Quantum Control, Metrology, and Simulation using Ion Crystals in a Penning Trap

M.J. Biercuk (University of Sydney), J.W. Britton, J.K. Freericks, B. Sawyer, H. Uys, J.J. Bollinger

Coulomb crystals of Beryllium ions in a Penning trap represent an elegant system for a wide variety of studies in the field of quantum science. As a complement to few-ion experiments in radiofrequency Paul traps, this system provides a relatively simple, flexible, and well characterized route to performing experiments with mesoscopic ion arrays ($50<N<1{,}000$). These capabilities come at the cost of single particle addressing and increased qubit frequencies due to the presence of the confining magnetic field.

We present an overview of the system, and highlight recent experiments performed at NIST Boulder leveraging these capabilities. In particular, we will detail developments using crystals of $N<1000$ Beryllium ions for high-fidelity quantum control, quantum-enabled metrology, and quantum simulation at computationally relevant scales. In the latter topic, we describe how the naturally arising 2D triangular lattice may be exploited in order to conduct probing studies of frustration and correlations in quantum magnetism (see also poster contribution by Britton).

NIST experiments supported by the DARPA OLE program