Using Entangled Generalized Coherent States for Photonic Quantum Metrology

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Quantum metrology involves estimating unknown parameters in quantum systems, utilizing techniques like entanglement and squeezing to surpass classical measurement limits [1, 2]. Classical protocols for parameter estimation with N probes are restricted by the shot-noise limit of $1/\sqrt{N}$, but quantum protocols can achieve the Heisenberg limit of $1/N$, enhancing estimation sensitivity. Such quantum-enhanced sensitivity finds application in fields ranging from gravitational wave detection [3] to quantum imaging and quantum frequency standards [4]. Photonic quantum metrology is based on using an interferometric setup with non-classical light state as the input. Numerous studies have explored the advantages of certain entangled states of light such as the NOON state [5] and entangled coherent state [6]. However, their experimental realisations through various strategies remain a problem in terms of scalability.

Our work introduces entangled generalised coherent state (EGCS) and its potential for photonic quantum metrology.
We have theoretically shown that such states achieve the Heisenberg limit for phase sensitivity, and under certain conditions, even surpass that limit. This proves it to be more advantageous compared to the NOON and entangled coherent states, even at smaller mean photon numbers. We further propose a simple scheme to experimentally generate these entangled generalised coherent states with current technology [7].

References

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Figures

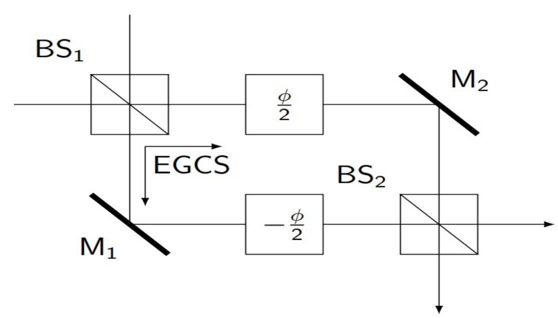

Figure 1: Mach-Zehnder interferometric set-up used to analyse the phase sensitivity in photonic quantum metrology schemes