

Anomalous transport in classical many-body dynamics

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Classical cellular automata represent a class of explicit discrete spacetime lattice models in which complex large-scale phenomena emerge from simple deterministic rules. With the goal to uncover different physically distinct classes of ergodic behavior, we perform a systematic study of three-state cellular automata (with a stable 'vacuum' state and 'particles' with $\pm$ charges). The classification is aided by the automata's different transformation properties under discrete symmetries: charge conjugation, spatial parity and time reversal. In particular, we propose a simple classification that distinguishes between types and levels of ergodic behavior in such system as quantified by the following observables: the mean return time, the number of conserved quantities, and the scaling of correlation functions. In each of the physically distinct classes, we present examples and discuss some of their phenomenology. This includes chaotic or ergodic dynamics, phase-space fragmentation, Ruelle-Pollicott resonances, existence of quasilocal charges, and anomalous transport with a variety of dynamical exponents.

[1] <https://arxiv.org/pdf/2503.16593>.