Self-Assembled Two-Dimensional Lattice of Liquid Crystal Torons as a Potential Landscape for Massive Photons with Spin

Marcin Muszyński [1], Przemysław Oliwa[1], Piotr Kapuściński[1], Eva Oton[2], Rafał Mazur[2], Przemysław Morawiak[2], Wiktor Piecek[2], Barbara Piętka[1] and Jacek Szczytko[1]

[1] *Institute of Experimental Physics, Faculty of Physics, University of Warsaw, ul. Pasteura 5, 02-093 Warsaw, Poland*

[2] *Institute of Applied Physics, Military University of Technology, ul. Gen. S. Kaliskiego 2, 00-908 Warsaw, Poland*

The description of parabolic dispersion relation of photons confined within an optical microcavity might be provided by a Hamiltonian for massive particles. This analogy to solid-state physics can be further explored by employing photonic structures with periodicity on the order of the wavelength of light. In this case, similar to an electron in a crystalline potential, the presence of a lattice leads to the formation of a photonic band structure. The combination of band structure engineering and birefringence offers the control over the polarization and spin-orbit coupling of light [1]. This results in the observation of phenomena such as the optical spin Hall effect and spin-directional propagation [2].

Here, we demonstrate an optical microcavity with an embedded well-organized lattice of liquid-crystalline torons (cholesteric bubbles), which are doped with light emitters. The resulting hexagonal lattice (Fig.1a) produces a photonic potential that confines light. The direct consequence of the periodic confinement is a band structure that shares the symmetry of the photonic crystal (Fig.1(b,c)). TE-TM splitting originating from the microcavity mirrors and the optical activity of the liquid crystal lead to a unique polarization of the bands (Fig.1d). The presence of light emitters in the structure enables laser emission from lattice nodes. Due to the internal structure of torons, the laser emission carries a non-zero orbital angular momentum.

The proposed platform paves the way toward the integration of liquid crystal optical microcavities and self-organizing two-dimensional photonic potentials. The tunable band structures and phenomena related to topology and strong light-matter coupling might be milestones for future discoveries.

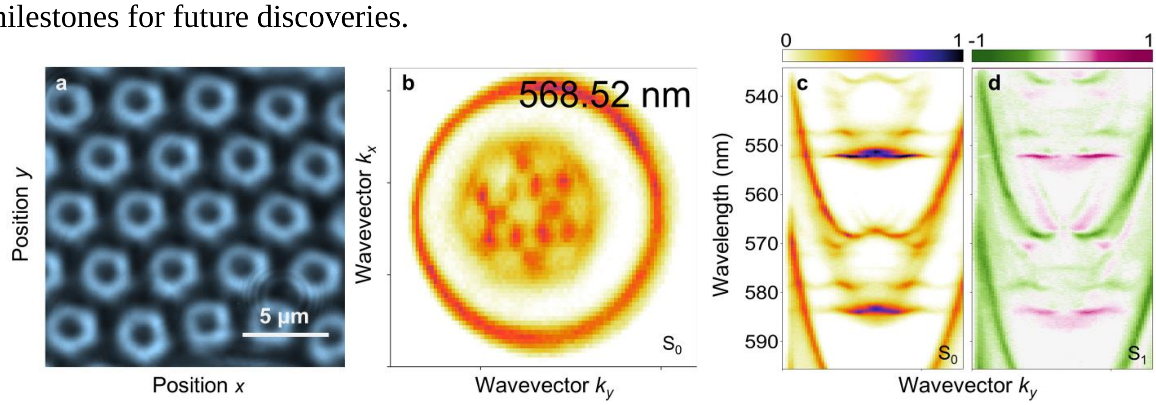

Figure 1: (a) Polarized optical microscopy photograph of the torons lattice (b) Momentum-space image collected for 568.5 nm reveals the symmetry of the photonic crystal. Angle-resolved photoluminescence spectrum of (c) total intensity and (d) Stokes parameter S_1. The strong polarization dependence of the photonic bands is well visible.

[1] M. Muszyński, et al. "*Tunable band structures coupled by intersubband spin-orbit coupling in a self-assembled photonic liquid crystal potential*" (Manuscript in preparation).
[2] K. Y. Bliokh, et al., *Nat. Photon.* **9**, 796–808 (2015).