# Abstract

Quantum metrology exploits non-classical phenomena, such as coherence and entanglement, to enhance measurement precision. This thesis advances theoretical metrology in two different directions. First, I develop general theoretical tools to study fundamental metrological limits in the relatively unexplored regime of correlated signal and noise. Second, I focus on quantum-inspired superresolution imaging and demonstrate how temporal optical signal correlations serve as a valuable metrological resource.

The first part (Chapters 2–4) develops techniques for quantum Fisher information (QFI) optimization over general adaptive metrological protocols in the presence of correlated noise. Exact solutions, demonstrated in previous works, are feasible only for small channel numbers (typically $N \leq 5$). In this thesis, the large-$N$ limit is explored, for which lower and upper bounds for the optimal QFI are derived.

Chapter 2 presents tensor-network-based methods that handle adaptive protocols under ancilla dimension constraints. Applicable to both correlated and uncorrelated scenarios, these methods provide constructive lower bounds for significantly larger systems than previously possible.

Chapter 3 derives universal upper bounds for adaptive QFI in uncorrelated models. The derived bounds are proven to be asymptotically tight. This enables the proof of the general asymptotic equivalence between the metrological performance of parallel and adaptive schemes, which was a long-standing open question.

Chapter 4 extends the bounds derived in Chapter 3 to the fully general case involving signal and noise correlations. This allows us to study two canonical physical cases involving correlations—phase estimation in the presence of correlated dephasing noise, and collisional quantum thermometry.

Chapter 5 introduces a universal measure of the vulnerability of quantum estimation precision to measurement imperfections, which we call Fisher information measurement noise susceptibility (FI MeNoS). We demonstrate the usefulness of this quantity in analyzing interferometry and superresolution imaging scenarios. We show that sub-Poissonian photon statistics, arising from antibunching, enable to construct a less noise-susceptible measurements for a binary source separation estimation.

Chapter 6 shows how temporal correlations of optical signal resulting from emitter blinking enhance quantum-inspired superresolution. We consider estimation of spatial moments for arbitrary objects. Correlations are shown to enhance precision of higher spatial moments estimation and, more importantly, to enable extraction of the information about these higher moments using significantly simpler measurements.