Thermodynamics of nonlinear Aharonov-Bohm cages

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We investigate the thermodynamic and non-equilibrium properties of an open diamond lattice under the influence of a uniform magnetic field and mean-field cubic nonlinearity. In the linear regime, the chain exhibits two dispersive bands and one zero-energy flat band. By fine-tuning the magnetic flux to a specific value, all three Bloch bands turn flat, resulting in Aharonov-Bohm caging and the total suppression of particle and energy currents. In this caging regime, non-zero currents are enabled by nonlinearity. We compute the ground state zero temperature and the infinite temperature lines as function of the flux. Then, by driving the system at the boundaries with two thermostats, we study the transport of norm and energy across the system induced by nonlinearity for different flux values and nonlinear strengths. We find that for weak nonlinearity, fine tuning the flux to the caging condition turns the system into an insulator, while the system is metallic for all other flux values. For intermediate nonlinear strength instead, the system behaves as a metal for any flux value. However, in this regime the caging condition enhances Seebeck coefficient and the figure of merit, improving the thermoelectric features of the chain. These results highlight the magnetic flux as a versatile control parameter for effectively tuning the thermodynamic and transport signatures of the chain.