Theory of Coherence: Coherence properties of light, phase retrieval from intensities

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The underlying concepts of the theory of coherence are quite simple, a fact that is almost always obscured behind a very complex mathematical formalism and an obscure terminology.

In this talk I will provide an intuitive physical picture of optical coherence that is able to capture almost all of the essential features. The conceptual picture is based on the Wigner function (Wigner 1932), a quantum mechanical description that relies on the writing of a quasi-probability distribution for position and momentum. The connection between optical coherence theory and the Wigner function will be established (Bastiaans 1986). The formalism treats the flow of optical energy as analogous to the flow of a time-independent compressible fluid. As with the case of fluid flow, structures such as eddies and vortices emerge naturally. And phase retrieval is seen as analogous to the process of determining the velocity distribution in the fluid. Examples of applications of this picture to optical coherence phenomena will be given.

The ideas that flow from this picture will then be used to explore methods of phase retrieval in a rather unified manner (Nugent 2007). The same ideas will also be used to consider the underlying principles of coherent diffractive imaging (Miao, Charalambous et al. 1999), the issues that arise when the wavefield is not entirely coherent (Williams, Quiney et al. 2007) and to give some insight as to why the introduction of curved wavefields can improve the reliability of the imaging methodology (Williams, Quiney et al. 2006)

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