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Improving Gravitational-Wave Detectors with Entangled Light

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Squeezed light now has a firm place as a key technology for reducing the quantum noise in gravitational-wave detectors. Quantum noise of coherent and squeezed states is characterized by gaussian measurement uncertainties in their amplitude and phase quadratures. While in a coherent state both quadratures have the same (minimal) uncertainty, in squeezed states the uncertainty in one quadrature is reduced at the cost of increased uncertainty in the other, orthogonal quadrature. The phase quadrature uncertainty appears as shot noise in interferometry, while the amplitude noise appears as radiation pressure noise. This leads to the difficulty of having to transition between the two over a narrow frequency band, in order to get a quantum-noise reduction over a broad frequency range.

Conversely, two-mode squeezed states of light, or entangled states of light, have their uncertainty defined as a sum or difference between two separate modes. Only after measurements on these two modes are compared, their mutual correlation and reduced uncertainty is revealed. This allows for novel approaches in quantum-noise reduction in post-processing, such as the EPR squeezing scheme (Ma et al., 2017) or quantum-dense metrology (Steinlechner et al., 2013). I will review these approaches and report on experimental implementations and results in table-top setups.

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