Robust meta-stable qutrit and mid-circuit cooling of barium ions

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Abstract

Trapped ion qubits provide long coherence time and high-fidelity quantum operation. Many trapped-ion systems rely on qubits encoded in ground-state hyperfine levels, but they are only a part of the complex quantum structure of the trapped ion. More advanced control techniques that exploit metastable states and light shifts could advance the capabilities of trapped-ion quantum computers [1,2,3,4]. In this talk, I will discuss two on-going research efforts. The first uses three levels within a metastable manifold of the barium-137 ion to provide qutrit states that are nearly insensitive to magnetic field fluctuations. The characteristics of the qutrit states and methods for controlling them will be explored. The second uses a spatially selective light shift in a chain of ions to enable mid-circuit cooling that minimally affects the quantum information in the neighboring ions. This scheme enables coolant ions to be dynamically assigned in a single-isotope chain, avoiding the technical overhead of having to work with multiple isotopes or multiple atomic species for cooling.

References

1. D. Allcock et al., Appl. Phys. Lett. 119, 214002 (2021).

2. Y. Yu et al., Phys. Rev. Research 7, 043355 (2025).

3. Z. Chen et al., Phys. Rev. A 113, 012606 (2026).

4. K. Ranawat et al., arXiv:2605.27577 (2026).