Extraordinary Beam Modulation with Ordinary GRIN Lenses

Stress-induced birefringence is often regarded as a nuisance phenomenon that occurs in the fabrication process of many optics, including gradient index (GRIN) lenses. Recently, we have shown that this unwanted defect can in fact be harnessed and exploited for new applications beyond traditional usage of GRIN lenses,[1] including vector vortex beam generation, focus modification and snapshot Mueller matrix polarimetric measurement.[1–3]

GRIN lenses focus light through a radially symmetric refractive-index profile. Compared with traditional lenses that have a uniform refractive index, GRIN lenses have their own unique advantages in having flat surfaces, easy coupling, low mass and size. Hence, they are widely used in compact imaging systems or for coupling to optical fibers or waveguides.

However, the ion-exchange fabrication process that creates the index profiles of these lenses also causes a radially symmetric variation in birefringence. This property induces additional polarization aberrations into GRIN-lens-based systems. Manufacturing processes are optimized to keep these aberrations—a disadvantage in many applications—to a minimum.

We have shown that these same properties can be used as a basis for optical beam generation and analysis, or to extend the capabilities of current GRIN-lens-based imaging systems.[1] By cascading one or more GRIN lenses with other optical components, their intrinsic birefringence can be used to generate vector vortex beams—vectorial beams that feature complex phase and polarization properties. In this work, we thus take a common optical device and show that it can be used in new ways to greatly enhance the structured-light toolkit and to generate a variety of beams.

Furthermore, by adapting to the polarization aberration inside the GRIN lens via suitable combination with other optical devices, we have shown that it is possible to modulate the focus of such lenses to the benefit of existing GRIN-lens-based imaging systems. Last, but not least, we presented a new form of snapshot Mueller matrix polarimetry based on a dual-cascaded GRIN lens—also validating proof-of-principle demonstrations of its potential use for differentiation between healthy and diseased tissue against conventional methods.

Overall, the birefringence of GRIN lenses and their combination in cascade with other passive/active optical components provide a wealth of opportunity for further technical development. We believe this technique has the potential to benefit a wide range of applications, from quantum optics to clinical diagnosis. OPN

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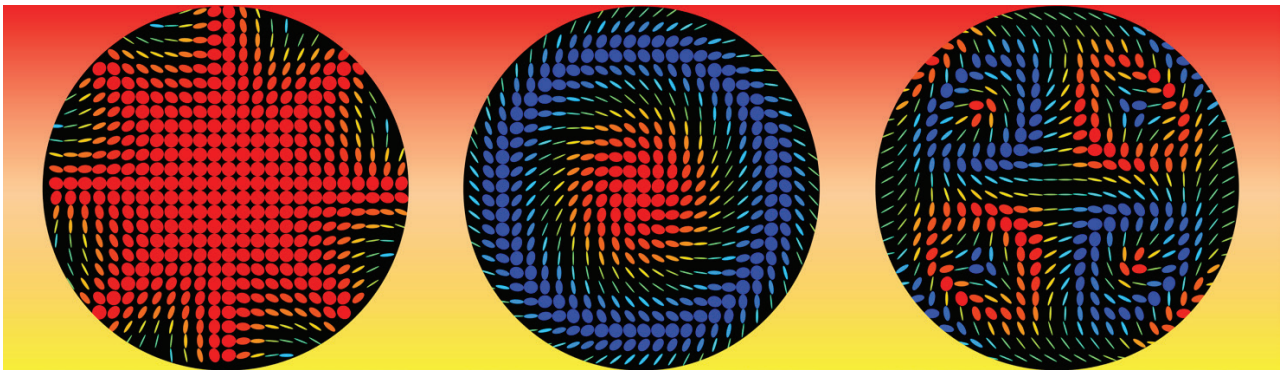

A selection of vectorial beams generated via GRIN lens cascades.