

Ergodicity breaking and quasiparticle dispersion in the PXP quantum cellular automaton

Kevisen Sellapillay, Alberto Verga, Giuseppe Di Molfetta

Aix-Marseille Université, Campus de Luminy, 13288 Marseille, France

kevisen.sellapillay@univ-amu.fr

Abstract

Thermalization in quantum many body systems is a main theme in physics. We study a Quantum Cellular Automaton (QCA) inspired by the PXP model [1]. This model, realizable on Rydberg atoms [3], has two interesting limits: the PXP model and the rule 201 classical automaton. We look at the entanglement spectrum of the dynamics close to the automaton limit. Quasiparticle excitations evolve towards chaotic states characterized by Wigner-Dyson statistics, whereas a state without quasiparticle excitation evolves towards a Poisson statistics. This ergodicity breaking mechanism in a QCA, which could be of interest for quantum information application, is reminiscent of the scarring phenomenon and the Z2 emergent symmetry of the PXP model [2]. We relate the thermalizing behaviour of the state containing a quasiparticle with the dispersion observed and we find that entanglement grows in the wake of the quasiparticles. We compute the dispersion relation to first order in the chiral and collision-free sector.

References

- [1] Iadecola, Thomas, et Sagar Vijay. « Nonergodic quantum dynamics from deformations of classical cellular automata ». *Physical Review B* 102, n° 18 (6 novembre 2020)
- [2] Serbyn, Maksym, Dmitry A. Abanin, et Zlatko Papić. « Quantum Many-Body Scars and Weak Breaking of Ergodicity ». *Nature Physics* 17, n° 6 (juin 2021)

- [3] Morgado, M., et S. Whitlock. « Quantum simulation and computing with Rydberg-interacting qubits ». *AVS Quantum Science* 3, n° 2 (juin 2021)

Figures

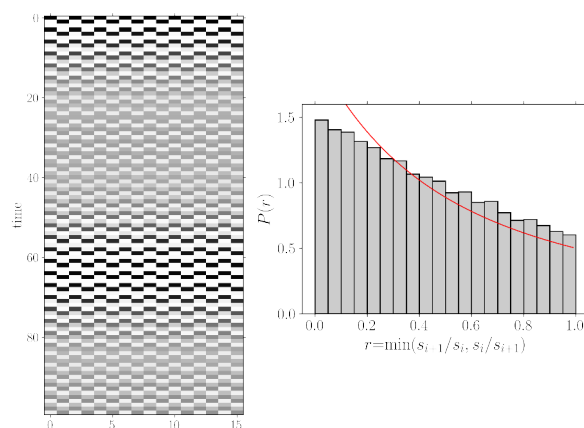


Figure 1:

QCA near the automaton limit, for a state without quasiparticle which displays the revival phenomenon (left) and associated entanglement spectrum spacings statistics (right).

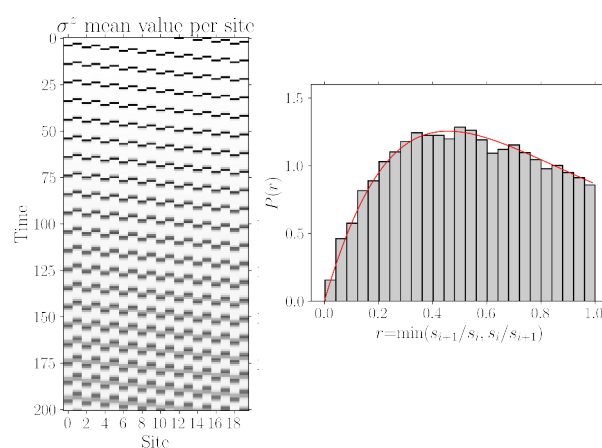


Figure 2: Dispersion of chiral quasiparticle (left) and associated entanglement spectrum spacings statistics (right).