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Two-color Einstein-Podolsky-Rosen entangled state in the sub-kHz regime

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Since the third observation run, Quantum Noise Reduction (QNR) techniques have become fundamental for Gravitational Wave Detectors (GWDs). Various alternatives to broadband QNR are currently being investigated. Specifically, we are exploring the measurement of a GWD signal in the reference frame of an auxiliary quantum system that mimics the dynamics of a free mass and exhibits the same response to the quantum noise of light [1,2]. The scheme requires the GWD to be coupled to the quantum reference via two-color Einstein-Podolsky-Rosen (EPR) entangled beams [3], establishing a quantum channel between the detector and a cesium atomic ensemble. The atomic ensemble has the special propriety of acting as an effective negative mass oscillator, essential for the QNR [4]. In this presentation, I will describe the first generation of a two-color EPR entangled state in the sub-kHz regime. The performance improvement is obtained by generalising the coherent control scheme currently implemented in single-mode squeezing sources to the control of a two-color EPR state. This represents a significant step towards enabling the negative mass reference system approach for broadband noise reduction in GWDs.

[1] F. Ya. Khalili and E. S. Polzik. Phys. Rev. Lett. 121, 031101 (2018).
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