Persistent Spin-Helix and Tunable Laser Operating at Room Temperature Based on Liquid Crystal Optical Microcavity

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Liquid crystal (LC) birefringent microcavities (MC) allow for a wide range of tunability of energy and polarization of confined photonic modes. In particular, if two photonic modes of an orthogonal polarization and different parity are tuned to the resonance, a characteristic scheme of spin-polarized dispersion is formed [1], which in solid-state physics is called the Rashba-Dresselhaus (RD) spin-orbit coupling. Spin coherence between such modes give a rise to long-range polarization texture, so-called an optical persistent spin-helix [2].

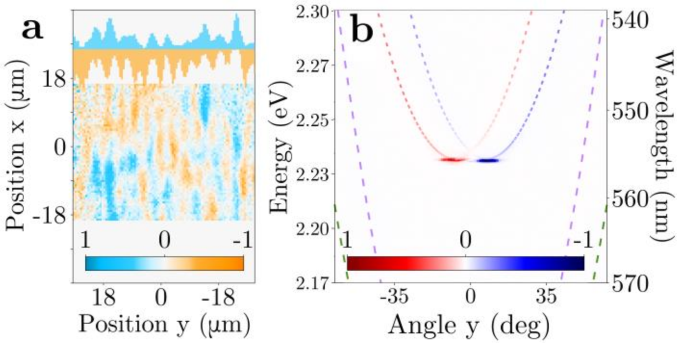

Figure: **a** Lasing in Rashba-Dresselhaus resonance. The difference between the emission intensities in σ^+ (red) and σ^- (blue) polarization. **b** The persistent spin-helix laser. The Stokes parameter S_2 for real-space imaging. The histogram in the insets at the top correspond to the positive and negative values along the *y* direction.

Here, we combine the recent advances in integrated photonic MCs filled with a LC of high birefringence and the tremendous progress in the development of high-efficiency organic dyes [3]. We demonstrate a laser operating at room temperature which can be continuously tuned within the range of 40 nm and which allowed to obtain lasing of the persistent spin-helix in the RD coupling regime (Figure **a**). The laser action takes place simultaneously from the bottoms of two orthogonally spin-polarized coupled valleys shifted apart in reciprocal space, leading to the formation of two circularly polarized deviated laser beams (Figure **b**) [4]. The platform we proposed can be used in quantum communication, in which information is encoded through light polarization.

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[3] E. Nowinowski-Kruszelnicki, et al., *Optica Applicata* **42**, 1 (2012).
[4] M. Muszyński, et al., *Phys. Rev. Applied* **17**, 014041 (2022).