Contribution ID: **93** Type: **not specified**

Classification of Quantum Cellular Automata

Quantum simulation aims to deepen our understanding of the physics of quantum systems with many constituents, whose analytical or numerical treatment on classical computers remains unattainable. Most quantum simulators are digital, evolving networks of qubits in discrete time steps; consequently, understanding discrete quantum dynamics is crucial for their development. When locality and reversibility are imposed, such models are known as Quantum Cellular Automata (QCA).

The classification of quantum cellular automata is a new thrilling research at the intersection of quantum simulation, topological phases of matter, and the foundations of physics. In this work, we classify QCA and their algorithmic implementation in a minimal setting: a grid of qubits with translationally invariant nearest-neighbor interactions. We establish a topological index that quantifies the information flux produced by these dynamics and we characterize their ability to produce entanglement, one of the primary resources consumed in quantum simulation.

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Session Classification: Caffè e poster (dal N. 9 al N. 51)