Topological Phase induced by Non-Linearities in Spontaneusly Symmetry Broken Quantum Resonators

Alessandro Coppo[1], **Simone Felicetti**[1], **Alexandre Le Boité**[2], **Valentina Brosco**[1]

1. Istituto dei Sistemi Complessi, Consiglio Nazionale delle Ricerche, Via dei Taurini, 19 I-00185 Roma, Italy and Physics Department, University of Rome "La Sapienza", P.le A. Moro, 2 I-00185 Roma, Italy

2. Université Paris Cité, CNRS, Laboratoire Matériaux et Phénomènes Quantiques (MPQ), Paris F-7501, France

Abstract: We show how cross-Kerr non-linearities can induce topological phases and edge modes in a chain of spontaneous symmetry broken parametrically driven quantum resonators.

Topology and non-linearity are deeply connected [1]. However, whether topological effects can arise solely from the structure of non-linear interaction terms, and the nature of the resulting topological phases, remain to large extent open questions. In this talk, we consider a chain of parametrically driven quantum resonators coupled only via nearest-neighbour cross-Kerr interactions [2], without any quadratic coupling term, and we show that, when the drive overcomes a critical threshold value, the system may enter a topological spontaneously symmetry-broken phase. Beyond threshold non-linear contributions play a key role for the stabilization of the system (Fig. 1) and gain the ability to induce non-trivial topological effects on the low-energy spectrum [2]. By means of different effective models for periodic and open boundary conditions, we derive analytical approximations for the spectrum, identifying the conditions to observe topological edge modes (Fig. 2). The many-body nature of the topological phase is finally thoroughly analysed. The relevance of the results for quantum sensing and computing applications is outlined [3].

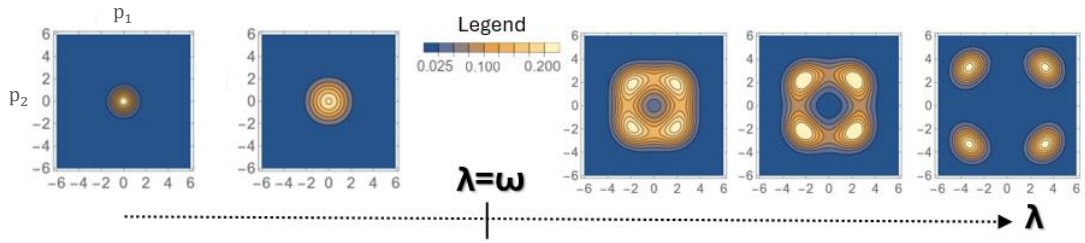

Fig. 1 Ground-state of two Kerr-interacting parametric quantum resonators in phase space (p_1, p_2). The two resonators have the same frequency ω and are driven with the same intensity λ. When $\lambda \gg \omega$ the ground state is described by a set of disconnected maxima and the system enters a spontaneously symmetry broken regime governed by non-linearities.

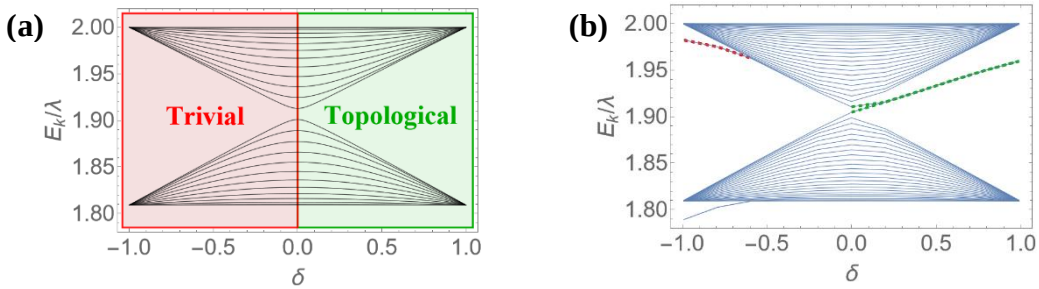

Fig. 2 2 (a) Low-energy spectrum for a parametrically driven periodic chain of Kerr-interacting resonators beyond threshold. The chain is composed by cells containing couples of resonators driven with intensity λ and the parameter δ on the x-axis quantifies the difference between the intensity of the inter-cell cross-Kerr interaction and the intra-cell one. When $\delta > 0$, it is possible to identify a non-vanishing topological invariant proper to the bands describing the spectrum. **(b)** The bands of the same chain in case of open boundary conditions with a couple of localized edge modes appearing inside the band gap for $\delta > 0$ (dashed green line). A set of non-topological spurious localized modes appears also in a small region $\delta < 0$ due to the presence of boundary disorder (dashed red line).

References

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