Nonlinear topological edge states: From dynamic delocalization to thermalization

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We study a mechanical analog of the Su-Schrieffer-Heeger (SSH) tight-binding lattice [1] with Klein-Gordon-type nonlinearity. In the linear limit, the finite-size SSH chain supports localized boundary modes at the mid gap of its frequency spectrum. These edge modes originate from the bipartite nature of the lattice and are known to be robust to deformations and/or imperfections. In particular, we discuss the two following problems: (i) what are the spectral, spatial and stability properties of the nonlinear continuation of topological edge modes in the presence of nonlinearity; and (ii) what are the characteristics of the dynamics associated with these nonlinear topological edge states. Our numerical computations rely on the Newton-Raphson scheme in the phase space which gives the shape and the frequency of the nonlinear edge states with a high degree of accuracy [2]. In this context, we carry the linear stability analysis of the obtained solutions based on the standard Floquet theory. Besides, we find energy-dependent frequencies for the nonlinear topological edge states which can be stable or unstable depending on the signs and strengths of the nonlinearity. Interestingly, the short-time dynamics of an unstable nonlinear topological edge state shows a delocalization of part of its energy toward the bulk and a tendency to restore the frequency of the linear topological edge mode [3]. Nevertheless, its long-time dynamics suggests that this delocalization of energy does not restore the linear topological edge state, but instead leads to the thermalization of the lattice, due to the presence of chaos and mode-mode interactions within the system. The obtained thermalized state is characterized by a renormalized dispersion relation whose shape is reminiscent of the symmetries of the linearized model [4].

References:

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