

Highlights

RESEARCH AREA 3 - Quantum Science and technologies - 2024

Fate of high winding number topological phases in the disordered extended Su-Schrieffer-Heeger model

E.G. Cinnirella^{1,2}, A. Nava³, G. Campagnano⁴ & D. Giuliano^{3,1,2}

¹Dipartimento di Fisica, Università della Calabria, Cosenza, Italy ²INFN Gruppo collegato di Cosenza, Italy

³Institut für Theoretische Physik IV, Heinrich-Heine-Universität Düsseldorf, Germany

⁴CNR-SPIN, c/o Complesso di Monte S. Angelo, Napoli, Italy

PHYSICAL REVIEW B 109, 035114 (2024)

This work investigates the robustness of high-winding-number topological phases in disordered extended Su-Schrieffer-Heeger (eSSH) chains by employing a Lindblad master equation approach to drive the system into a nonequilibrium steady state (NESS) and probe its topology through the even-odd differential occupation (EOD). The underlying model, consisting of an SSH chain with long-range hopping amplitudes that enable multiple edge states per boundary, is introduced schematically in Fig. 1. By considering several types of disorder, either preserving or breaking the chiral symmetry, it is shown that topological phases with larger winding numbers are hierarchically suppressed as disorder strength increases, with the emergence of intermediate buffer phases characterized by reduced EOD. The main numerical results, summarized in phase diagrams such as Fig. 2, show that chirality-preserving disorder, at increasing disorder strength, leads to sequential reduction of the topological invariant and to broadened transition regions, which arise from the averaging effects of the EOD, that in turn remains always quantized for every realization of disorder. Conversely, chirality-breaking disorder, shown in Fig. 3, destroys quantization altogether, giving rise to a noninteger EOD regime. These findings establish the EOD and its fluctuations as effective probes of topology in disordered systems and reveal a general mechanism governing the fate of complex topological phases under realistic perturbations.

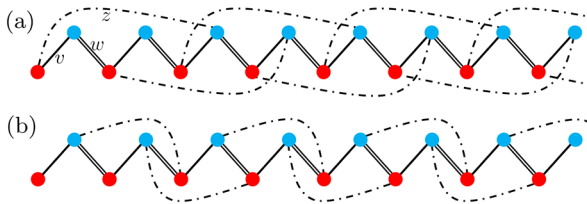


Fig. 1: Sketches of the eSSH model. The intra- and inter-dimer amplitudes, of the regular SSH model, are respectively indicated by single and double lines, while the long-range hoppings are indicated by dashed lines. Furthermore, a) and b) refer to the two types of eSSH models considered in our work.

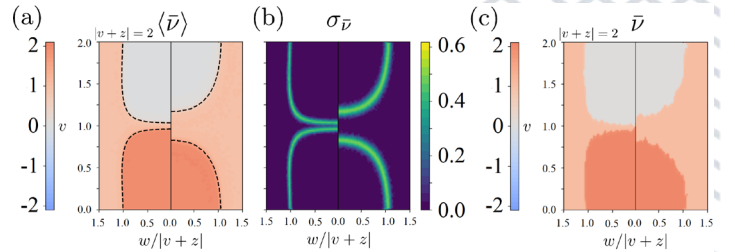


Fig. 2: Average (panel a)), standard deviation (panel b)) and single disorder realization (panel c)) of the EOD, for the eSSH model of panel b) of Fig. 1 and for a chirality-preserving disorder. The left side of the panels refers to weak disorder strength, while the right side refers to strong disorder strength. In a), dashed lines marks the points at which the EOD is an half-integer.

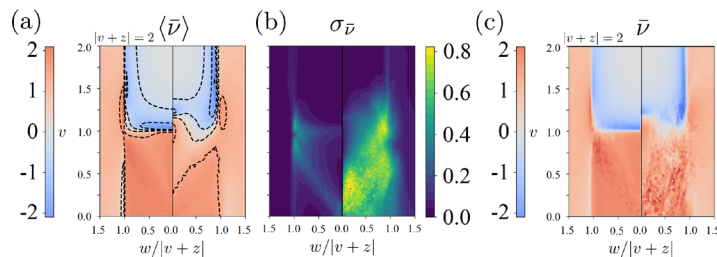


Fig. 3: Average (panel a)), standard deviation (panel b)) and single disorder realization (panel c)) of the EOD as plotted in Fig.2, but for a chirality-breaking disorder.