Discrete chiral ballistic polariton laser

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Light carries orbital angular momentum (OAM) when the phase of an electromagnetic wavefront winds around its direction of propagation, which is also known as *optical vorticity*. Unlike the binary spin of photons, the OAM can have an arbitrarily high value, which offers many possibilities in optical communication by enhancing the data encoding capacity. To harness this phenomenon effectively, a coherent light source with precisely defined and tunable OAM is essential. We introduce an optically tunable *discrete chiral ballistic exciton-polariton microlaser*, which aims to enable the emission of coherent nonlinear light of variable OAM that requires only a planar cavity, eliminating the reliance on irreversible cavity patterning or metasurfaces.

The proposed system [1] benefits from the hybrid nature of exciton-polaritons, the half-light, half-matter bosonic quasiparticles emerging from strong coupling between excitons and photons confined in cavities. The polaritons can undergo a power-driven non-equilibrium transition to a macroscopic coherent quantum state, referred to as a polariton condensate. Due to the finite cavity photon lifetime, it emits coherent light, forming a low-threshold polariton laser. Meanwhile, the strong interactions inherited from excitons enable the formation of giant quantized vortices [2]. Here, we show how, through the combination of spin-polarized pumping and photonic spin-orbit coupling [3], the OAM of the vortex condensates becomes locked with the SAM of the pump, facilitating the creation of an optically tunable chiral microlaser.

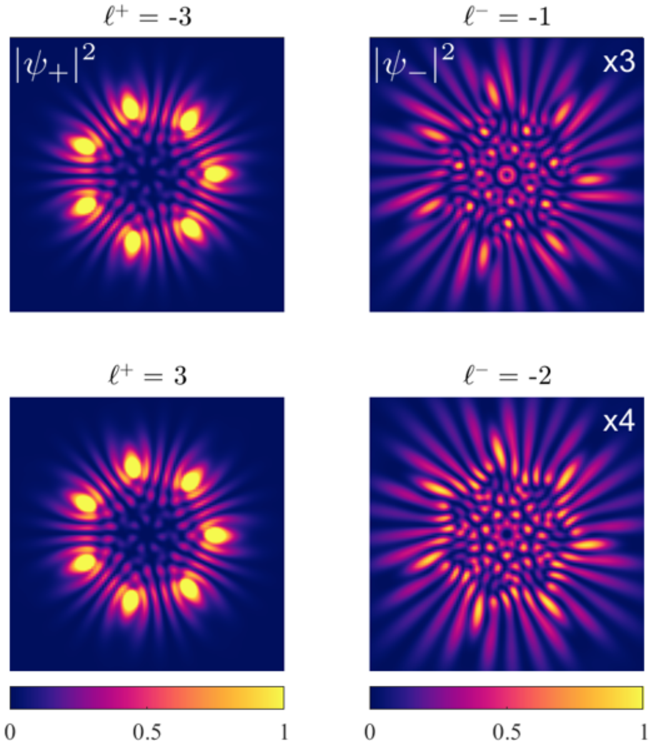

Figure 1: Condenstate spin-up $|\psi_+|^2$ and spin down density $|\psi_-|^2$ of steady giant vortex states with OAM in the more populated component equal to ±3.

The condensate can be forced to form vortex states through an appropriate choice of an excitation pump pattern that breaks the in-plane inversion symmetry. Geometries with an odd-numbered rotational (polygonal) symmetry invoke the geometric frustration between neighboring condensates, thus causing the formation of states carrying persistent circulating currents. Meanwhile, the optical Zeeman effect and polariton spin-orbit coupling establish the locking of the emission OAM with the SAM of the pump. The states of high-charge OAM become favored and stabilized. The discussed kind of excitation offers multiple previously unexplored parameters to optically control the OAM of the emission. As an additional feature, the ballistic nature of the condensate leads to a rich pattern of polarization singularities such as C-points.

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