SFB 1432

Colloquium

Dr. Thiago L. M. Guedes
Institut für Quanteninformation RWTH Aachen &
Forschungszentrum Jülich

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Talk at 15:15
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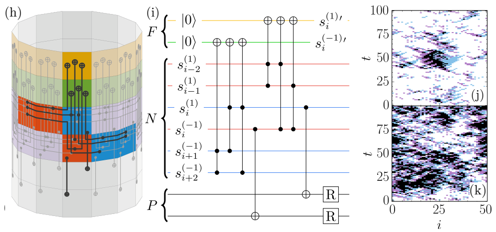
Quantum cellular automata for quantum error correction



Quantum cellular automata are alternative quantum-computing paradigms to quantum Turing machines and quantum circuits. They work in an automated manner, being therefore entirely measurement free, and act in a translation invariant manner on all cells of a register, generating a global rule that updates cell states locally, i.e., based on the states of their neighbors. Although desirable features in many applications, it is generally not clear to which extent these fully automated discrete-time local updates can generate and sustain long-range order in the (noisy) systems they act upon. In particular, whether and how quantum cellular automata can perform quantum error correction remain open questions. Our work closes this conceptual gap by proposing quantum cellular automata with quantum-error-correction capabilities. We design and investigate two (quasi-)one dimensional quantum cellular automata based on known classical cellular-automata rules with density-classification capabilities, namely the local majority voting and the two-line voting. We investigate the performances of those quantum cellular automata by simulating the number of update steps required for the logical information they act upon to be afflicted by a logical bit flip. We then show how our designs can be adapted for full bit- and phase-flip correction. The proposed designs pave a way to further explore the potential of new types of quantum cellular automata with built-in quantum error correction capabilities.

Contact:
G. Burkard, 5256

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