Session 2: Trapped Ion QI

Quantum Information Science with Trapped Ca+ Ions

Rainer Blatt, University of Innsbruck

(Session 2 : Friday 8:30am – 9:15am)

Abstract. Trapped strings of cold ions provide an ideal system for quantum information processing. The quantum information can be stored in individual ions and these qubits can be individually prepared; the corresponding quantum states can be manipulated and measured with nearly 100% detection efficiency. With a small ion-trap quantum computer based on up to eight trapped Ca+ ions as qubits we have generated genuine quantum states in a pre-programmed way. In particular, we have generated GHZ and W states in a fast and scalable way and we have demonstrated for the first time a Toffoli gate with trapped ions which is analyzed via state and process tomography. High fidelity CNOT-gate operations are investigated towards fault-tolerant quantum computing and using logical qubits encoded in decoherence-free subspaces, a universal set of gate operations was implemented and analyzed. As applications of quantum information processing, an experimental state-independent test of quantum contextuality was performed, a simulation of the Dirac equation was implemented and a quantum walk with a trapped ion was realized.

Putting the pieces together: Recent progress with trapped ions at NIST

David Hanneke, National Institute of Standards and Technology

(Session 2 : Friday 9:15am – 9:45am)

Abstract. Storing quantum bits in the internal states of trapped atomic ions has proven a successful approach to quantum information processing because of long coherence times and precise interaction with light fields for coherent control and entanglement generation. Here, we present an experiment that combines a complete set of scalable techniques to realize a programmable two-qubit quantum processor. We also highlight other work at NIST that aims at facilitating the realization of large-scale quantum processors using trapped ions. This work includes the development of scalable trap technologies, studies of dynamical-decoupling techniques for memory preservation, and progress towards large scale entanglement generation and quantum simulation. *Work supported by DARPA, NSA, ONR, IARPA, Sandia, and the NIST Quantum Information Program.

Entanglement of Atomic Qubits using an Optical Frequency Comb

David Hayes, Joint Quantum Institute/University of Maryland

(Session 2 : Friday 10:15am – 10:45am)

Abstract. Our group has demonstrated the use of an optical frequency comb to coherently control and entangle atomic qubits. A train of off-resonant ultrafast laser pulses is used to efficiently and coherently transfer population between electronic and vibrational states of trapped atomic ions and implement entangling quantum logic gates with high fidelity. This technique can be extended to the strong field limit with single ultrafast pulses, and this general approach can be applied to the quantum control of more complex systems, such as large collections of interacting atoms or molecules.