Squeezing by Nonlinear Amplitude-Dependent Phase Shift and How to Make Use of It

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One of the most promising applications for squeezed light is interferometry beyond the shot-noise limit (SNL). To date, only squeezed light generated by parametric down-conversion has been used to improve interferometer sensitivity. Remarkable results have been achieved with this approach, including applications to large-scale gravitational wave detectors. On the other hand, there exists a potentially more robust way to generate squeezed light, that is, using the optical Kerr effect. It occurs almost for free in optical fibers and requires no phase matching. However, no interferometer sensitivity enhancement has been demonstrated so far using this method. One of the reasons for that is that the uncertainty distribution of a Kerr-squeezed state in phase space is tilted with respect to the amplitude or phase quadratures. Additional obstacles include Raman and guided acoustic wave Brillouin scattering in fibers.

One way to work with Kerr-squeezed states is to produce a polarization-squeezed state [1]. We developed a novel setup for the generation of polarization squeezed states via the Kerr effect in optical fibers [2], which greatly improves stability and robustness. By splicing two equal-length pieces of polarization-maintaining fiber with a 90-degree rotation around its axis, we removed the need for free-space phase-sensitive elements. This essentially all-fiber setup has little sensitivity to external fluctuating factors and delivers more than 5 dB of squeezing. The generated squeezing persisted on the timescale of days without any adjustments.

This Kerr squeezed light we applied to an interferometer and enhanced the signal-to-noise ratio by 4 dB beyond the SNL [3]. This is the first demonstration of interferometric phase sensitivity enhancement by Kerr squeezed light.

References

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