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Quantum enhanced estimation of a multi-dimensional field.[1] ANIMESH DATTA, University of Warwick, TILLMANN BAUMGRATZ, University of Oxford — We present a framework for the quantum-enhanced estimation of multiple parameters corresponding to non-commuting unitary generators. We derive the quantum Fisher information matrix to put a lower bound on the total variance of all the parameters involved. We present the conditions for the attainment of the multi-parameter bound, which is not guaranteed unlike the quantum metrology of single parameters. Our study also reveals that too much quantum entanglement may be detrimental to attaining the Heisenberg scaling in the estimation of unitarily generated parameters. One particular case of our framework is the simultaneous estimation of all three components of a magnetic field. We propose a probe state that demonstrates that the simultaneous estimation of the three components is better than the precision of estimating the three components individually. We provide realistic measurements that come close to attaining the quantum limit, exhibiting the advantage of simultaneous quantum estimation even in the case of non-commuting generators. Our work applies to precision estimation any Hamiltonian, and may be employed in efficient process tomography and verification. Our theoretical proposal can be implement in any finite dimensional quantum system such as trapped ions and nitrogen vacancy centres in diamond.

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