Oxford Ion Trap Quantum Computing Team

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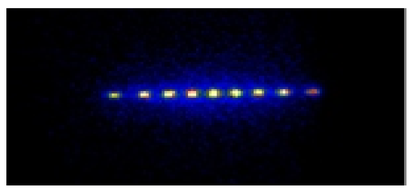
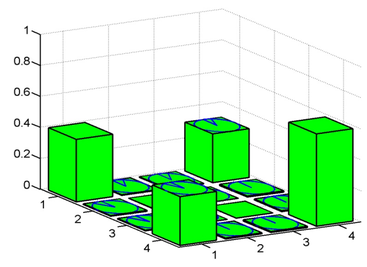
Qualifications and Capabilities

- Trapping Calcium-40 and Calcium-43 ions for multi-qubit quantum logic



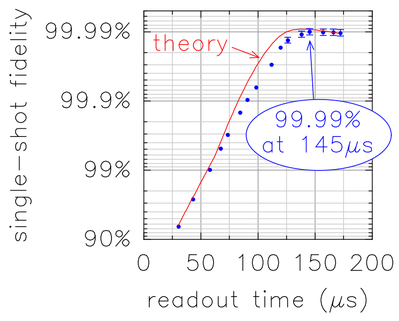
- Single-qubit and two-qubit deterministic logic gates

  Single-qubit: ~99% fidelity in ~10μs
  Two-qubit: 83(2)% fidelity in 77μs

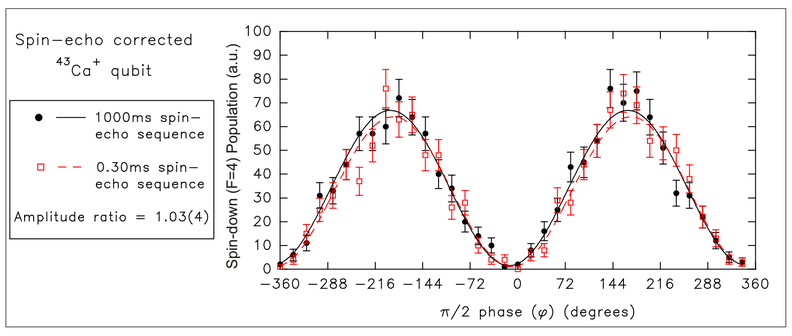


- Multi-qubit *single-shot* readout at fault-tolerant fidelities

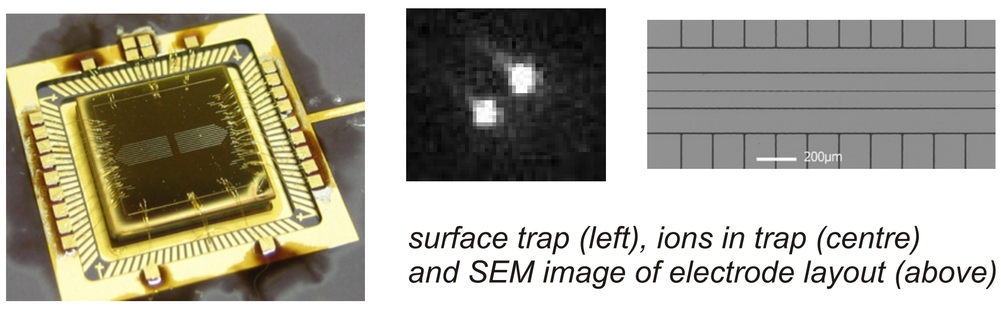
  Single-qubit: 99.990(1)% fidelity in 145μs
  Multi-qubit: 99.990(3)% fidelity in 230μs



- Long-lived memory qubits
  Coherence >98% after 1 second ($T_2 \approx 1$ minute?)
  Coherence demonstrated during sympathetic cooling using second isotope
  Coherence time extended ~50x using "dynamical decoupling" pulses



- Surface trap design and in-house fabrication in Oxford clean room facility
  Demonstration of "six-wire" surface trap design

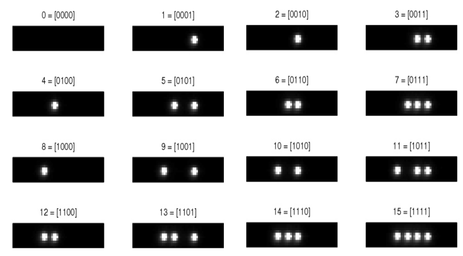


surface trap (left), ions in trap (centre) and SEM image of electrode layout (above)

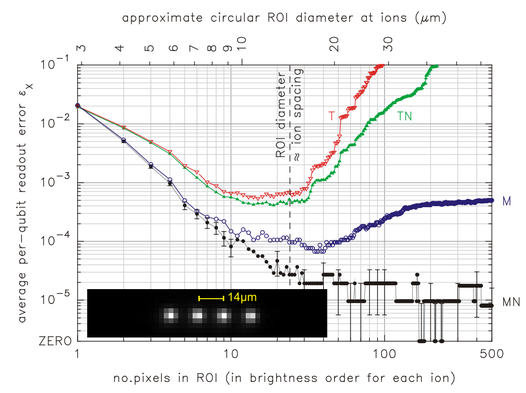
- Testing of micro-fabricated multi-zone traps
  Semi-conductor traps from Sandia and Lucent tested
  Gold-on-alumina X-junction two-layer micro-fab trap currently under assembly
- Theoretical expertise
  Quantum error-correction and fault-tolerance theory
  Modelling of coherent laser-atom interactions
- Separate apparatus for quantum logic and for dedicated trap testing
  Non-frequency-doubled laser sources throughout (IR and violet laser diodes)

Research Interests

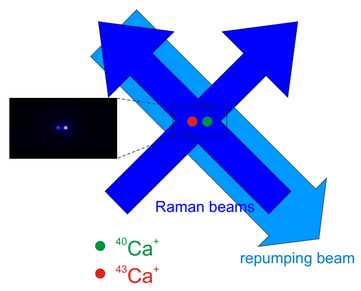
- Improving fidelity of basic qubit operations close to fault-tolerant level
  Newly acquired 250mW SHG diode laser source to perform higher-fidelity Raman gate operations.
- High-fidelity multi-qubit measurement

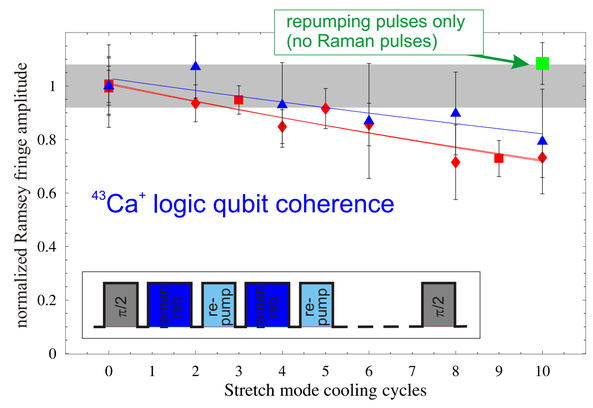


Preparation and measurement of all 16 states of a "qunybble": readout fidelity reaches 99.999% when qubit decay is excluded, in spite of ~5% image cross-talk



- Sympathetic cooling to allow repeated gates

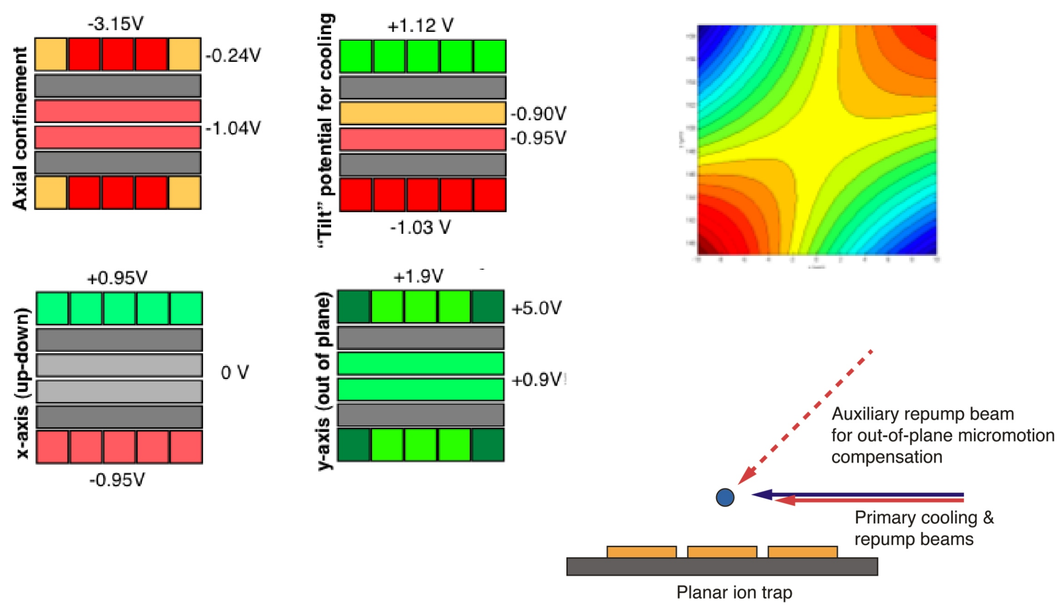




Coherence of a Ca-43 "memory" qubit whilst being sympathetically cooled by a Ca-40 "refrigerator" qubit

- Surface trap juctions for multiplexed ion trap arrays with relatively simple fabrication techniques

- Manipulation of surface trap normal-modes for efficient cooling and micromotion compensation in directions orthogonal to cooling laser using infrared beams



Capablities Sought

- Advanced multi-channel signal generation for fast, high-preceision, control of several independent ion traps, with specifications approximating:
  16-bit precision, 20 MHz update rate, scalable to 100's of channels
- Cryogenic/UHV mounting system for scalable traps
- Sympathetic laser cooling with different ion species
- Increased collaboration with trap fabrication and custom optics design facilities
- Fast, high-quantum efficiency, CCD-like detectors with addressable readout

Contact Information

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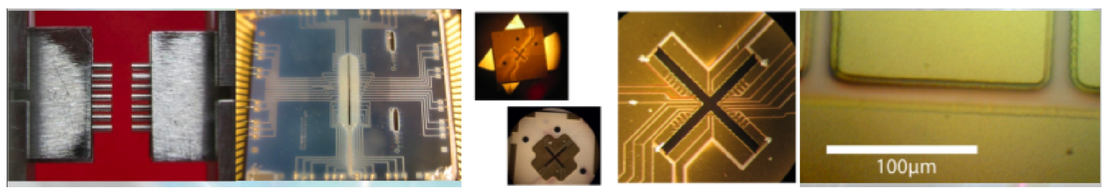

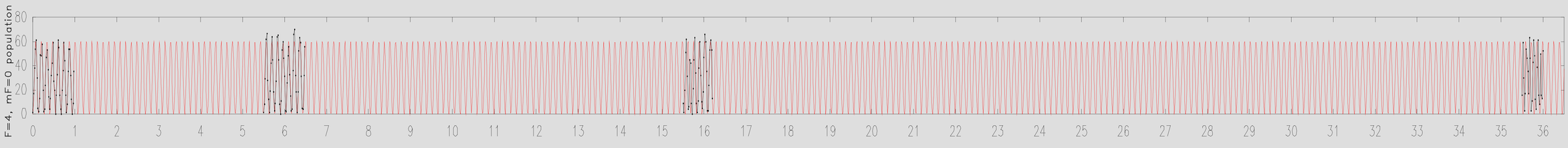

Rabi-flopping on field-independent $^{43}Ca^+$ qubit. (~270 flops)