

# Optically reconfigurable chiral ballistic polariton laser

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Orbital angular momentum (OAM) of light appears when the phase of an electromagnetic wavefront winds around its direction of propagation, defining *optical vorticity*. Contrary to the momentum related to the spin of photons it can have an arbitrarily high value, which offers many possibilities in optical communication and enhancing the capacity of data encoding and multiplexing. To gain from this phenomenon it is necessary to create a coherent source of light with well-defined and adjustable OAM. We propose the *chiral ballistic microcavity exciton-polariton laser* that through combination of geometric frustration and inherent photon spin-to-angular momentum conversion can be optically reconfigured to emit coherent light of variable OAM.

Exciton-polaritons are bosonic quasiparticles emerging from strong coupling between photons confined in cavities and excitons. They can undergo a pump power-driven transition to a non-equilibrium condensed state which, due to the finite cavity photon lifetime, emits coherent light, forming a low threshold *polariton laser*. The condensate density is proportional to the power of the external off-resonant optical pump which offers a chance to control the condensate profile using spatial light modulator technology on the optical pump. To create a chiral polariton laser we suggest a pattern of a polygon with an odd number of vertices.

Because of the odd number of vertices, the condensates are unable to synchronize anti-phase. For certain distances between spots, vortices of corresponding topological charge will appear due to geometric frustration [1]. Because of inherent splitting between transverse-electric and transverse-magnetic cavity modes, a synthetic spin-orbit-coupling mechanism appears for the polaritons, which allows controlling the chirality of the condensate by using an optical pump of either clockwise or counterclockwise circular polarization [2]. Combining these two concepts, we demonstrate the optically reconfigurable *chiral ballistic polariton laser* requiring no specialized irreversible cavity patterning or optical metasurfaces.

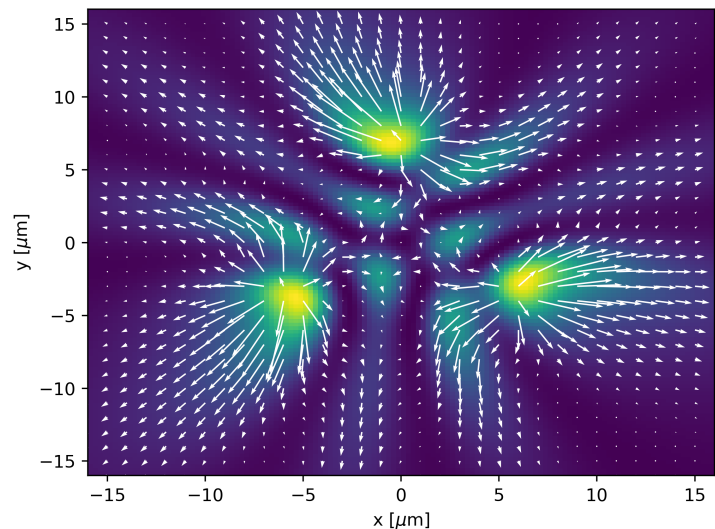


Figure 1: Real space image of the probability density of a system consisting of three interacting condensates. White arrows mark the probability current, which rotates in the center.

[1] T. Cookson et al., *Nature Communications* **12**, 2120 (2021).

[2] N. Carlon Zambon et al., *Nature Photonics* **13**, 283-288 (2019).