Multimode Squeezing Reconstruction *Via* Direct Intensity Measurement

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Multimode squeezed light is an increasingly popular tool in photonic quantum technologies, including sensing, imaging, and computing [1]. In metrology, it provides the measurement of the phase beyond the classical sensitivity limit [2,3], its role was crucial for the first observation of gravitational waves [4]. At the same time, multiple squeezed modes are promising tools for continuous-variable quantum computing, quantum information processing and quantum communication, where each mode (qumode) serves as an information carrier and a large set of modes can be used for the cluster sates generation and measurement-based quantum computation [5].

With numerous applications of multimode squeezed light, it is important to characterize squeezing in multiple spatial and temporal modes. However, the existing methods of its characterization (homodyne detection, projective filtering) are technically complicated, and in the best case, deal with a single mode at a time. We present a method [6] based on a cascaded system of nonlinear crystals to simultaneously measure squeezing in different spatial modes. In such a system, the second crystal serves as an amplifier/deamplifier for the squeezed light generated in the first crystal (squeezer). The direct intensity measurement of light after the amplifier allows us to reconstruct the squeezing of the light generated in the first crystal.

Our theoretical approach is based on solving systems of integro-differential equations for each crystal separately and for the entire cascaded system, forming an SU(1,1) interferometer. Using a diffraction-compensated interferometer configuration, we construct a processing method for obtaining information about the squeezing in each output mode of the squeezer by measuring the output intensity of light of the full nonlinear interferometer. In such a case, all squeezer modes are amplified (or deamplified) simultaneously. We demonstrate a good agreement between the presented theoretical approach and experiment, in which the degrees of squeezing and anti-squeezing for eight strongest spatial modes were measured.

References

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