DAMOP16-2016-001124

Abstract for an Invited Paper
for the DAMOP16 Meeting of
the American Physical Society

Signatures of entanglement in a quantum simulator with hundreds of trapped ions[1]

JOHN BOLLINGER, National Institute of Standards and Technology, Boulder, CO

As the size of a quantum simulation grows, quantifying to what degree the simulator represents a non-classical resource can be controversial, and the number of measurements required to fully characterize the density matrix of the output state exponentially increases with the number of qubits. Therefore, efficient methods for measuring quantum signatures are needed to effectively identify, categorize, and quantify highly entangled states. Here we use planar arrays of laser-cooled $^{9}Be^{+}$ ions, confined in a Penning trap, as a platform for quantum simulations of spin models. The number of spins can be easily varied from tens to hundreds, and our system benefits from strong engineered spin-spin interactions, high fidelity global state control, and the potential for single-spin resolved readout. To benchmark quantum effects generated by the engineered Ising interaction, we generate spin-squeezed states and directly observe up to 5.5 dB of spectroscopic enhancement. In addition, we characterize over-squeezed states, where spin-squeezing fails to identify entanglement, with a more general entanglement witness using the quantum Fisher information. Furthermore, we analyze the multiple quantum coherence spectrum as a means of efficiently investigating higher order correlations in the ensemble. These methods will likely be useful in analyzing the results of future simulations of the transverse Ising model with variable range interactions.

[1]In collaboration with B. C. Sawyer, J. W. Britton, M. L. Wall, A. Safavi-Naini, M. Foss-Feig, M. Gaerttner, A. M. Rey, J. J. Bollinger, and supported by NIST NRC, NSF-PHY 1521080, JILA-NSF-PFC-1125844, ARO, MURI-AFOSR and AFOSR.