Quantum Information Processing and Simulation with Rydberg Atom Arrays

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In this set of lectures we are going to take an experimentalist perspective on how to realize large, well-controlled quantum systems that can be used both as quantum simulators and quantum information processors. I will introduce arrays of individually trapped atoms – a architecture that has recently emerged as a highly promising platform for quantum science due to its excellent coherence, control, and programmability.

The lectures will have the following parts:

1. We will cover the basics of atomic physics that is needed and then discuss how to trap and control individual atoms.
2. I will introduce Rydberg atoms (highly excited atoms) as a way to engineer highly coherent interactions between atoms.
3. We will study how the tools of 1 and 2 can be used to realize many-body systems in particular spin models (both in and out of equilibrium) on atomic arrays. Recent experiments will be discussed.
4. We will discuss the prospect of quantum computing with Rydberg arrays and study recent demonstrations.

Suggested reading:

Morgado & Whitlock AVS Quantum Sci. 3, 023501 (2021)
https://arxiv.org/abs/2011.03031

Kaufman & Ni Nat. Phys. ***17****, 1324 (2021)*
https://www.theochem.ru.nl/files/local/np-17-1324-2021.pdf