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Ultra-High Fidelity Operation of the $^{133}Ba^{+}$ qubit JUSTIN CHRISTENSEN, University of California, Los Angeles, DAVID HUCUL, Air Force, ERIC R. HUDSON, WESLEY CAMPBELL, University of California, Los Angeles — Trapped ions are attractive qubit hosts due to their long coherence times and straightforward manipulation via electromagnetic fields. Future fault-tolerant quantum computers will not only require ultra-high fidelity gate operations, which has been the focus of recent efforts, but also ultra-high fidelity state preparation and measurement (SPAM), which is currently orders of magnitude lower. We present recent work with the synthetic trapped-ion qubit $^{133}Ba^{+}$, a radioactive isotope of barium with a 10.5yr half-life. The spin-1/2 nucleus, visible wavelength electronic transitions, and long-lived $^{2}D_{5/2}$ state make this trapped-ion qubit ideal for ultra-high fidelity work. We demonstrate fast, ultra-high fidelity operation of $^{133}Ba^{+}$ resulting in an average SPAM fidelity of 0.9997, the highest reported of any qubit of any architecture. Future directions as well as straightforward ways to increase this SPAM fidelity beyond fault tolerance thresholds will also be discussed.

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