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# **WITHDRAWN** Particle vs. Mode Entanglement in Quantum Enhanced Optical Metrology

*Wednesday, 17 June 2015 19:16 (2 minutes)*

We describe the role of mode and particle entanglement in Quantum Enhanced Optical Metrology (QEOP). To this end we study the properties of the quantum Fisher information $\mathfrak{F}$ that bounds from below the sensitivity $\Delta^2\varphi$ of any phase estimation protocol $\Delta^2\varphi \geq 1/\mathfrak{F}$.
We recently showed [1] that the optimal measurement sensitivity of quantum light in a path symmetric Mach-zender interferometer depends on its inter-mode correlations and intra-mode correlations in the following manner $\mathfrak{F} = \bar{n}(1+\mathcal{Q})(1-\mathcal{J})$
where $\bar{n}$ is the total number of photons in the MZI (assumed to be equally distributed in both arms), $\mathcal{Q}$ is the Mandel $\mathcal{Q}$ parameter (assumed to be the same for the two modes) and $\mathcal{J}$ is the mode correlation parameter.

The intra-mode correlations in the form of non-classical counting statistics associated with the $\mathcal{Q}$ parameter of each arm of the interferometer are identified with particle entanglement whereas the inter-mode correlations in term of $\mathcal{J}$ are associated with mode entanglement.

We discuss the effects of each type of entanglement in phase estimation and show that mode entanglement is not necessary for quantum enhanced sensitivity and that particle entanglement is always necessary for an enhancement, but, it is also always necessary for a suppression of sensitivity.

In more general terms we show that particle entanglement does not fit the usual notions of a resource for QEOP since one can map states that are useful for QEOP to states that are not via particle local operations.

[1] J. Sahota and N. Quesada, Phys. Rev. A **91**, 013808 (2015)

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