Tunable Localized States of Light in a Liquid-Crystal Microcavity Waveguide

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The equations describing the motion of photons trapped in an optical cavity resemble the equations of motion of electrons with spin. The dispersion relation of photons is parabolic, like in the case of massive particle, and the polarization of light plays the role of spin. Using the cavity filled with a birefringent medium - liquid crystals - the optical analog of the Rashba-Dresselhaus (RD) spin-orbit coupling (SOC) has been observed [1]. It was possible to build a photonic system that perfectly imitates electronic properties and leads to many surprising physical effects, such as the persistent spin helix and Stern-Gerlach deflection of light [2].

In this work we created a tuneable waveguide – an optical analog of the semiconductor 1D quantum wire – which can be controlled by two independent electrodes. We observed quantized optical modes of light in the direction perpendicular to the wire and continuous states with parabolic dispersion along the wire. The control of optical modes on the borders of the wire allowed for swithing on and off SOC. The localized states of light were measured by means of the optical tomography in the real and the momentum space (Fig. 1). A theoretical model was proposed to describe the results obtained in the experiment. Our platform allows us to study SOC-related effects simulating non-trivial phenomena known from quantum mechanics.

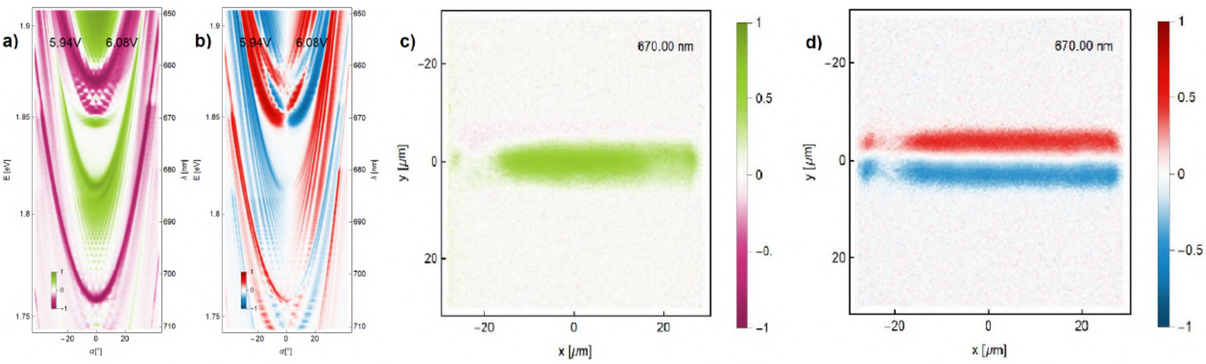

Fig. 1 Experimental results of the polarization-resolved optical tomography. Energy - momentum spectra of RD regime for localized states (i.e. perpendicular to the wire): a) degree of linear polarization b) degree of circular polarization. Spatially-resolved map of optical modes at wavelength of 670 nm c) degree of linear polarization d) degree of circular polarization.

[1] K. Rechcińska et al. *Science* **366**, 727 (2019).
[2] M. Król et al. *PRL* **127**, 190401 (2021).