INVERSE PROBLEMS IN HIGH NUMERICAL APERTURE FOCUSING SYSTEMS

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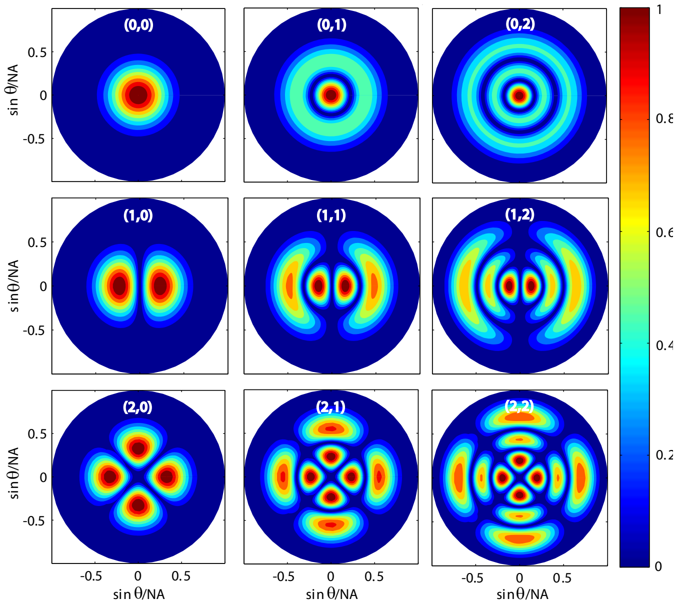

Figure 1: Two dimensional in-focus eigenfunctions of order (N, n) for focusing by ahigh NA optical system.

Synthesis of arbitrary field distributions in optical systems is useful for a wide variety of applications including lithography, optical data storage, atomic manipulation and polarisation microscopy. Although there are a number of alternative methods by which to produce a desired field distribution such as apodisation or phase masks, polarisation structuring and computer generated holograms numerical optimisation is normally used to determine the appropriate mask or field distribution to use. We however present an analytic method based upon an eigenfunction expansion developed by the authors [1] (see Fig. 1) to invert the Debye-Wolf integral which is routinely used to describe focusing by high numerical (NA) lenses [2]. In principle the new method allows an arbitrary field distribution to be specified in the focal region of a high numerical aperture lens and the appropriate weighting function, or equivalently the pupil plane distribution, to be calculated. Various additional considerations do however constrain the inversion to ensure physicality and practicality of the results including degrees of freedom, encircled energy and noise amplification.

Furthermore exact reproduction of the required pupil plane field distribution is not generally possible in practise due to the pixelated nature of the liquid crystal spatial light modulators often used to implement complex masks [3]. As such an error on the focused field distribution is introduced. Results pertaining to determination of the appropriate pixel values such that this error is minimised are also presented.

[1] S.S. Sherif, M.R. Foreman and P. Török, submitted to Optics Express (2008)
[2] B. Richards and E. Wolf, Proc. Roy. Soc. London A, **253**, 358-379 (1959).
[3] M.A.A. Neil, F. Massoumian, R. Juškaitis, and T. Wilson Opt. Lett. **27** 1929–1931 (2002)