4Pi-microscopy with one focussing objective

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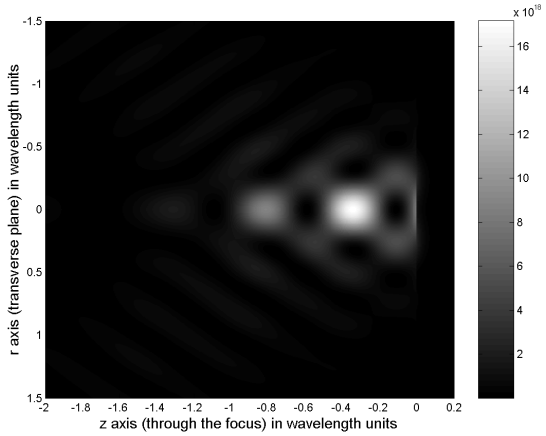
Super resolution is an important issue in high resolution microscopy. Several ways to achieve super resolution have been investigated and are being applied with success such as immersion microscopy and the use of pupil masks. However, in general, the spot is tight in the transverse focal plane, but not in the longitudinal direction, i.e., through the focus. One solution to this problem is the so called 4Pi microscopy, where the point spread function is manipulated by coherently combining two focussed fields of two objectives placed opposite to each other.[1] In this paper, we present an alternative way to the present 4Pi microscope scheme which uses only one objective. In order to achieve that, we have analyzed the effect on the field in focus in the presence of a reflecting surface. Our proposed system consists of an immersion objective with as input a circularly symmetric radially polarized beam. Near the focal region we place a metallic interface parallel to the transversal focal plane. With these conditions, one can calculate the field in the focal region.[2] Given the symmetry of the polarization state at the input of the lens, the field in the focal plane is cylindrically symmetric and has a quite large component in the longitudinal polarization direction. Furthermore, the size of the spot in the focal plane of the longitudinal polarization component approaches the spot predicted by the scalar theory. By placing a reflecting surface in the neighborhood of the geometrical focal plane, we studied the interference between the incoming and reflected fields, and as result we obtain a 3D focussed field with a central spot that can be made spherical, i.e., with the same resolution in the lateral and azimuthal directions. As an example we analyze an immersion system with a numerical aperture of 1.4, wavelength of 200 nm, and aluminum as the reflecting surface. The spot is cylindrically symmetric in the transverse focal plane and the central spot has a volume of 0.01 λ^3. The field intensity through the focus is shown below, with z=0 being the position of the metal surface.



[1] for a review, see S. W. Hell, Topics in Fluorescence Spectroscopy, vol.5, Ed. By Lakowicz, 1997.
[2] S. Quabis et al., Opt. Commun. **179**, 1 (2000).