Micro-endoscopy using gradient index optics based vector vortex beam manipulation

Chao He[1] & Martin J. Booth[1,2]

[1]Department of Engineering Science, University of Oxford, Parks Road, Oxford, OX1 3PJ, UK
[2]Centre for Neural Circuits and Behavior, University of Oxford, Mansfield Road, Oxford, OX1 3SR, UK

Email: martin.booth@eng.ox.ac.uk

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The gradient index (GRIN) lens has a graded refractive index profile that enables focusing and imaging through a compact rod-like structure. The lower mass and size of GRIN lenses mean that are preferable to conventional optics in many applications, such as in endoscopes and other compact imaging systems. Procedures for fabrication of GRIN lenses are well established: an ion-exchange process creates a rotationally symmetric index profile in the glass rod. There is however an undesirable side-effect: the process also introduces a concomitant intrinsic birefringence that maintains the same rotational symmetry. This gradually changing birefringence profile exhibits the following properties: 1) the magnitude of the retardance is constant at a given radius, 2) the retardance increases with increasing radius; and 3) the slow axis is oriented in the radial direction. These properties mean that the GRIN lens behaves like a spatially variant waveplate, providing a continuum of birefringence states that can manipulate the polarization and phase of a light beam. Here, we have drawn upon these GRIN lens properties to build new light manipulation structures. We call these structures "GRIN lens cascades". These cascades comprise one or more GRIN lenses with interstitial optical elements, such as polarizers, waveplates and so on.

Vector vortex beams (VVBs) have attracted great interest for a range of applications that take advantage of their structured polarization and phase profile. They can be used to control the properties of a beam focus in microscopy. Here, we show that GRIN lens cascades can act as a new beam generator to create numerous VVBs that may further aid various of imaging systems. The ability to control the profile across the VVBs also allows us to control the focal distribution of the GRIN lens itself, thus give us a chance to enhance the resolution of traditional GRIN lens based endoscopes or micro-endoscopes imaging systems.

References:

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