



**Old Dominion University
Department of Physics
Colloquium**

Tuesday, October 24, 2023

"High-Field Qubits in Compact Penning Ion Traps"

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Abstract:

Ensembles of trapped atomic ions are a resource for experimental quantum sensing, simulation, and computation. The ions' charge allows for tight confinement within the static or time-varying electromagnetic fields of Penning or Paul traps, respectively. The inter-ion Coulomb repulsion induces spatial correlations and, ultimately, crystallization at temperatures accessible via traditional Doppler laser cooling techniques. Previous work has demonstrated the utility of Penning ion traps for control of large (> 100 -ion) Coulomb crystals for precision metrology and quantum simulation using qubits at high magnetic field (> 1 T). We have recently developed compact Penning traps for precision measurement and quantum simulation experiments that are built with room-temperature permanent magnet arrays instead of the more traditional cryogenic superconducting coils. Our compact Penning traps enable precise control of high-magnetic-field qubits in a small and agile form factor akin to traditional Paul traps. We discuss recent results including coherent optical addressing of individual $^{40}\text{Ca}^+$ metastable qubits within rotating two-dimensional arrays, long-lived $^9\text{Be}^+$ spin coherence in Ca^+ - Be^+ mixed-species crystals, integration of an optical enhancement cavity for efficient laser cooling using near-infrared electric-dipole-forbidden transitions, and progress towards generation of spin-spin entanglement in high-field metastable qubits.

Presentation: **OCNPS 200 @ 3:00 pm**

Refreshments: **OCNPS Atrium @ 2:30 pm**

All interested persons are cordially invited to attend.