

AMO Physics Seminar

Monday, May 18th, 2026 @ 1 PM

PAB 4-330

Optical, Metastable, and Ground State Qubits in Compact Penning Traps

Brian Sawyer

Trapped atomic ions are useful platforms for experimental quantum sensing, metrology, simulation, and computation. Previous work has demonstrated the utility of Penning ion traps for controlling large (> 100 -ion) Coulomb crystals for quantum-enhanced metrology and quantum simulation of Ising spin models using ground-state qubits in a large trap magnetic field (> 4 T). At GTRI, we have developed compact Penning traps built with room-temperature and cryogenic permanent-magnet arrays replacing the more traditional cryogenic superconducting coils. Our compact Penning traps enable precise control of high-magnetic-field (~ 1 T) optical, metastable, or ground (*omg*) state qubits in a form factor similar to that of traditional Paul traps. Notably, the large Zeeman shifts in the Penning trap permit novel realizations of *omg* qubits in species without hyperfine structure (e.g. 40Ca^+). We describe a recent demonstration of individual optical addressing of metastable 40Ca^+ qubits within rotating triangular arrays using a tightly-focused infrared laser beam and 3D sub-Doppler laser cooling in the same apparatus. We also discuss current efforts to extend the trapped-ion Quantum-Charge-Coupled-Device (QCCD) architecture to surface electrode Penning trap systems.