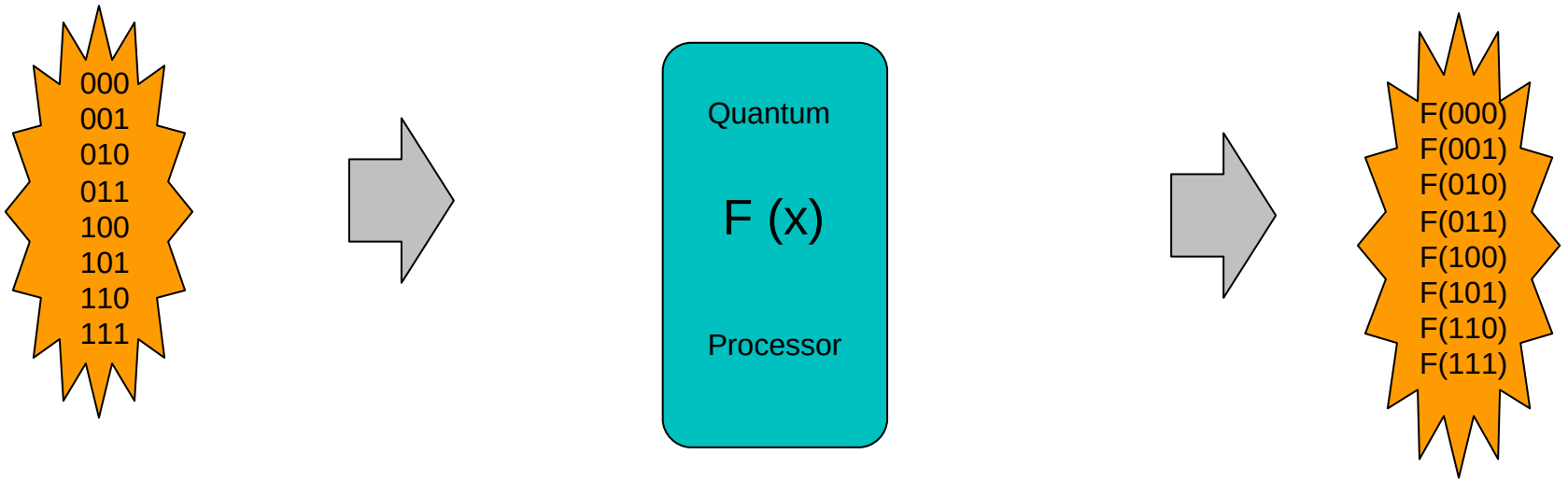
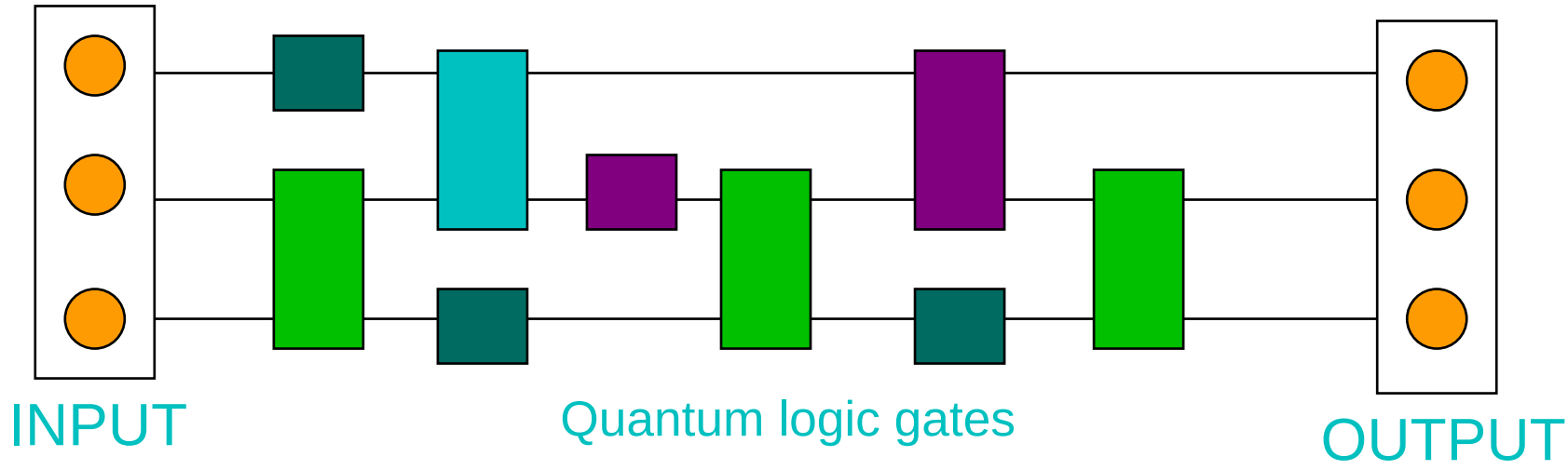
Quantum Information Processing

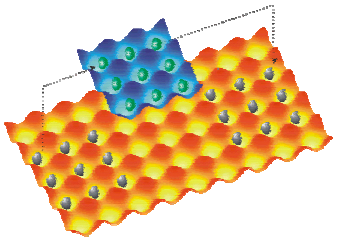
Jonathan Jones

Quantum parallel processing

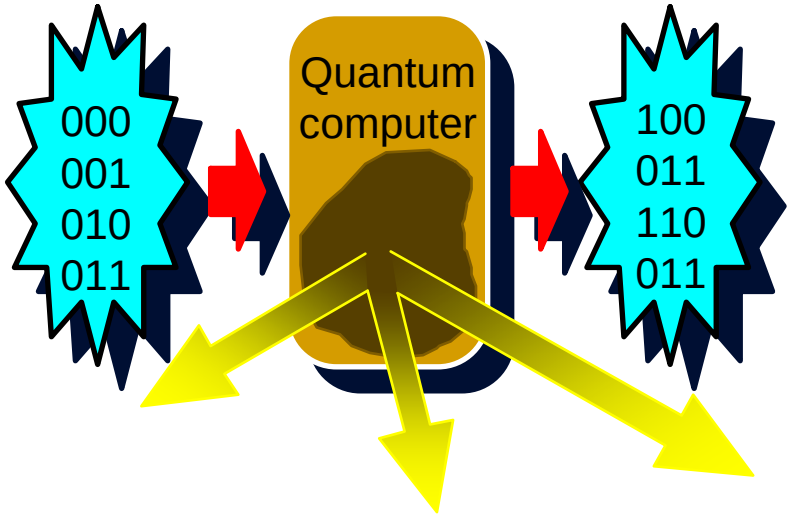




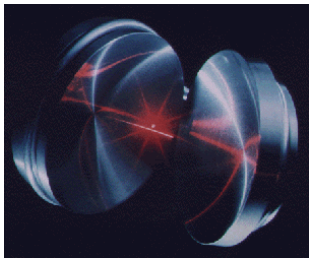
Technologies



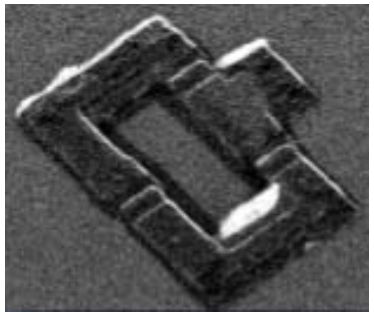
optical lattices



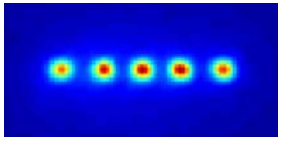
NMR



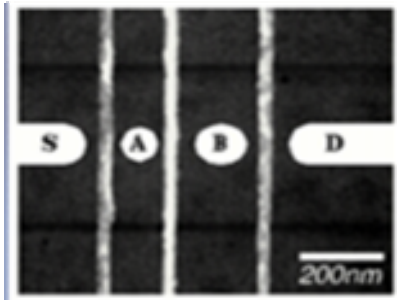
cavity QED



superconductors



ion traps



quantum dots

DiVincenzo criteria

1. Scalable well characterized qubits
2. Initialization
3. Long decoherence times
4. Universal quantum gates
5. Readout (measurement)
6. Interconvert stationary and flying qubits
7. Transmit flying qubits

SILURIT

ARDA Roadmap 2004

Table 4.0-1
The Mid-Level Quantum Computation Roadmap: Promise Criteria

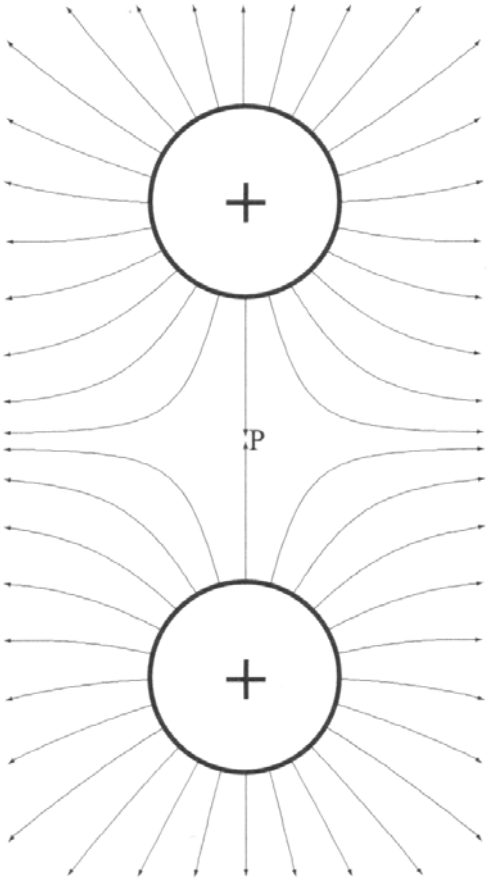
QC Approach	The DiVincenzo Criteria							
	Quantum Computation						QC Networkability	
	#1	#2	#3	#4	#5		#6	#7
NMR								
Trapped Ion								
Neutral Atom								
Cavity QED								
Optical								
Solid State								
Superconducting								
Unique Qubits	This field is so diverse that it is not feasible to label the criteria with "Promise" symbols.							

Legend: = a potentially viable approach has achieved sufficient proof of principle

 = a potentially viable approach has been proposed, but there has not been sufficient proof of principle

 = no viable approach is known

Earnshaw's theorem



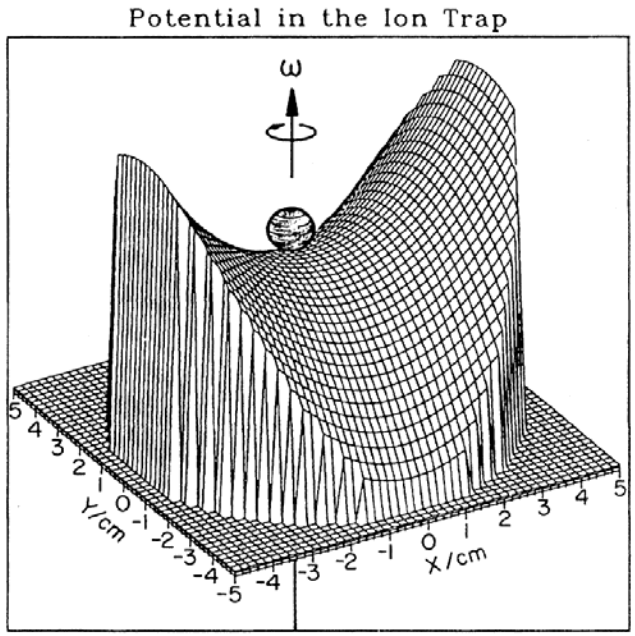
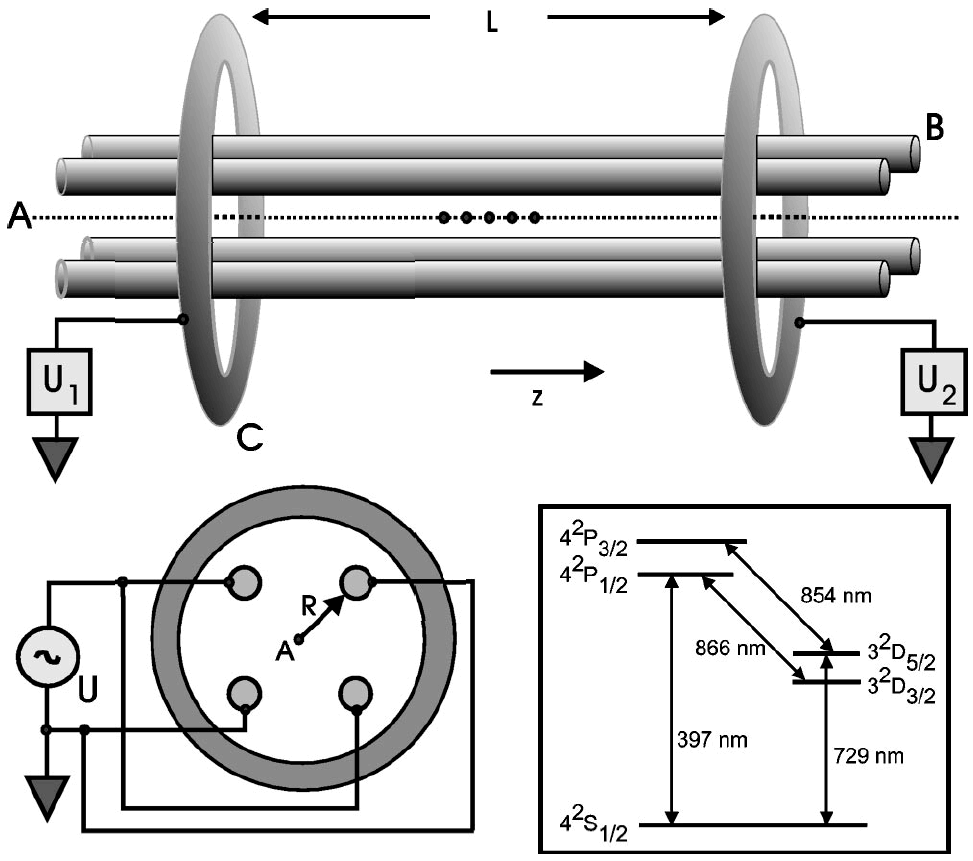


FIG. 8. Mechanical analogue model for the ion trap with steel-ball as "particle."

Ion trap for $^{40}Ca^{+}$ ions



Trapped $^{40}Ca^{+}$ ions

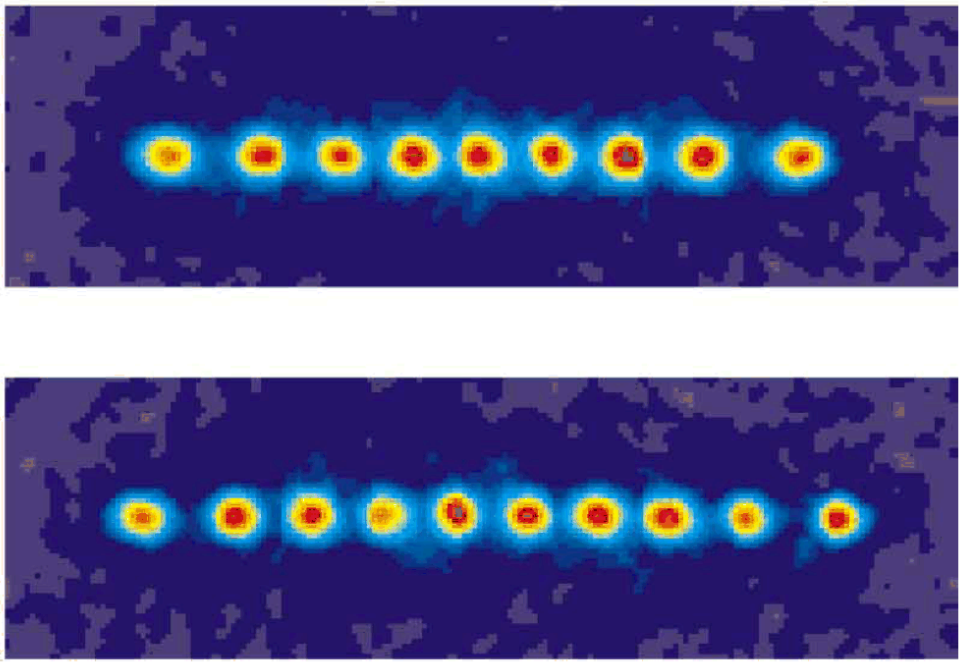
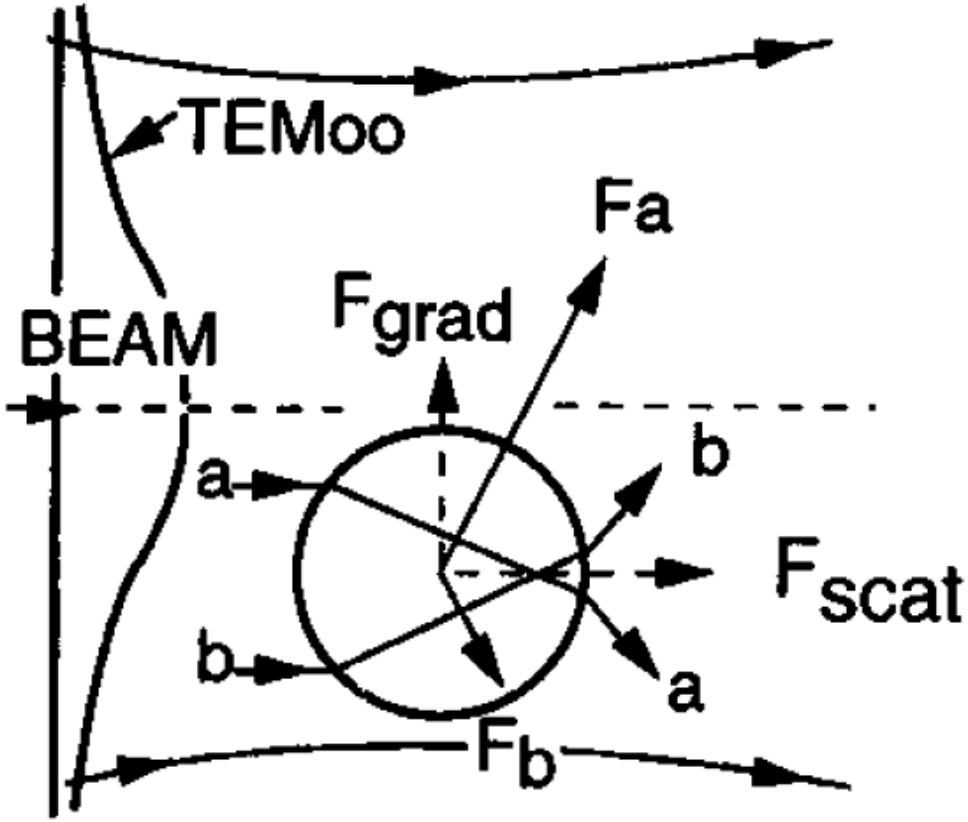
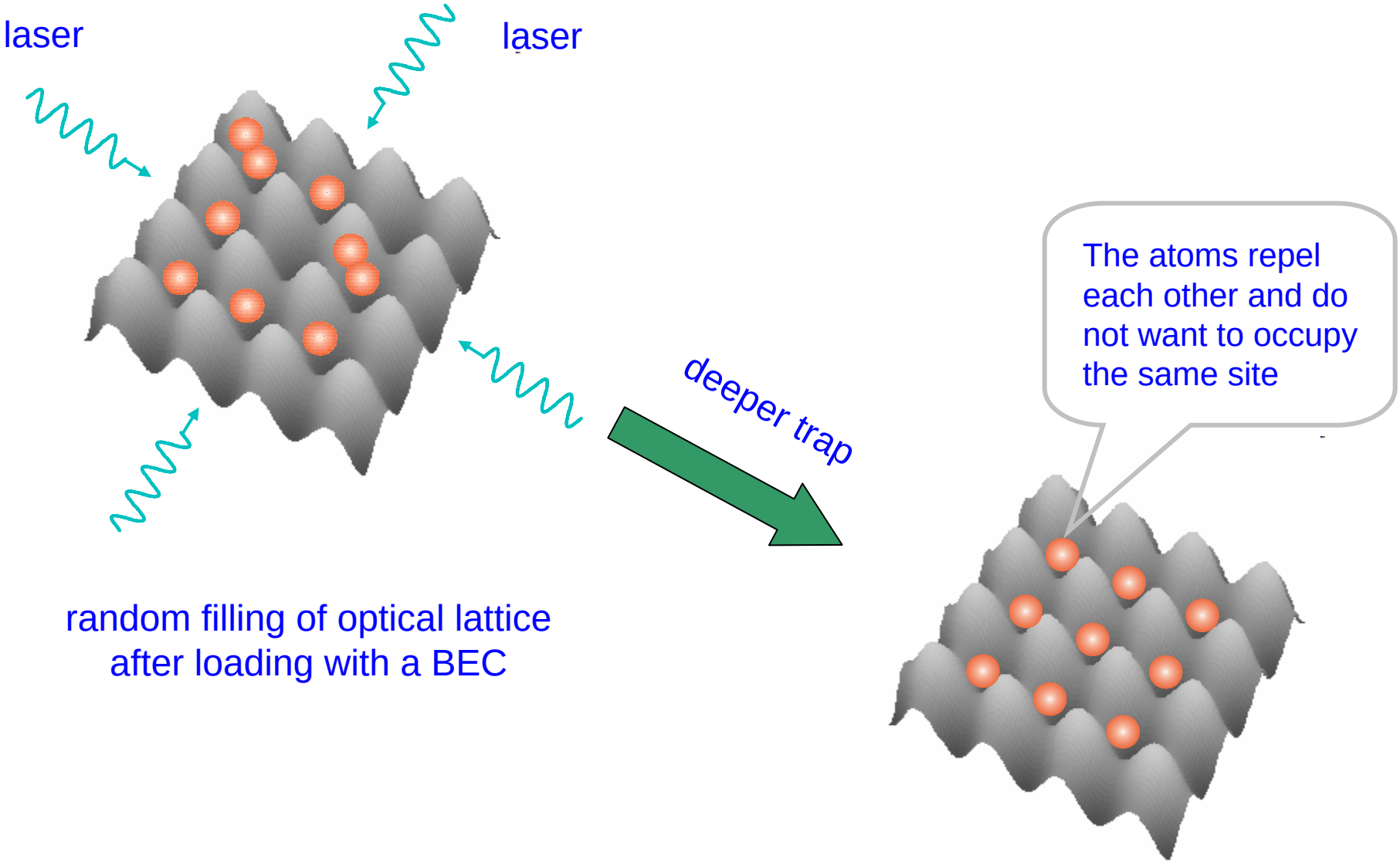


Fig. 5. Examples of some small linear strings of ions. The average distance between two ions is about 10 μm. The exposure time for the CCD camera was 1 s. The measured resolution of the imaging system consisting of the lens and CCD camera is better than 4 μm

Optical traps

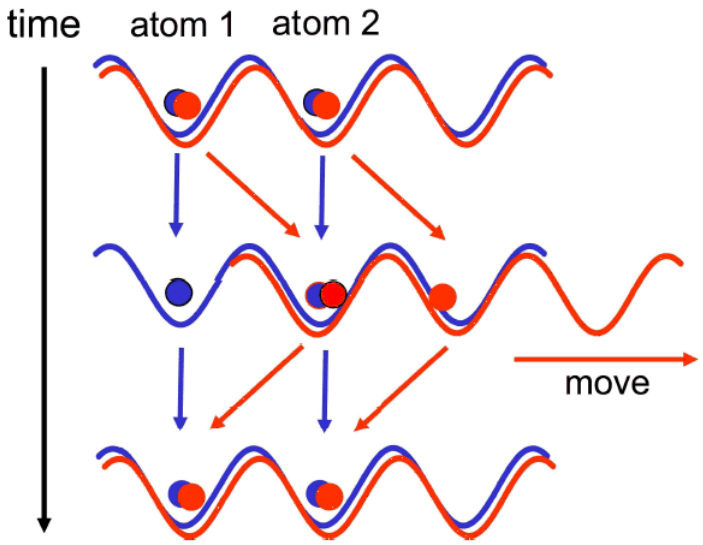


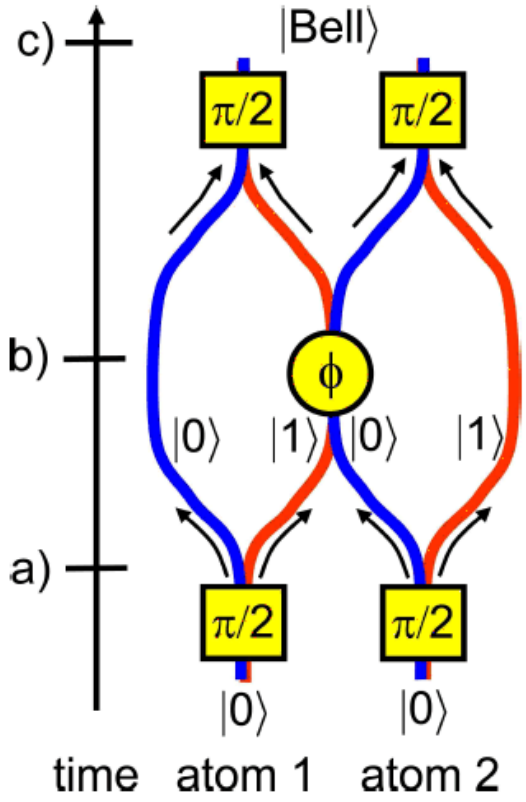


random filling of optical lattice
after loading with a BEC

Regular filling by increasing
the interaction in a deep trap

Optical lattice phase gates





$^{40}Ca^{+}$ ion readout

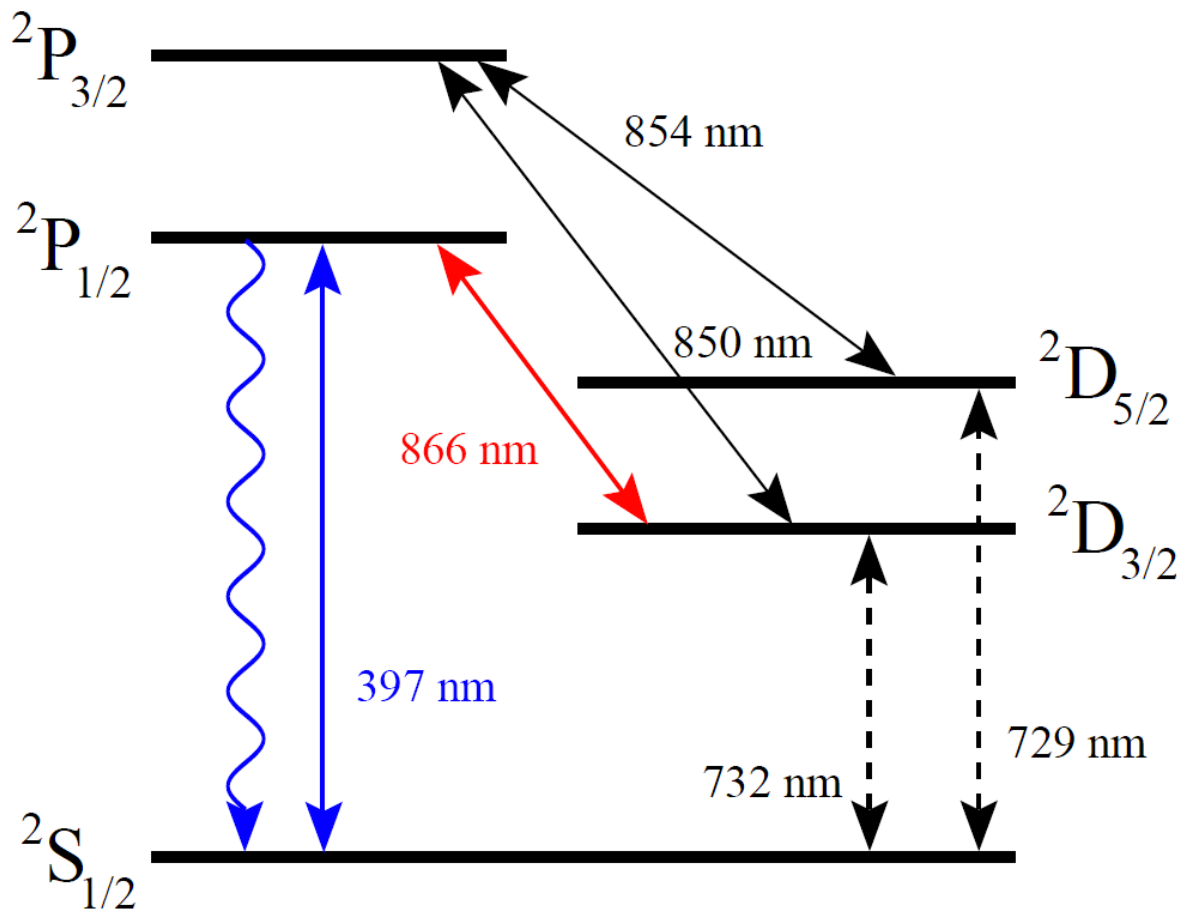
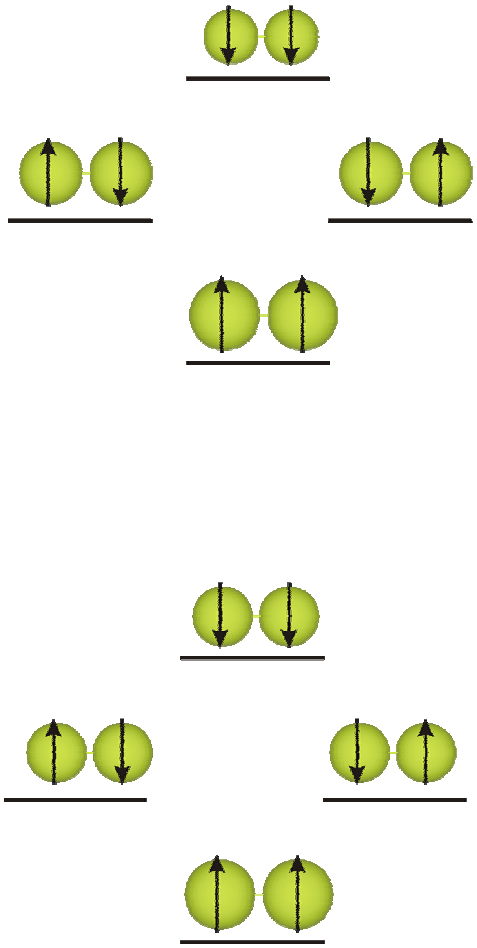


Fig. 1. Level scheme of $^{40}Ca^{+}$

Two spin system

- A homonuclear system of two spin 1/2 nuclei: four energy levels with nearly equal populations
- Equalise the populations of the upper states leaving a small excess in the lowest level



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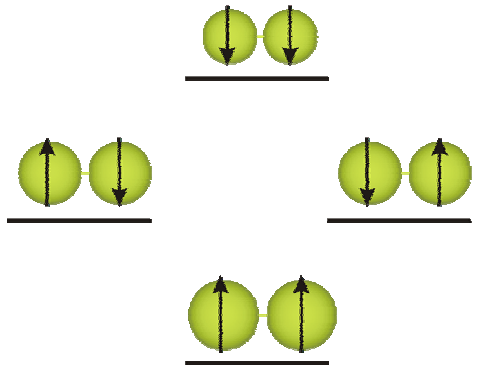

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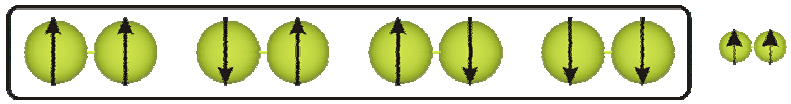
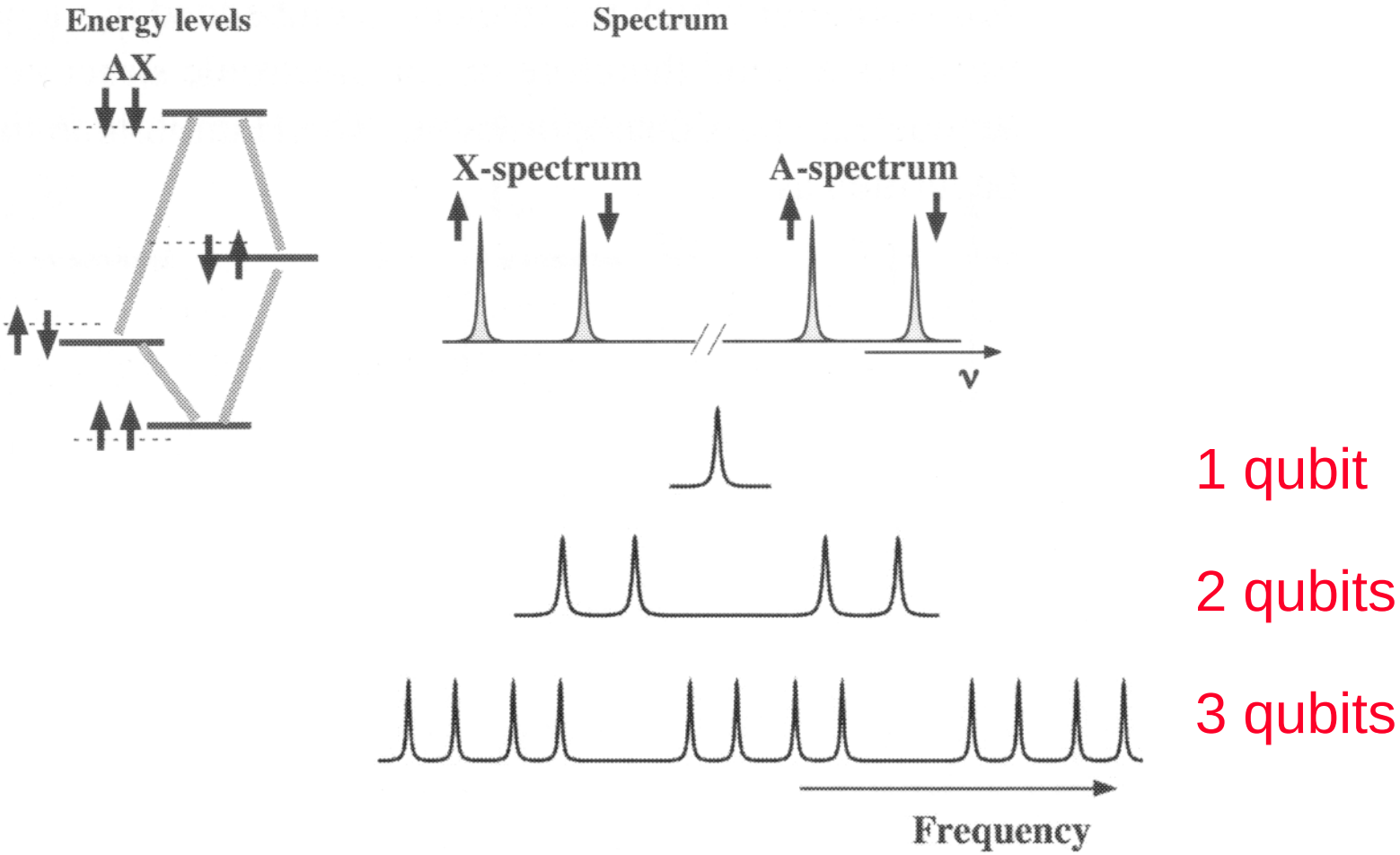


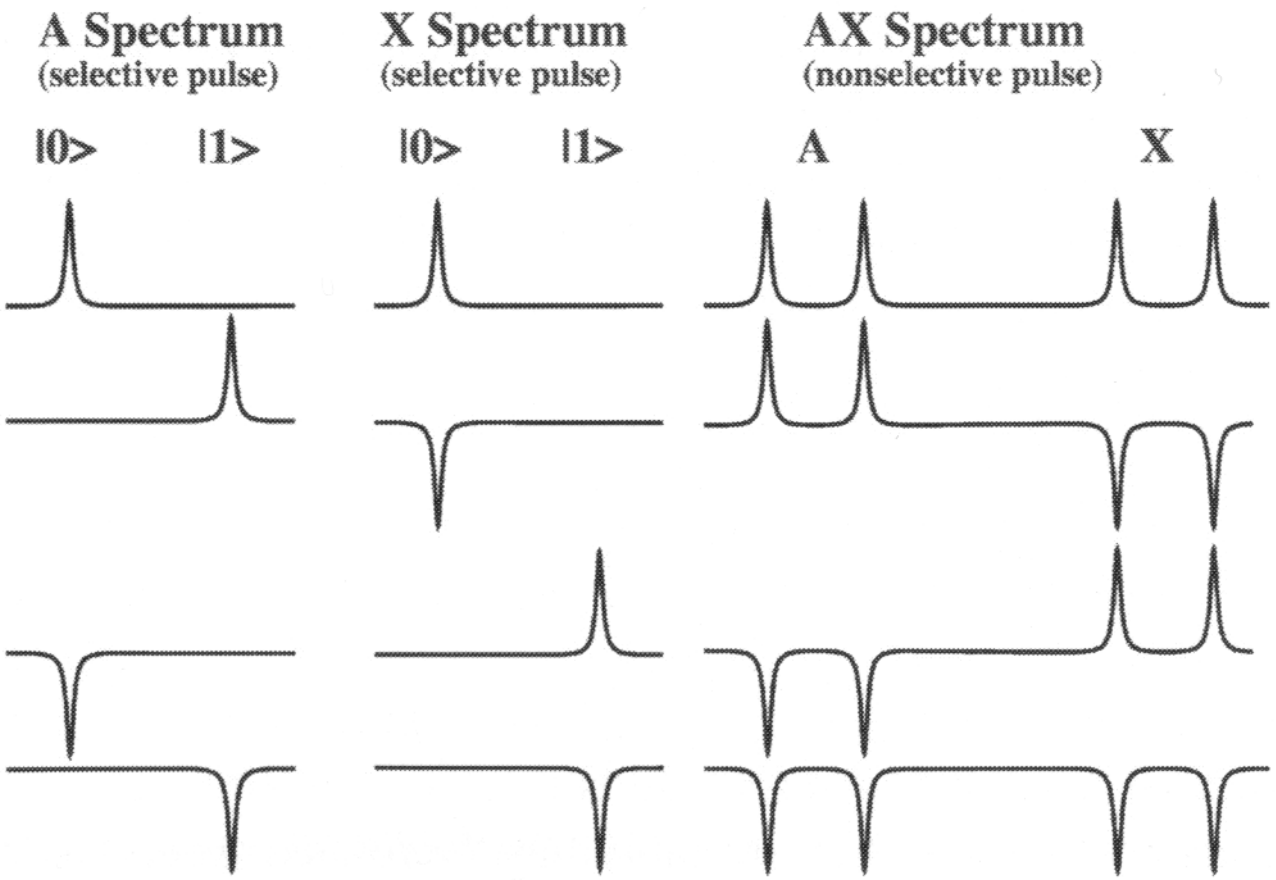
A “pseudo-pure” state

Excess population is exponentially small

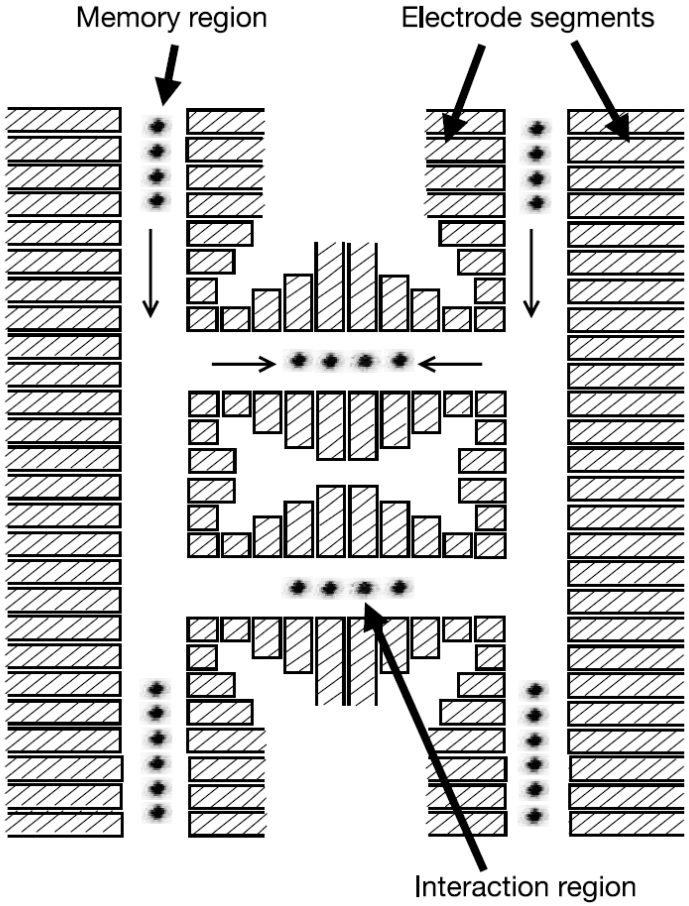
NMR levels and specta



NMR readout


A Spectrum
(selective pulse)
|0>
|1>
X Spectrum
(selective pulse)
|0>
|1>
AX Spectrum
(nonselective pulse)
A
X

Large scale ion trap QC



Large scale ion experiments