Superresolution by means of polarisation, phase and amplitude pupil masks

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Focussing light to a very tight spot is a subject of interest in several fields such as confocal microscopy, optical recording, optical traps, and scanning optical near field microscopes. As it is well known, for a given system composed of an incident field distribution and an objective, the shape of the field in focus in the case of low numerical aperture systems is simply given by the Fourier transform of the field at the aperture. However, as the numerical aperture approaches unity as is the case for high resolution microscopes, the scalar theory is not valid anymore since polarisation starts to play an important role, and as a result, the field distribution in focus becomes more intricate. One classical example is a uniform distributed, linearly polarised entrance field focussed by a high numerical aperture lens which becomes elliptical in contrast with the symmetric field expected from the scalar theory. Some suggestions to change the shape of the field in focus are encountered in the literature and they involve the use of phase and amplitude masks[1,2], and recently the use of radially polarised light.[3] But as a general rule, one can say that the trade-off between superresolution and efficiency in concentration of energy at the center spot is unavoidable: one is reached at the cost of the other.

We propose here a new way to shape the field in focus in order to achieve superresolution while keeping the side lobes small which is based on a filter where not only the amplitude and the phase of the field at the pupil but also the polarisation can be varied. Polarisation adds a new degree of freedom to the optimisation problem which can be interesting in some cases, since the polarisation vectors may add constructively, destructively or not interfere at all (in the case of orthogonally polarised vectors).

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[2] M. Bertero, P. Boccacci, R. E. Davies, F. Malfanti, E. R. Pike, J. G. Walker, Inverse Problems **8**, 1 (1992).
[3] S. Quabis, R. Dorn, M. Eberler, O. Glöckl, and G. Leuchs, Opt. Commun. **179**, 1 (2000).