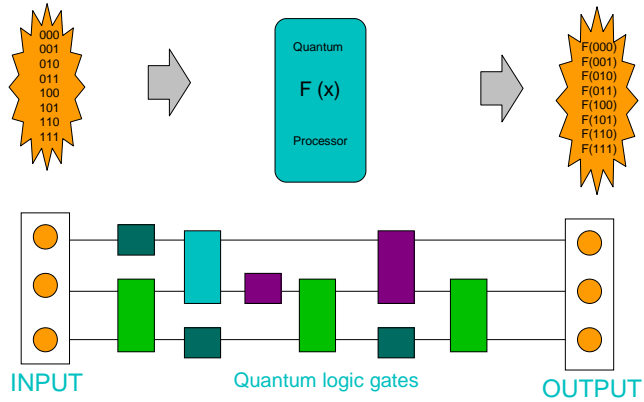
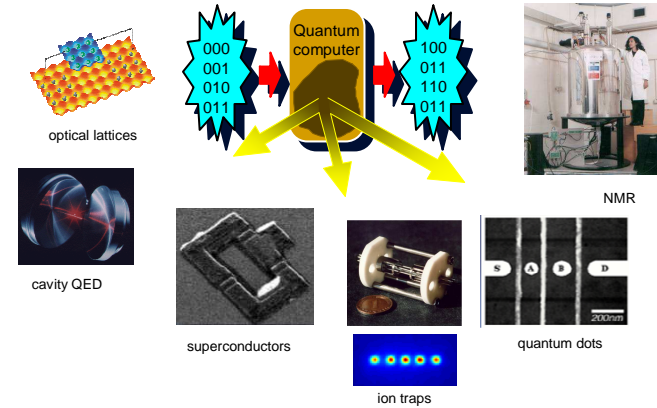


## Quantum parallel processing



## Technologies



## 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					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

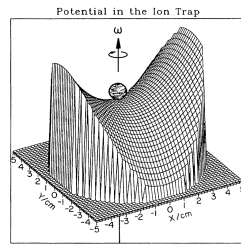
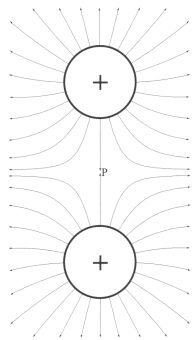
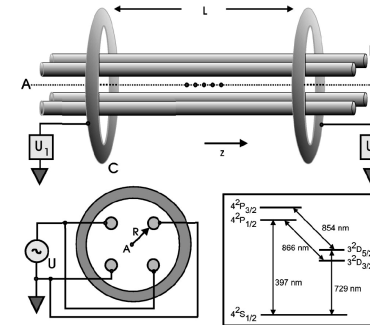


FIG. 8. Mechanical analogue model for the ion trap with steel-ball as "particle."

## Ion trap for $^{40}\text{Ca}^+$ ions



## Trapped $^{40}\text{Ca}^+$ ions

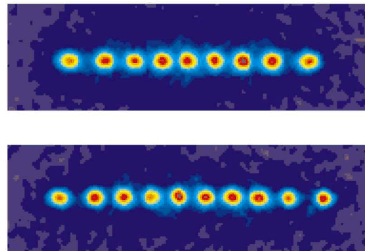
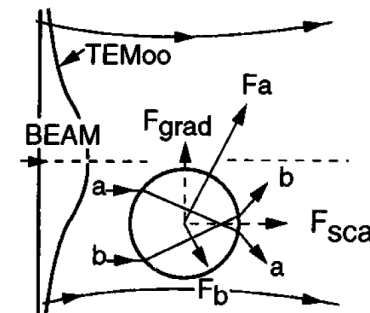
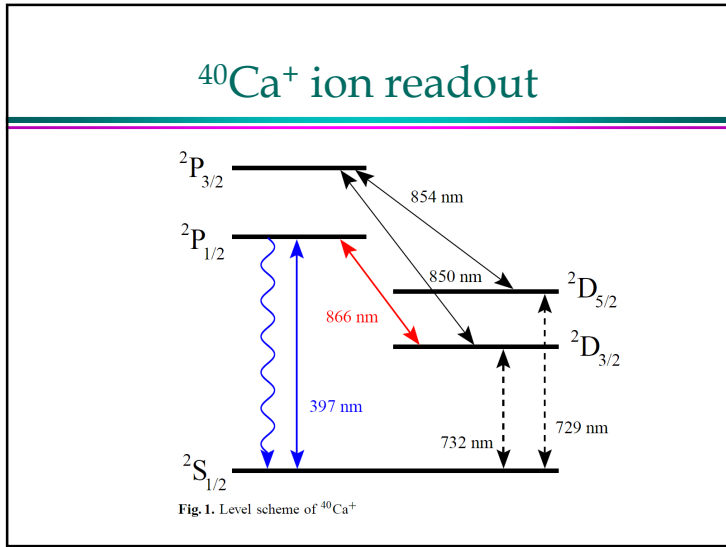
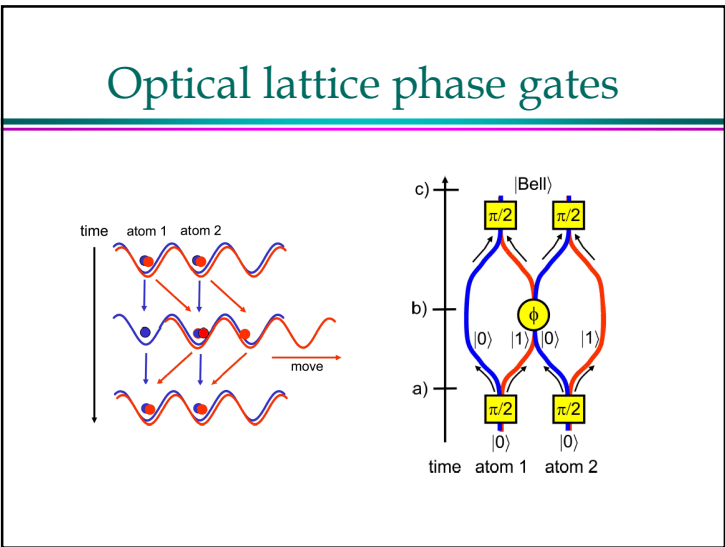
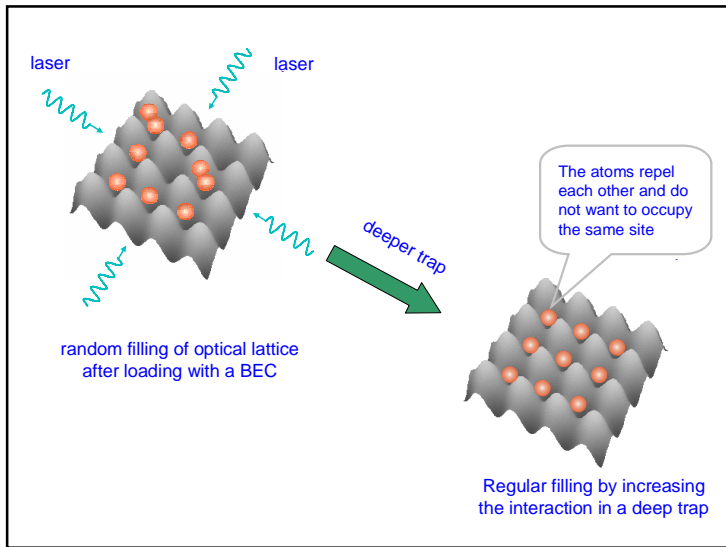


Fig. 5. Examples of some small linear strings of ions. The average distance between two ions is about  $10\ \mu\text{m}$ . The exposure time for the CCD camera was 1 s. The measured resolution of the imaging system consisting of the lens and CCD camera is better than  $4\ \mu\text{m}$ .

## Optical traps





### 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

A "pseudo-pure" state

Excess population is exponentially small

