Equilibrium and nonequilibrium description of negative temperature states in a one-dimensional lattice using a wave kinetic approach

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We predict negative temperature states in the discrete nonlinear Schrödinger (DNLS) equation as exact solutions of the associated wave kinetic equation. Within the wave kinetic approach, we define an entropy that results monotonic in time and reaches a stationary state that is consistent with classical equilibrium statistical mechanics. We also perform a detailed analysis of the fluctuations of the actions at fixed wave numbers around their mean values. We give evidence that such fluctuations relax to their equilibrium behavior on a shorter timescale than the one needed for the spectrum to reach the equilibrium state.

Numerical simulations of the DNLS equation are shown to be in agreement with our theoretical results. The key ingredient for observing negative temperatures in lattices characterized by two invariants is the boundedness of the dispersion relation.

(Based on the joint work M. Onorato, et al., PRE 105, 014206, 2022)