Twisted Photonic Lattices Created by Elliptical Mathieu Beams

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Nondiffracting beams are highly applicable in optics, photonics, and atom physics, peculiar because their transverse intensity distributions propagate unchanged for hundreds of diffraction lengths and allow the creation 1D and 2D photonic lattices in photosensitive media[1]. Four different fundamental families of propagation invariant light fields exist, distinguish in the underlying real space coordinate system: Discrete, Bessel, Weber, and Mathieu nondiffracting beams [2-5]. *Mathieu beams* are the solution of the Helmholtz equation in elliptic cylindrical coordinates [5-7], therefore they are the best suited to address physical effects in elliptical coordinates. Mathieu beams are classified according to their symmetry properties as even and odd. Their transverse discrete intensity distributions can be shaped by their order and an ellipticity parameter. These real-valued beams are characterized by only discrete spatial phase distributions. By complex superposition of appropriate even and odd Mathieu beams, *elliptical Mathieu beams* are obtained, with remarkable continuously modulated spatial phase distributions that act as orbital angular momenta, related with transverse energy flow [8].

Experimentally and numerically, we investigated linear and nonlinear self-action of elliptical Mathieu beams in a photorefractive SBN crystal [8]. Linear propagation of elliptic Mathieu beams enables a nondiffracting transverse intensity distribution with transverse energy redistribution along elliptic paths compensated in each point. In contrast, their nonlinear self-action in SBN breaks this sensitive equilibrium and leads to the formation of high-intensity filaments, which rotate in the direction determined by the energy flow. We show that such filamentation depends on the strength of the nonlinearity and the structure size of used Mathieu beams. We investigate the nonlinear propagation of such refractive index formations in SBN crystal and show they are convenient as lattice-writing light to optical induction of two-dimensional chiral twisted photonic refractive index structures with tunable ellipticity. This study provides considerably advancing the field of chiral light and photonic structures since we demonstrated that elliptical Mathieu beams are suitable for the fabrication of two-dimensional photonic lattices with elliptic trajectories by optical induction technique.

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