Recovering quantum metrology advantage in the presence of noise

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The field of quantum metrology has been intensively studied, aiming to find quantum measurement strategies which provide the most precision in experiments. In the absence of noise, the Cramer-Rao bound dictates ultimate precision, known as the standard quantum limit (SQL), for uncorrelated input states scaling with $N^{-1/2}$, where N is the number of the probes. It has been shown that utilizing quantum resources, e.g., entanglement, squeezed states [1], can enhance the measurement precision, reaching the Heisenberg limit with N^{-1} scaling. Previous works have investigated the qubit's phase estimation via Ramsey measurement for several noise scenarios [2, 3]. However, in the presence of certain types of noise, the Heisenberg scaling is no longer achievable, thus negating any quantum advantage [4]. Using controls [5, 6, 7], however, it is possible to mitigate the effect of noise. In this work, we show that using multi axis control (see e.g. [8]) leads to better than SQL scaling, and can even recover Heisenberg scaling under appropriate conditions.

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