Single Toron in an Optical Microcavity as a Photonic Trap with Unique Polarisation Properties

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Microcavities with embedded liquid crystals (LCMC) offer tunability, making them an ideal platform for simulating solid-state phenomena in photonic systems through the use of effective Hamiltonians [1]. The self-organization property of liquid crystals, largely unexplored in LCMCs, presents an opportunity to engineer photonic potentials. An example of such a structure is the toron—a chiral topological texture in cholesteric liquid crystals. The liquid crystal director's texture in torons resembles a twisted vortex configuration.

In this study, we present a micrometer-sized, chiral liquid-crystalline toron, doped with a lasing dye and embedded in an optical microcavity (Fig. 1a), that acts as a photonic trap. This light localization results in a ladder of states in the dispersion relations (Fig. 1b), significantly reducing the lasing threshold compared to a planar LCMC. Furthermore, the optical activity of the liquid crystal causes polarization to strongly depend on momentum (Fig. 1c). Our findings suggest that a single toron embedded in an LCMC can be viewed as a photonic analogue to a semiconductor quantum dot.

The system introduced here has potential applications in various photonic devices, including polarized low-threshold lasers. It could also serve as a single node in a photonic lattice with pronounced polarization properties.

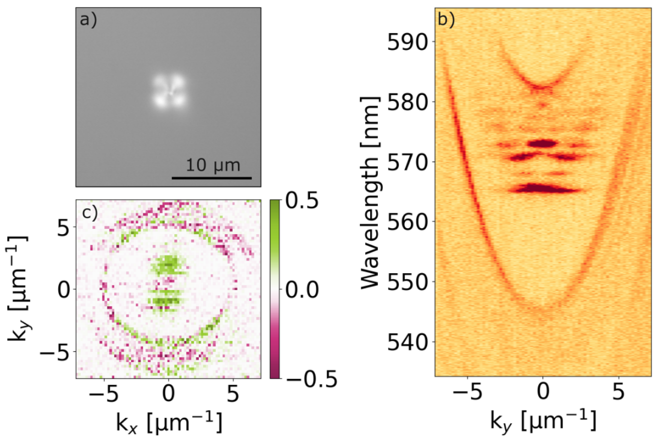

Figure 1: (a) Polarised optical microscopy photograph of single toron embedded inside LCMC. (b) Angle-resolved photoluminescence spectra measured for horizontal polarisation of light. (c) Momentum space image of S_1 Stokes component measured for wavelength $\lambda = 562$ nm. The dispersion relation with photonic bandgaps indicates the confinement of light inside a single toron.

[1] Lekenta, K., Król, M., Mirek, R. et al. Tunable optical spin Hall effect in a liquid crystal microcavity. *Light Sci Appl* **7**, 74 (2018).