Multiparameter Quantum Metrology enhanced by entanglement

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Quantum Metrology explores the optimal exploitation of quantum resources, such as coherent superpositions, squeezing, and entanglement, to amplify the precision of measurements relying on parameter estimation. This interdisciplinary field spans a wide range of physical systems and applications, encompassing atomic clocks, interferometers, magnetometers, and gravitational wave detectors, thereby constituting a fundamental pillar within the emerging domain of Quantum Technologies. In this talk, I will illustrate fundamental concepts in quantum metrology [1], emphasizing notable accomplishments and avenues for ongoing research. Subsequently, I will focus on the pivotal role of entanglement in the estimation of multiple parameters within quantum networks [2,3]. The theoretical framework will be exemplified through a specific case study [4] involving a multi-mode quantum interferometer model that is relevant to both photons and atoms.

[1] LP, A. Smerzi, M.K. Oberthaler, R. Schmied, and P. Treutlein, "Quantum metrology with nonclassical states of atomic ensembles", Rev. Mod. Phys. 90, 035005 (2018)

[2] M Gessner, LP, and A. Smerzi, "Sensitivity bounds for multiparameter quantum metrology", Phys, Rev. Lett. 121, 130503 (2018)

[3] M. Gessner, A. Smerzi, and LP, "Multiparameter squeezing for optimal quantum enhancements in sensor networks", Nat. Comm. 11, 3817 (2020)

[4] M. Malitesta, A. Smerzi, and LP, "Distributed quantum sensing with squeezed-vacuum light in a configurable array of Mach-Zehnder interferometers"
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