Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **188** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

Surface Ion Trap System for Barium-Based Quantum Information Processing

Tuesday 10 June 2025 11:15 (15 minutes)

We present our progress in developing a surface ion trap system designed for quantum information processing with barium ions. Ba^+ ions are among the most promising qubit candidates due to their long-lived quantum states and visible-wavelength optical transitions, allowing the use of commercial optics and waveguide-based modulators for individual qubit control. Our system features a Sandia National Lab-fabricated surface ion trap with 94 controllable DC electrode channels enabling precise control of the confining potential. The trap is centrally mounted in the vacuum chamber, departing from conventional flange-mounted designs to maximize optical access while maintaining ultra-high vacuum conditions (3×10^{-11} mbar). We have developed specialized methods to prepare both natural abundance and radioactive ^{133}Ba atomic sources and implemented a modular fiber-coupled optical system where multiple wavelengths are combined and delivered via custom designed boards. Our architecture accommodates individual addressing of multiple ion qubits with negligible intensity crosstalk at 1e-4 level. As part of the Open Quantum Design initiative, this system will integrate with a full-stack control system, enabling remote access to the system at various levels of abstraction.

Keyword-1

Surface ion trap

Keyword-2

Quantum computing

Keyword-3

Barium ions

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Session Classification: (DQI) T1-11 | (DIQ)

Track Classification: Technical Sessions / Sessions techniques: Division for Quantum Information / Division de l'information quantique (DQI / DIQ)