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Distributed quantum sensing with a network of Mach-Zehnder interferometers

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Distributed quantum sensing is at the forefront of multiparameter quantum metrology [1], offering a powerful framework where quantum states are spatially distributed among multiple sensing nodes to enable the simultaneous estimation of several parameters. Despite significant progress, a clear consensus on the advantages of quantum resources —such as entanglement and squeezing —over standard single-parameter schemes remains elusive.
In this talk, I will address the fundamental sensitivity bounds in distributed quantum sensing by analyzing a sensor composed by an array of spatially distributed Mach-Zehnder interferometers (MZIs) [2,3,4]. The model provides a fully analytical playground for optimizing and understanding distributed sensing, with applications in clock synchronisation, inertial sensing and navigation [5]. I will provide a thoughtful comparison with separable schemes using independent MZIs, which highlights the tangible advantages of entanglement under different resource constraints. I will also discuss very recent experimental results [6].
Overall, this talk offers new insights into the role of quantum resources in distributed sensing and their potential to enhance practical multiparameter metrology.

[1] L. Pezzè and A. Smerzi, Advances in multiparameter quantum sensing and metrology, arXiv:2502.17396

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[3] M Malitesta, A Smerzi, and L Pezzè, Distributed quantum sensing with squeezed-vacuum light in a configurable array of Mach-Zehnder interferometers, Physical Review A 108 (3), 032621 (2023)

[4] L Pezzè and A Smerzi, Distributed quantum multiparameter estimation with optimal local measurements, arXiv:2405.18404

[5] R. Corgier et al. Quantum-enhanced differential atom interferometers and clocks with spin-squeezing swapping, Quantum 7, 965 (2023)

[6] Z Yan, Y Feng, L Pezze, et al. Scalable Network of Mach-Zehnder Interferometers with a Single Entangled Resource, arXiv:2509.08230

Orateur: PEZZE, Luca (INO, Firenze)