum metrology, allows to overcame these limits, by exploiting quantum properties of light, therefore representing a promising avenue for enabling new discoveries.

Here we present an experiment of quantum-enhanced correlated interferometry, showing an improved sensitivity with respect to a single interferometer in revealing faint stochastic noise, such as the ones predicted by some Planck scale model. Using quantum-enhanced correlation techniques between two Michelson interferometers, we reach a sensitivity of 10-17 m/(Hz)1/2 at 13.5 MHz in a few seconds of integration time, which is 20 times better than the one of a single device. Moreover, by injecting bipartite quantum correlated states, we also demonstrated a sub shot noise sensitivity in the comparison of different interferometers' signals. In perspective, the proposed technique could allow either to reduce the size to a table top scale or to further improve the sensitivity of large setup such as the Fermilab facility.

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Session Classification: Investigating the fundamental properties of physics