SU(1,1) interferometers and the concept of induced coherence: a tool for imaging, sensing and exploring fundamental physics

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In 1986, Yurke et al. [Phys. Rev. A **33**, 4033 (1986)] introduced a new class of interferometers characterized from a Group Theory perspective by matrices belonging to the SU(1,1) group. In 1991, Zou et al. [Phys. Rev. Lett. **67**, 318 (1991); Phys. Rev. Lett. **69**, 3041 (1992)] introduced an interferometer based on the concept of induced coherence. In the last decade, there has been a surge in papers that make use of these concepts for imaging, sensing, spectroscopy and optical coherence tomography, among other applications, as well as for exploring fundamental aspects of quantum physics [Rev. Mod. Phys 94, 025007 (2022)]. These interferometers allow to reach a sensitivity of 1/N in phase estimation, with N being the number of photons travelling the interferometer. As practical advantage, these schemes also allow probing a sample under investigation with one wavelength and measuring light with another wavelength. This can result in a deeper penetration into the sample thanks to probing with longer wavelengths, while still using the optimum wavelength for detection.

In this talk we will revisit the main experimental configurations considered in most applications, and will discuss some requirements that these interferometers should fulfill. We will review some applications. We will also discuss results that show how these interferometers can be incorporated to the set of physical systems where one can demonstrate experimentally a complementarity relationship, i. e, the interplay between the degree of quantum coherence between the two paths that a photon can take in an interferometer and the amount of distinguishing information regarding the path taken by the photon. In mathematical terms, this complementarity relationship translates beautifully in a simple quantitative relationship of the form $D^2 + V^2 = 1$ where D (distinguishability) is a measure of how much information is available about the path taken by the photon and V is a measure of the degree of quantum coherence.