Non-linearities in a driven-dissipative SSH lattice

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One of the hallmarks of topological phases of matter is the emergence of edge states that are robust against local disorder and external perturbations. Extending this topological physics to photonic platforms recently appeared as a promising avenue for engineering novel photonic devices benefiting from such robust properties [1]. In this sense, exploring the interplay between topology, non-Hermiticity and nonlinearity in photonic systems offers very interesting perspectives [2]. Cavity polaritons, which originate from the strong coupling between quantum well excitons and cavity photons, are particularly suited for this investigation: their excitonic component gives rise to a strong Kerr nonlinearity [3], while their photonic component allows for engineering topological properties in lattices and provides a non-Hermitian character to the system.

In this talk, I will describe the nonlinear response of the bulk of the simplest model exhibiting topological features, namely the Su-Schrieffer-Heeger (SSH) model. The lattice is emulated using a 1D array of coupled GaAs-based micropillars with alternating long and short inter-pillar distances (Fig. 1.a and 1.b), resulting in a chain of coupled dimers [4] where the left and right pillars of each unit cell correspond to the two sub-lattices of the SSH model.

Pumping the system in the topological gap of the chain, the non-linear response of the system presents a structure that originate from the chirality of the underlying Hamiltonian: it takes the form of a chiral gap soliton [5] with exponentially decaying tails localized only on one of the sub-lattices (Fig. 1.b). This sub-lattice imbalance can be described as a pseudo-spin, which changes sign across the nonlinear domain.

Probing its interaction with an optically induced defect, we demonstrate that the soliton present new robustness properties linked to this pseudo-spin texture. Finally, using the non-Hermitian nature of the system as an asset, we tailor a driving phase pattern that allows reaching nonlinear stationary solutions that are not accessible in purely conservative systems. They present the exact same profile as that of a topological edge state. The effect of the pump is thus analogous to creating a topologically non-trivial interface.

Our results [6] offer new perspectives for the exploration of nonlinear topological photonics in driven-dissipative systems.

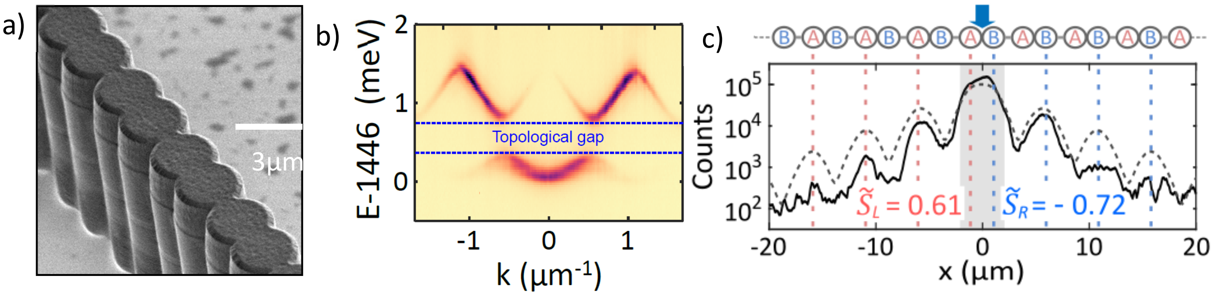

Figure 1 (a) Scanning electron microscope image of a 1D lattice of coupled micropillars emulating the SSH Hamiltonian. (b) Energy resolved emission as a function of momentum. (c) Experimental and theoretical intensity profiles of a chiral gap soliton, the pseudo-spin value is indicated for each tail.

References:

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