Liquid crystal spiral diffraction lenses

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Electrooptic materials, whose refractive index can be modified by external fields, can be employed to create tunable lenses with no movable parts, that result useful for many applications from spatial environment to mobile phone cameras and adaptive contact lenses. Liquid crystals are especially suitable for these applications since LC reorientation is relatively simple and low voltage driving signals are required.

However, the design of tunable LC lenses is not simple. The main difficulty is to achieve optimized electrode profiles giving the right wavefront deformation to focus flat wavefronts into a single focal point without compromising the symmetry of the electrodes [1]. Regular lenses show very low power for any reasonable birefringence and cell thickness –unless their size is reduced to microlenses; radial phase-wrapping devices like Fresnel diffractive lenses (FDL) are the best way to overcome this limitation. However, Fresnel lenses are made of a number of concentric electrodes, the larger the better, whose external electrical interconnection is extremely involved, requiring dozens of independent tracks that discontinue the circular electrodes and constrain the cell fill factor.

In this work we have developed a device having independent azimuthal and radial phase-wrapping. This is a combination of a spiral phase plate and an FDL, giving a spiral diffractive lens. No internal connections are required; the fill factor is about 0.98. Divergent and convergent lenses (1" Ø, ±2.5 diopters) can be obtained from the same device (Fig. 1).

Fig. 1. SDL system coupled to a 90cm focal lens and focused at various distances. Numbers show distance to objects. T is the topological charge.

[1] Caño-García, M., Quintana, X., Otón, J.M., Geday, M.A.; "Dynamic Multilevel Spiral Phase Plate Generator" Sci. Reports **8**, 15804 (2018). doi: 10.1038/s41598-018-34041-2.

Ackowledgements: Authors are indebted for financial help received from the "Programa RETOS" from the Ministerio de Economía y Competitividad (TEC2016-77242-C3-2-R), and the "Programa Regional de I+D SINFOTON" from the Comunidad de Madrid and European Structural funds (P2018/NMT-4326 SINFOTON2-CM) (FEDER).