Enhanced diode-like operation mediated by an asymmetric non-Hermitian and nonlinear defect

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Recently, investigations of transport phenomena in structured media have experienced a substantial revival envisaging the development of new devices with potential technological applications. These structures exhibit a wide range of quantum phenomena in the presence of magnetic fields including the quantum Hall, Faraday and Cotton-Mouton effects. In particular, the study of such systems has boosted the design of new nano and mesoscopic devices that can perform unidirectional transport. Nelson and Hatano pioneered the study of Anderson localization in one-dimensional disordered non-Hermitian lattices. The non-Hermiticity was introduced as resulting from an imaginary gauge field acting on the lattice sites. They showed that the presence of non-Hermiticity can prevent the Anderson localization. Such phenomenon, known as non-Hermitian delocalization, has been further studied by several authors. The implementation of an imaginary gauge field is still a challenge in the condensed matter physics context. However, in optical devices this can be emulated by using a sequence of micro-resonator rings. Motivated by non-Hermitian delocalization, some recent works have explored the transport properties in one-dimensional non-Hermitian lattices. In these model systems, asymmetric transport is expected to arise because the time reversal symmetry (T) is broken. In general, non-Hermiticity can be introduced by the presence of an imaginary gauge field, complex on-site potentials or asymmetric hopping rates. Nonreciprocal transport can also be achieved due to the presence of nonlinear contributions in systems with broken parity symmetry. In this work we study the nonreciprocal transport along two tight-binding chains which are connected by a single defect having an asymmetric non-Hermitian nonlinear off-diagonal coupling. The spectrum of transmission and reflection, the gain curve and the rectifying factor are analytically obtained using a backward iterative process. A set of discrete linear Schrödinger equations is used to model the wave propagation through the two Hermitian side chains, while a discrete nonlinear Ablowitz-Ladik equation governs their coupling by the single defect. We show that the emergence of a multistability window induced by the non-linear contribution, together with the biased transport promoted by a parity-breaking non-Hermiticity, generates an efficient rectification of the transmitted wave component.