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Einstein-Podolsky-Rosen conditional squeezing for next generation Gravitational-Wave detectors

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The dawn of Gravitational-wave (GW) astronomy is dated September 14th, 2015, with the first direct detection of a GW signal through long-baseline Michelson-Fabry-Perot interferometers. Among the noise sources affecting these GW detectors, Quantum Noise is present in their whole bandwidth (10 Hz –10 kHz).
In the current scientific run named O4, the GW advanced detectors LIGO and Virgo attain broadband Quantum Noise reduction via frequency-dependent squeezed states of light. They are generated through a system which includes an about 300m-long detuned filter cavity, coupled to the interferometer. However, this required additional infrastructure work and maintenance, and it increases the optical losses by at least 50 ppm for each round-trip inside the filter cavity.
In the Advanced Virgo detector site, we are working on a table-top prototype to probe an alternative strategy for broadband Quantum Noise reduction based on two-mode Einstein-Podolsky-Rosen (EPR) entangled squeezed light. In principle, this novel scheme works without the presence of any external cavity in the detector. The EPR-entangled beams will propagate in a small-scale suspended interferometer with high-finesse arm-cavities. This proof-of-principle experiment aims at a future integration of the EPR technique in GW detectors, being the first to validate it at audio frequencies, suited for GW detection. Before experimental proofs, simulations are required to support the validity of the chosen setup and to evaluate the sensitivity improvement brought by the EPR scheme in GW detectors.
An EPR squeezer would represent a cheaper, more compact and more flexible alternative than the current scheme, especially in consideration of further upgrades of Advanced Virgo, and of future detectors, such as the Einstein Telescope.
The talk proposed here illustrates the most recent advancements concerning the EPR experiment, both in laboratory implementation and in software simulations.

Collaboration

Role of Submitter

I am the presenter

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