Quantum-enhanced joint estimation of phase and phase diffusion

Jayanth Jayakumar
Monika E. Mycroft, Marco Barbieri, and Magdalena Stobińska

Faculty of Physics, University of Warsaw,
ul. Pasteura 5, 02-093 Warszawa, Poland

jay2nth@gmail.com

Accurate phase estimation in the presence of unknown phase diffusive noise is a crucial yet challenging task in noisy quantum metrology. This problem is particularly interesting due to the detrimental impact of the associated noise [1]. In our work, we numerically investigate the joint estimation of phase and phase diffusion using generalized Holland-Burnett (gHB) states [3]. We adopt a twofold approach by analyzing the joint information extraction through double homodyne measurement [2] and the joint information availability across all probe states. Through our analysis, we find that the highest sensitivities are obtained by using states created by directing all input photons into one port of a balanced beam splitter. Furthermore, we infer that good levels of sensitivity persist even in the presence of moderate photon losses, demonstrating both the metrological resourcefulness and experimental feasibility of our probe states.

References

[1] M. G. Genoni, S. Olivares, and M. G. A. Paris, Phys. Rev. Lett 106, 153603 (2011).

[2] M. D. Vidrighin, G. Donati, M. G. Genoni, X.-M. Jin, W. S. Kolthammer, M. Kim, A. Datta, M. Barbieri, and I. A. Walmsley, Nature communications 5, 3532 (2014).

[3] G. S. Thekkadath, M. E. Mycroft, et al., NPJ quantum information **6**, 89 (2020).

Figures

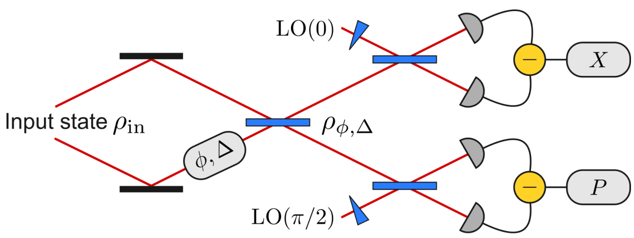

Figure 1: The theoretical scheme for the joint estimation of phase **ϕ** and phase diffusion **Δ** involves a Mach-Zehnder interferometer followed by double homodyne detection.

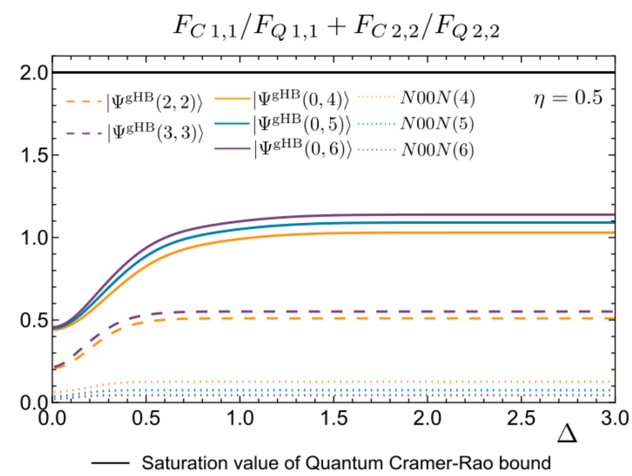

Figure 2: The double homodyne measurement extracts the highest amount of joint information from the family of probe states: $|\Psi^{gHB}(0, N)\rangle$ (N = 4, 5, 6) when compared to HB and N00N states. Note that 50% photon losses (**η** = 0.5) are accounted for, and the joint information extraction is quantified by the sum of the ratios of diagonal elements of classical and quantum Fisher information matrices: $F_{C\,(Q)\,i,\,i}$.