PHASE IMAGING IN PARTIALLY-COHERENT MICROSCOPY

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There are advantages to the reconstruction of phase information using a partially-coherent microscope. In particular, the spatial frequency bandwidth is increased as compared with a coherent system. Approaches to phase imaging include using defocused image information, as in the transport of intensity method, or asymmetric illumination as in differential phase contrast. Image formation in a partially-coherent microscope can be investigated based on representations in phase space (mutual intensity, Wigner distribution function, and ambiguity function). The theory simplifies considerably for the special cases of a weak object or a slowly-varying phase object. In these cases, imaging can be described using a weak object transfer function (WOTF) or phase gradient transfer function (PGTF), respectively.

Explicit expressions are presented for different phase space representations of the partially coherent image wave field in a microscope system [1]. These are separated into system and object dependent parts, in a similar fashion to the transfer function approach in conventional imaging. The image intensity can be expressed in terms of a 4D kernel, the convolution in spatial frequency of the source and the Wigner distribution function of the objective pupil. The partially coherent image in phase space, on the other hand, can be described in terms of different 6D system-dependent kernels, all Fourier transforms of the system mutual spectrum, the region of overlap of two displaced objective pupils and the effective source.

The relationships between the defocused partially coherent cross-coefficient and the different phase space representations in the image plane are derived [2]. Measurement of a phase space representation in the image plane in principle allows the complex image to be extracted. Implications for phase retrieval using the weak object transfer function or the transport of intensity equation are considered. The phase gradient transfer function, which determines the image for an object exhibiting a slowly varying phase gradient, for a partially coherent microscope system is derived. The effect of the effective source size and geometry on phase imaging with the transport of intensity equation is investigated. The primary consequence of source shape is a rescaling of the phase reconstruction. An annular source is found to give close to a linear response, at the same time providing improved transverse resolution and improved response to low spatial frequencies.

REFERENCES

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