Variational Approach to Quantum Metrology

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The question if quantum whether quantum metrology can be enhanced by using entangled states is around for many years. In a noise free environment the question is answered by squeezed states [1] or GHZ states [2] respectively. However these sates seem to particularly susceptible to noise [3].

The question we try to address is how much we can improve if the interferometric experiment is exposed to realistic noise. While there have been various approaches to address this question by exploiting error correction schemes [4] we want to focus on a different approach. The idea is to use a closed loop variational state preparation that can compensate for different noise sources without explicitly knowing them. To pave the way to this ambitious goal we are right know digitally simulating the variational state preparation and frequency noise, with different coherence times, to figure out in which scenarios we can actually improve compared to un-entangled states.

To address this question we evolve the density matrix, which is initially the variational prepared state, according to the dissipative map that describes the considered frequency noise. To bound the sensitivity of these density matrices we calculate the (quantum) Fisher informatio. Experimentally the different sensitivities measures correspond to different requirements on the resolution of the measurement.

This analysis allows to us to predict the possible entanglement improvement depending on the resources (possible variational gates and measurements) that a certain experimental platform provides.

Keywords: QUANTUM METROLOGY, ENTANGLEMENT, VARIATIONAL QUANTUM SIMULATION, HYBRID QUANTUM-CLASSICAL ALGORITHM

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