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Compensating decoherence of squeezed light in cavity-enhanced quantum metrology

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Quantum states of light are being more commonly used to increase the sensitivity of various sensors. They allow to reach high sensitivity without using significant light power, and thus find application in various fields, from biological sensing to gravitational-wave detection. At the same time, these states are very fragile, and even a small amount of decoherence can significantly reduce their benefit. We propose a new approach that allows to compensate part of quantum decoherence, thus increasing the sensitivity beyond the previously established decoherence-induced quantum limit. To achieve this, we use an optimally tuned quantum squeezer placed directly inside the detector cavity. This squeezer operates to restore the externally injected squeezing or to amplify the signal, depending on the level of loss. It can be flexibly tuned to the optimal operation. We present the first experimental combination of intra-cavity and externally injected squeezing used to enhance detector's sensitivity. We demonstrate for the first time how optimal tuning allows to compensate quantum decoherence. Finally, we derive the new decoherence-induced quantum limit. Based on this approach, we develop the quantum expander for the detection bandwidth of GW detectors, which allows to significantly increase the sensitivity at high frequencies.

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