Self-organizing photonic potential with tunable band structures coupled by spin-orbit interaction in birefringent optical cavity

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Photonic crystals with optical anisotropy possess degrees of freedom related to the polarization of light and specified directions allowed by dispersion. The coupling of photonic modes of different parity – which is possible due to birefringence – may introduce chirality [1]. If an additional periodic potential is present, the resulting photonic band gaps and eigenstates of light inherit the polazation properties of the whole system [2].

Here, we demonstrate a dye-doped optical microcavity with a built-in uniform lying helix (ULH) structure that was induced in a chiral nematic liquid crystal matrix. As a result of the presence of ULH, a one-dimensional self-organized periodic lattice of refractive index modulation was formed. We observed two separate photonic band structures with orthogonal linear polarizations of light (Figures a, b). The inclination of the helix with respect to the plane of the cavity additionally induced a Rashba-Dresselhaus spin-orbit interaction for light, which couples these two bands together. As a result of the spin-orbit coupling, new chiral states with distinct circular polarizations are formed (Figure c).

The proposed platform has several unique technological advantages. A self-assembled one-dimensional well-oriented photonic potential is formed over a macroscopic area. The period of ULH can be tuned by external electric field, thickness of the cavity and temperature. In addition, due to doping the structure with light emitters, the system can exhibit non-linear effects like the laser light emission from photonic bands, which opens new possibilities for the photonic control of light-emitting devices.

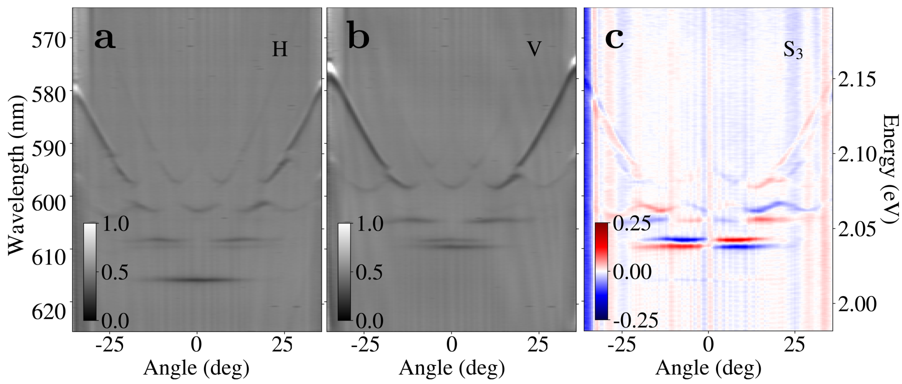

Figure 1 – Dispersion relation measured for the orthogonal linear (a) horizontal H and (b) vertical V polarization of the detected light. (c) The Stokes parameter S_3 shows circularly polarized states of light caused by Rashba-Dresselhaus spin-orbit coupling.

[1] K. Rechcińska, et al. *Science* **366**, 727-730 (2019).

[2] M. Muszyński, et al. "Band structures coupled by spin-orbit interaction in self-assembled photonic lattice in liquid crystal optical microcavities" (Manuscript in preparation)