QSS35 - Igor Lesanovsky - Questions & Answers

Igor Lesanovsky

Is there something we can learn about the original classical process by studying its quantum version?

IGOR: To study the classical process one can rely on Monte Carlo simulations, which usually permits the investigation of system sizes much larger than it is possible for quantum problems. Therefore, at least from the perspective of numerical simulations, I have trouble seeing how the quantum process could help to understand the classical one. Moreover, what we are interested in understanding are situations where classical and quantum process behave differently.

How do you calculate the quantum infectious process? Is this a full many-body simulation with 2^N states?

IGOR: The calculation was performed with a tensor network based algorithm that propagates the density matrix with its $2^{(2N)}$ entries.

The notion of the automaton in 1+1 dimensions resembles the idea of surface codes for quantum error correction with one temporal dimension. Are these related?

IGOR: To my understanding the surface code works in a way that the time updates are applied always to the same lattice, i.e. the updates act on the qubits that encode the current quantum state. In contrast the CAs work in a way that in each time steps qubits are updated which haven't been part of the previous evolution. I think the analogy is more with dissipative quantum computing where the time slice plays the role of a register that keeps track of the time step.

In the 5-site mode, is it possible to increase the amount of entanglement between 3&4 by changing the unitary operator?

IGOR: I believe that this is possible. The gate that I presented in the talk is by no means optimized. Note, that the amount of entanglement that is created between atoms 3 & 4 also depends on the state of the atoms 1, 2 & 5. This also adds a "degree of freedom" which we have not explored thoroughly, yet.

I am wondering if you have considered atomic ensembles instead of single atoms for your model?

IGOR: A similar CA construction will certainly work also when each of the traps contain more than one atom. However, one might have to deal with disorder effects, e.g. stemming from a random collective Rabi frequency (and rotation angles) due to the particle number fluctuations.

Also, do you think QCA can capture chaotic dynamic of the system? How you think this might affect the correlations? Are these correlations robust to cells/atoms lost from the system?

IGOR: I think one may indeed speculate that there are QCA variants that mimic (random) circuit models, which could display scrambling. In this sense, I believe, that it could be possible to explore chaotic dynamics. We haven't really thought about this. Concerning the atom loss; this also links to the previous question, where fluctuating atom numbers introduce disorder. It would indeed be interesting to understand how atom loss impacts on the correlations, but we have not looked at this. One could even think of contrasting a situation where atoms are lost dynamically with another one where atoms simply are absent right at the beginning.

You said that the process is fully coherent, yet you are talking about "open" systems. Is it that the irreversability is built in because the gates are operated sequentially? (Open versus close)

IGOR: The dynamics is fully reversible and coherent. The "openness" is coming from the fact that we were mostly studying the reduced state of one time slice. This reduced state evolves via an open system dynamics, in the sense that its propagation from time slice to time slice is governed by a dynamical map, which is not unitary. The full 1+1d quantum state, on the other hand, is a pure state.

Your method seems like another way to analyze quantum computing circuits. Is there any new understanding to gain here?

IGOR: I think that there is a close conceptual link to dissipative quantum computing. What I personally find appealing is the connection to classical probabilistic cellular automata, and that there is a systematic to augment their dynamical rules with quantum effects. So, I am pretty confident, that there is something to be learned here with regards to quantum non-equilibrium physics of many-body systems.

Stephen Wolfram has promised us that the study of cellular automata will revolutionize all of science. What's your take on that?

IGOR: I am certainly fascinated by Wolfram's work.