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Quantum light in coupled interferometers for quantum gravity tests: the importance of quantum correlations

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Quantum states of light such as squeezing, quantum correlations and entanglement have disclosed the possibility of devising measurement schemes beyond the classical limits, originating the new field of quantum metrology. However in most of the realistic scenarios the intrinsic difficulties in generating the required quantum states, the noise and the losses has been considered for a long time hard to cope, nullifying in practice the advantage of adopting quantum strategy.
Recently, the LIGO consortium demonstrates this is no more true. The use of squeezed states allows to improve the performance of the new set-up of the gravitational waves detector GEO600, reducing the shot noise level of the measurement of 3 dB and therefore reaching its best ever sensitivity.
Incited by LIGO achievement, we developed a theoretical proposal considering squeezing and twin beams in a system of coupled interferometers devoted to the detection of quantum gravity effects, the so called "holometer" [1,2]. The great interest in these new developments of fundamental physics has led to the planning of a double 40 m interferometer at Fermilab [5].
On one side we confirmed the advantage of using independent single mode squeezing sources also in this kind of systems for reducing the photon noise (incidentally demonstrating that radiation pressure is even negligible) [3].
Even more interesting, we discovered the possibility of reaching a noise free detection of the phases correlation of two interferometers by exploiting the perfect photon number correlation in twin beams (easily realizable in lab). This means not only overcoming the shot noise limit but even avoiding the Heisenberg limit typical of the single interferometers phase estimation.
Therefore, our work [3] not only paves the way for reaching much higher accuracy in the holometer in construction at Fermilab or for the realization of a table top experiment to test quantum gravity. It sheds some first light on new unexpected opportunities offered by the use quantum correlations for a fundamental reduction of noise in interferometric schemes.

[1] Hogan, C. Phys. Rev. D 85, 064007 (2012).
[2] www.holometer.fnal.gov.
[3] I. Ruo-Berchera, I. P. Degiovanni, S. Olivares, M. Genovese, Phys. Rev. Lett. 110, 213601 (2013).