Simulation of topological phases in quantum dot arrays

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Recent experiments demonstrate a controllable 12- quantum-dot (QD) device [1]. The fabrication and control of long semiconductor quantum dot arrays open the possibility to use these systems for transferring quantum information between distant sites. Interestingly, it also opens the possibility of simulating, in quantum dot arrays, complex hamiltonians as for instance one-dimensional topological insulators. An example of them in 1D is the Su-Schrieffer-Hegger (SSH) model, a chain of dimers. This system presents chiral symmetry and bond ordering of nearest-neighbor couplings and displays two topological phases. In a finite chain, the presence of protected edge states, allows to transfer electrons between edges, and therefore their implementation is promising for quantum information transfer. However, the SSH model does not account for long range hopping effects which should occur in real systems and which can destroy the topological properties and the edge states formation [2]. In this presentation I will first discuss how to use QD arrays with long-range hoppings (extended SSH model) as quantum simulators for new 1D chiral topological phases. I will show that, by applying a driving protocol, all hopping amplitudes can be modified at will, imprinting bond-order and effectively producing structures such as dimers chains. Importantly, our protocol allows for the simultaneous suppression of all the undesired long-range hopping processes, enhancement of the necessary ones, and the appearance of new topological phases with increasing number of edge states. I will discuss the dynamics of two interacting electrons in a 12-QD array when configurations with different number of edge states are considered. The correlated dynamics, which can be experimentally detected with QDs charge detectors, allows to discriminate between different topological phases and importantly, it opens a new avenue for quantum state transfer protocols [3].

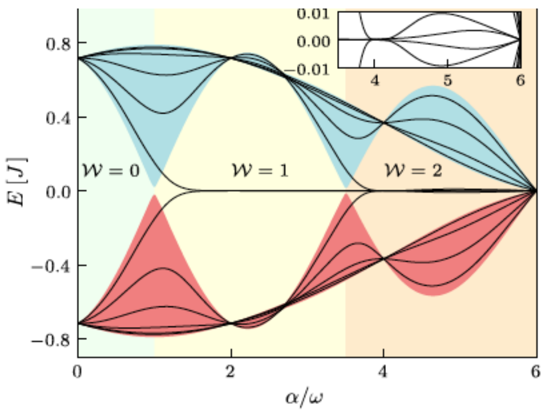

Figure 1: Quasi-energy levels of a driven 12 quantum dot array as a function of the ratio of the intensity and frequency of the driving field, including first and third neighbour hoppings. Inset: each pair of edge states for *W*=2 has a different energy splitting.

References

[1] D.M. Zajac et al., Phys. Rev. App., 6 (2016), 054013

[2] B. Pérez-González et al., Phys Rev. B, 99 (2019), 035146

[3] B. Pérez-González et al., Phys. Rev. Lett., 123 (2019),126401

Figures

Figure 1: Insert caption to place caption below figure (Century Gothic 10)

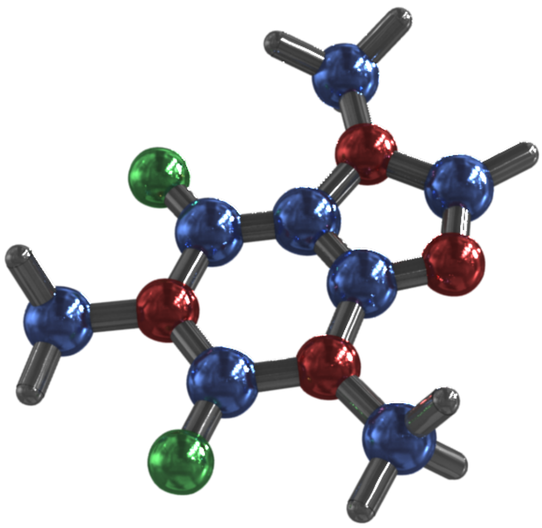

Figure 2: Insert caption to place caption below figure (Century Gothic 10)