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Quantum Information Experiments with Trapped Ions at NIST

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We present an overview of recent trapped-ion quantum information experiments at NIST. Advancing beyond few-qubit "proof-of-principle" experiments to the many-qubit systems needed for practical quantum simulation and information processing, without compromising on the performance demonstrated with small systems, remains a major challenge. One approach to scalable hardware development is surface-electrode traps. Micro-fabricated planar traps can have a number of useful features, including flexible electrode geometries, integrated microwave delivery, and spatio-temporal tuning of potentials for ion transport and spin-spin interactions. In this talk we report on a number of on-going investigations with surface traps. Experiments feature a multi-zone trap with closely spaced ions in a triangular arrangement (a first step towards 2D arrays of ions with tunable spin-spin interactions), a scheme for smooth transport through a junction in a 2D structure based on switchable RF potentials, and a micro-fabricated photo-detector integrated into a trap. We also give a progress report on our latest efforts to improve the fidelity of both optical and microwave 2-qubit gates. This work was supported by IARPA, ONR and the NIST Quantum Information Program. The 3-ion and switchable-RF-junction traps were developed in collaboration with Sandia National Laboratory.