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Characterizing a two-dimensional high-order topological insulator

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A two-dimensional topological insulator presents gapless topologically protected edge states and there is a correspondence between the topological invariant and the number of edge-states, known as the bulk-boundary correspondence. Recently proposed higher- order topological insulators (HOTIs) generalize the bulk-boundary correspondence and present topological states with dimensions two or more lower than that of the bulk. Two-dimensional HOTIs, for instance, present topologically protected corner states. The main goal of this work was to study numerically a variation of a 2D Su-Schrieffer-Heeger (SSH) tight-binding model in order to characterize the topologically protected corner states.

As a first example, a numerical study of the one-dimensional SSH chain will be presented. The electron hopping ratio is studied and identified as a parameter for a topological phase transition, by calculating the density of states (DOS) of the SSH chain with different hopping energies.

Secondly, a 2D SSH model was analyzed, where the band structure and the local density of states (LDOS) were studied. Square and ribbon geometries were studied in order to observe different topological phases.

Thirdly, and lastly, a modified 2D SSH model was studied, where a quadrupolar to trivial topological phase transition is clearly observed. Holes of different geometries (square and cross holes) were created in a square lattice. The effect of the holes' presence in the lattice, regarding its band structure and LDOS, was shown to change the behavior of the topological phase transitions. A quadrupolar topological phase transition was observed in an infinite periodical square super-lattice with a cross hole geometry. This result can be of interesting applications, e.g., in photonics, to mediate energy transfer in photonic crystals.

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