Tensor Networks for Quantum Metrology

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Abstract: we provide a comprehensive framework exploiting matrix product operators (MPO) type tensor networks for quantum metrological problems. The MPO formalism allows for spatial and temporal noise correlations, in particular, one may determine the maximal achievable estimation precision in such models, as well as the optimal probe states in previously inaccessible regimes. Moreover, the application of infinite MPO (iMPO) techniques allows for a direct and efficient determination of the asymptotic precision of optimal protocols in the limit of infinite particle numbers. We illustrate the potential of our framework in terms of an atomic clock stabilization (temporal noise correlation) example as well as for magnetic field sensing in the presence of locally correlated magnetic field fluctuations (spatial noise correlations). As a byproduct, the developed methods for calculating the quantum Fisher information via MPOs may be used to calculate the fidelity susceptibility - a parameter widely used in many-body physics to study phase transitions.