EPR entanglement in asymmetric systems

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Entangled beams of light have been proposed for use as a resource in many quantum systems. One experimental challenge encountered in continuous variable optical entanglement is the inevitable existence of losses in the system, which ultimately degrade the entanglement that can be used and measured. The deterioration of the entangled state when losses exist in different parts of the experiment is discussed. Two different measures of entanglement, inseparability and EPR entanglement, are compared.

We present work on optimizing biased entanglement, where one squeezed beam is mixed with a vacuum mode to produce an entangled state [1]. EPR entanglement that results from this method is of interest to Quantum Key Distribution (QKD) systems, where one party (Bob) tries to predict the data sent by another party (Alice). QKD establishes a secure key for sending encrypted information between these two parties. Such schemes, in the continuous variable regime, originally required a line loss of less than 50 % [2]. This limitation has since been overcome with post-selection protocols, and by the use of reverse reconciliation [3]. Nevertheless, an improvement of EPR correlations for a given amount of loss in a system is useful, as it can lead to an increase in the rate at which the key and subsequent information can be transferred.

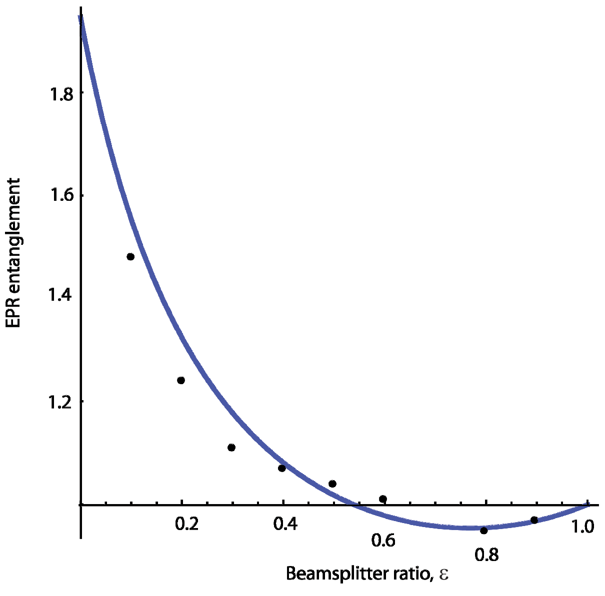

Fig. 1: EPR entanglement in one direction for a biased entanglement setup. There is no entanglement for a conventional 50:50 beamsplitter, but entanglement is achieved using an 80:20 beamsplitter.

We investigate the effect of changing the beam-splitting ratio in a biased entanglement setup. We compare our experimental and theoretical results, and find the optimal EPR entanglement for a given set of losses in the system as we change the mixing ratio. We consider losses in two different places in the setup - losses on the beam before the beam-splitter is encountered, and losses on one arm after the splitting. Losses before the beam-splitter always occur, to some extent, in the squeezed beam, and the losses on one arm of the entanglement correspond to a line loss in a data transfer system.In a biased entanglement setup, the optimal beamsplitter ratio is given by $\epsilon = \frac{1}{2\eta}$, where η is the transmission before the beamsplitter. For the case where losses exist both before the beamsplitter, and on one arm of the entanglement, there is also an optimum ratio that can occur away from the 50/50 ratio normally used. Using this, we measured biased EPR entanglement for losses that would normally prevent it from being measured.

References

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