

Programmable Quantum Simulation with Trapped Ions

R VAN BIJNEN¹

¹*University of Innsbruck, Innsbruck, Austria*

Contact Email: Rick.Van-Bijnen@uibk.ac.at

Trapped ions provide a prominent platform to implement quantum information processing tasks, including quantum computing and quantum simulation with tens of qubits. The ability to precisely engineer many-body Hamiltonians and to perform single-site and single-shot readouts have seen trapped ions evolve into a new generation of programmable quantum simulators, which combine a certain amount of programmability with scalability to large particle numbers. In this talk, we first introduce the core idea of collective phonon modes that allow generating controlled entanglement in a chain of ultracold ions. Then we move on to discuss recent results obtained on a trapped ion platform with up to fifty qubits/spins, with the goal to develop and demonstrate quantum protocols, addressing questions from the fundamental to the practical. Examples include variational ground state engineering, measurement protocols revealing the entanglement structure of the many-body wavefunction, and implementing 'optimal' quantum metrology with variational quantum circuits.