Spin-orbit coupling in photonic systems: from optical spin Hall effect to Z topological insulator

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Exciton-polaritons are bosonic hybrid exciton-photon quasi particles with 2 spin projections. In microcavities, the polariton spin dynamics is governed by an effective spin-orbit coupling associated with the polarisation splitting between TE and TM eigenmodes, Zeeman splitting, and, in the non-linear regime, by the spin-anisotropic interactions. These two combines features make of this system a unique platform to demonstrate and study original spin dependent phenomena, such as the optical spin Hall effect [1,2,3], half-integer topological defects [4,5,6,7,8], magnetricity [9], artificial gauge fields [10]. The possibilities offered by the system have been recently enlarged by the realization of polariton molecules and polariton lattices [11], which, combined with the features discussed above, allowed to observe spontaneous and persistent spin currents [12], and to predict the emergence of gauge fields acting on Dirac quasi-particles [13] and the existence of photonic/polaritonic topological insulators [14].

We will discuss these interesting phenomena with a special focus on the polariton Z topological insulator based on polariton graphene. We will see how the TE-TM splitting breaks the symmetry between the Dirac points in reciprocal space. The Zeeman splitting reveals this symmetry breaking by opening a gap between topologically non trivial bands with integer Chern numbers ±2.

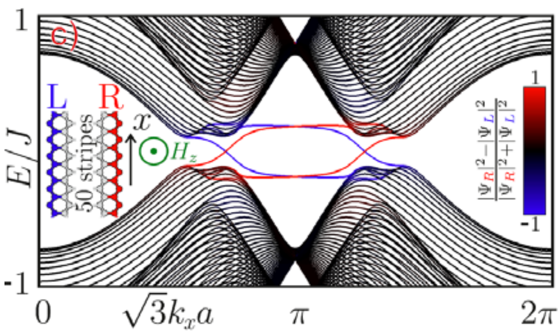

Figure 1 : Surface states of a polariton ribbon appearing in the gap

The band structure of a polariton ribbon calculated with a tight binding approach taking into account the polarization dependence of tunneling coefficients arising from the TE-TM splitting and an applied magnetic field is shown on the figure 1. Each surface supports two chiral modes (blue: left surface, red: right surface) propagating in the same direction, protected from the backscattering and from scattering into the gap.

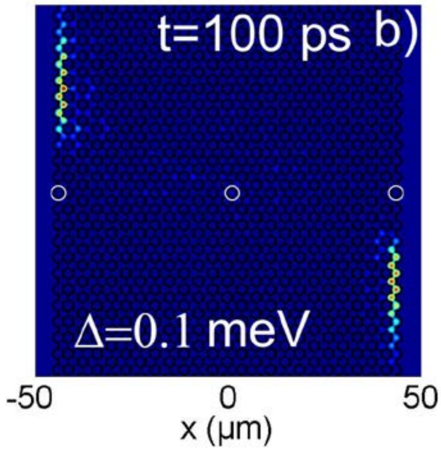

Figure 2: Spatial emission pattern from surface states on the edges of a polariton ribbon. Injection points are shown as white circles. The gap opened in the bulk prevents the injection of particles.

The figure 2 shows a snapshot image taken after pulsed resonant excitation at the gap energy and at the positions shown by the white circles. One can clearly see the one-way propagation in opposite directions on the two edges of the ribbon. This topological insulator scheme is not based on the appearance of Landau Levels and has many similarities with the Haldane proposals of 1988 [15] and 2008 [16].

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