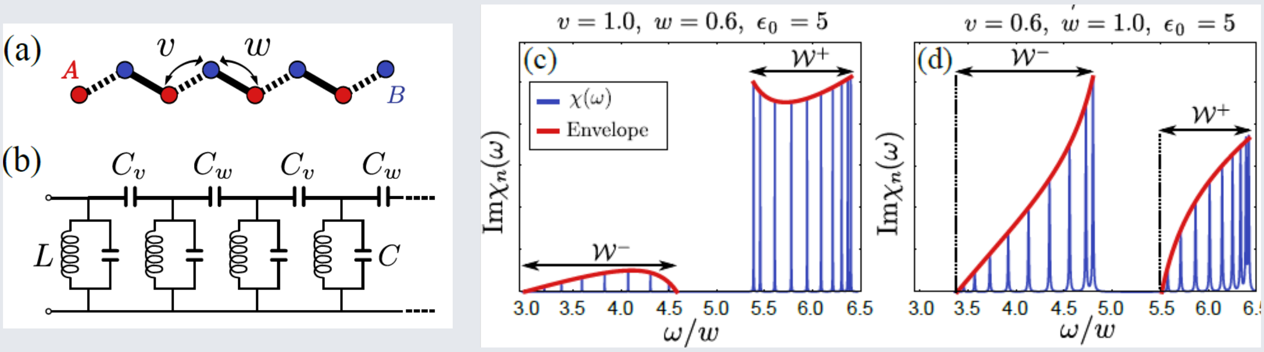
How to probe and realize topological phases with light?

T. Goren, F. Appas, K. Le Hur (CPhT), K. Plekhanov (LPTMS).

Properties of topological Bloch bands have important physical consequences. One of the main manifestations of such properties is the presence of protected edge states. For non-interacting fermions this leads to the celebrated integer quantum Hall effect and to novel conducting surface states of topological insulators and semi-metals. These properties can also be accessed with bosonic systems such as cold atoms, photons and polaritons.

The Su-Schrieffer-Heeger (SSH) model defined on the dimerized one-dimensional lattice with two sites per unit cell is one of the simplest models demonstrating topological properties, The edge states are protected by the bipartite nature of the system (particles can hop only between the two sublattices).

We have studied topology in the strong coupling regime of quantum circuits in which the rotating wave approximation (RWA) is not applicable, leading to the appearance of counter rotating (pairing) terms. Such strong coupling limit also leads to the evolution of the Jaynes-Cummings model towards the Rabi model when describing the qubit-cavity interaction, and to the super radiant phase in Dicke model with a macroscopic number of photons in the ground state but has not been studied in he framework of topological systems.



We show the emergence of topological Bogoliubov bosonic excitations in the relatively strong coupling limit of an LC (inductance-capacitance) one-dimensional quantum circuit (see figures (a-b)).

The winding of the topological Zak phase across the Brillouin zone can be measured by a refection measurement of (microwave) light. Our method probes bulk quantities and can be implemented even in small systems (~10 unit cells). Figures (c-d) shows the imaginary part of the reflection coefficient as a function of the light frequency ω for the trivial phase (w<v, figure c) and the topological phase (ω>υ, figure d). In the two phases the spectrum revealed by the resonances is the same. However the envelope function of the resonances amplitudes show the winding of the Zak phase. In the trivial phase, the envelope has the same value at the bottom and top of the bands. In the topological phase the envelope of the bands is a monotonically increasing function.

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