Skyrmionic beam shaping from structured anisotropic media

Etienne Brasselet

CNRS, Laboratoire Ondes et Matière d'Aquitaine, University of Bordeaux, 33400 Talence, France

etienne.brasselet@u-bordeaux.fr

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Optical skyrmions — vectorial light fields with nontrivial topological textures — offer new perspectives for the manipulation of light's spin and orbital degrees of freedom, with promising applications in topological optics, optical communication, and sensing. Yet, their generation typically relies on spatial light modulators or other bulky devices, limiting practical implementation. We explore innovative strategies for compact and versatile skyrmionic beam shaping, relying on structured anisotropic media.

We first extend the concept of q-plates to design structured birefringent plates with engineered topological winding in both azimuthal and radial coordinates. This enables the generation of high-order and multi-skyrmionic beams with polarization-dependent topology, and opens the door to deterministic topological beam shaping by design [1,2].

We then demonstrate that spontaneously formed topological configurations in liquid crystal can serve as tunable, self-assembled optical skyrmion generators. These soft-matter systems enable control of both the operating wavelength and the topological characteristics of the emitted beam, through a combination of structural selection and spin-orbit optical interaction. This soft matter platform offers a route toward integrated, tunable, and reconfigurable optical elements [3].

Altogether, these approaches highlight the potential of structured anisotropic media — whether nanostructured or self-assembled — for the development of next-generation, compact and tunable skyrmionic optical devices, with unprecedented control over both wavelength and topological content.

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[3] M. Chavilkkadan and E. Brasselet, *Tunable optical skyrmions from liquid crystal structures*, in preparation.