Mini-course: Quantum Imaging

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The course will provide a brief introduction to optical microscopy and an extensive survey of the current state of affairs in quantum imaging modalities, aiming for improved performance (resolution, sensitivity, reduced photobleaching) by harnessing quantum phenomena.

Syllabus

I. A brief historical overview of (classical) optical microscopy

The optical microscope, the resolution limit, commonly used microscopy methods, advanced microscopy (multiphoton, superresolution)

II. Quantum-inspired and quantum photon statistics-based microscopy

Computational imaging, mode sorting, photon statistics as a resource in imaging.

III. Quantum entanglement and squeezing based imaging

The Heisenberg limit, entanglement and squeezing, ghost imaging, imaging with undetected photons, k-space and polarization entanglement in imaging.

Relevant references:

I. J. Mertz, "Introduction to optical microscopy" (Cambridge University Press)
B. R. Masters, "Superresolution optical microscopy" (Springer)

II. M. Tsang et al., "Quantum theory of superresolution for two incoherent optical point sources", Phys. Rev. X 6, 031033 (2016).

O. Schwartz et al., “Superresolution Microscopy with Quantum Emitters”, Nano Lett. 13, 5832 (2013).

III. G.B. Lemos et al., “Quantum imaging with undetected photons”, Nature 512, 409 (2014).

B. Dayan et al., “Nonlinear Interactions with an Ultrahigh Flux of Broadband Entangled Photons”, Phys. Rev. Lett. 94, 043602 (2005).

C.A. Casacio et al., “Quantum-enhanced nonlinear microscopy”, Nature 594, 201 (2021).

H. Defienne et al., “Polarization entanglement-enabled quantum holography”, Nature Physics 17, 591 (2021).

A recent review: W.P. Bowen et al., “Quantum light microscopy”, CONTEMPORARY PHYSICS
https://doi.org/10.1080/00107514.2023.2292380