Nonlinear Floquet Edge States in an Asymmetric Driven SSH Lattice

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Exponentially localized, time-periodic solutions in nonlinear lattice models are crucial for understanding dynamical phenomena across biophysics, solid-state physics, nonlinear optics, and cold-atom systems. In parallel, developments in topological insulators have shown that time-periodic driving can induce topologically nontrivial phases [1]. Advances in longitudinally modulated optical waveguide arrays have, in turn, enabled the experimental study of systems with time-periodic Hamiltonians, including Floquet time crystals and novel topological phases [2]. A paradigmatic one-dimensional topological insulator is the tight-binding Su–Schrieffer–Heeger (SSH) model [3]. Under periodic longitudinal modulation, it can exhibit Floquet topological edge modes [4] and, in the presence of nonlinearity, additional exponentially localized modes [5].

Here, we investigate a one-dimensional bipartite SSH model with asymmetric average couplings under time-periodic modulation, in both the linear and nonlinear regimes. In the linear Floquet regime, the topologically nontrivial parameter regions and the associated edge modes are analyzed using two complementary approaches: a two-time-frame method [6] and the experimentally more accessible mean-field displacement technique [7]. Our results show that, for certain parameters, time-periodic modulation opens quasienergy gaps hosting topologically protected Floquet edge modes in the π- and zero-gap regions, even when the average coupling ratio of the SSH lattice would otherwise indicate a trivial phase. In the presence of nonlinearity, these edge modes persist within the modulation-induced gaps. Their stability is analyzed by linear stability analysis and direct time evolution. Preliminary results indicate that instability sets in when the modes approach the band edges, due to resonant interactions with bulk states. We also find that exponentially localized edge breathers can exist in a higher gap, above the band whose states destabilize the nonlinear π-edge modes in the lower gap. These higher-gap localized states remain stable over a finite parameter interval and can support higher power than their lower-gap counterparts. This property is of particular interest for understanding the role of nonlinearity in driven topological systems and for possible applications involving robust localized states.

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