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Probing Quantum Magnetism in 2D with an Array of Hundreds of Trapped Ions[1]

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Quantum simulations using AMO systems promise a new way to experimentally study emergent quantum phenomena, but few systems have demonstrated the capability to control ensembles in which quantum effects cannot be directly computed. The 2D array of 100s of $^9Be^+$ ions in a Penning trap, crystallized in a triangular lattice when laser cooled, is a promising platform for intractable quantum simulations using the $^9Be^+$ valence electron spin as a qubit [1]. Spin-dependent forces are employed to modify the strong Coulomb interaction of the ions, mimicking a quantum magnetic interaction. The range of the magnetic interaction can be tuned from infinite to a dipole-dipole like coupling. Combining the application of the spin-dependent force with a transverse magnetic field should lead to the development of quantum correlations between the spins, which can be measured through optical readout of the spin state, both globally and with site-resolved imaging. In this way, trapped atomic ions can be used to probe novel and intractable aspects of quantum magnetism, including the effects of long-range interactions and simulations of quantum non-equilibrium phenomena [2]. In addition to a general overview, I will discuss recent work from a new Penning trap set-up at NIST.

[1] J. W. Britton, et al., Nature 484, 489492 (2012).
[2] P. Jurcevic, et al., Nature 511, 202 (2014); P. Richerme, et. al., Nature 511, 198 (2014).

[1]In collaboration with Joseph Britton, Brian Sawyer, and Justin Bohnet