

Title: What A Quantumful World

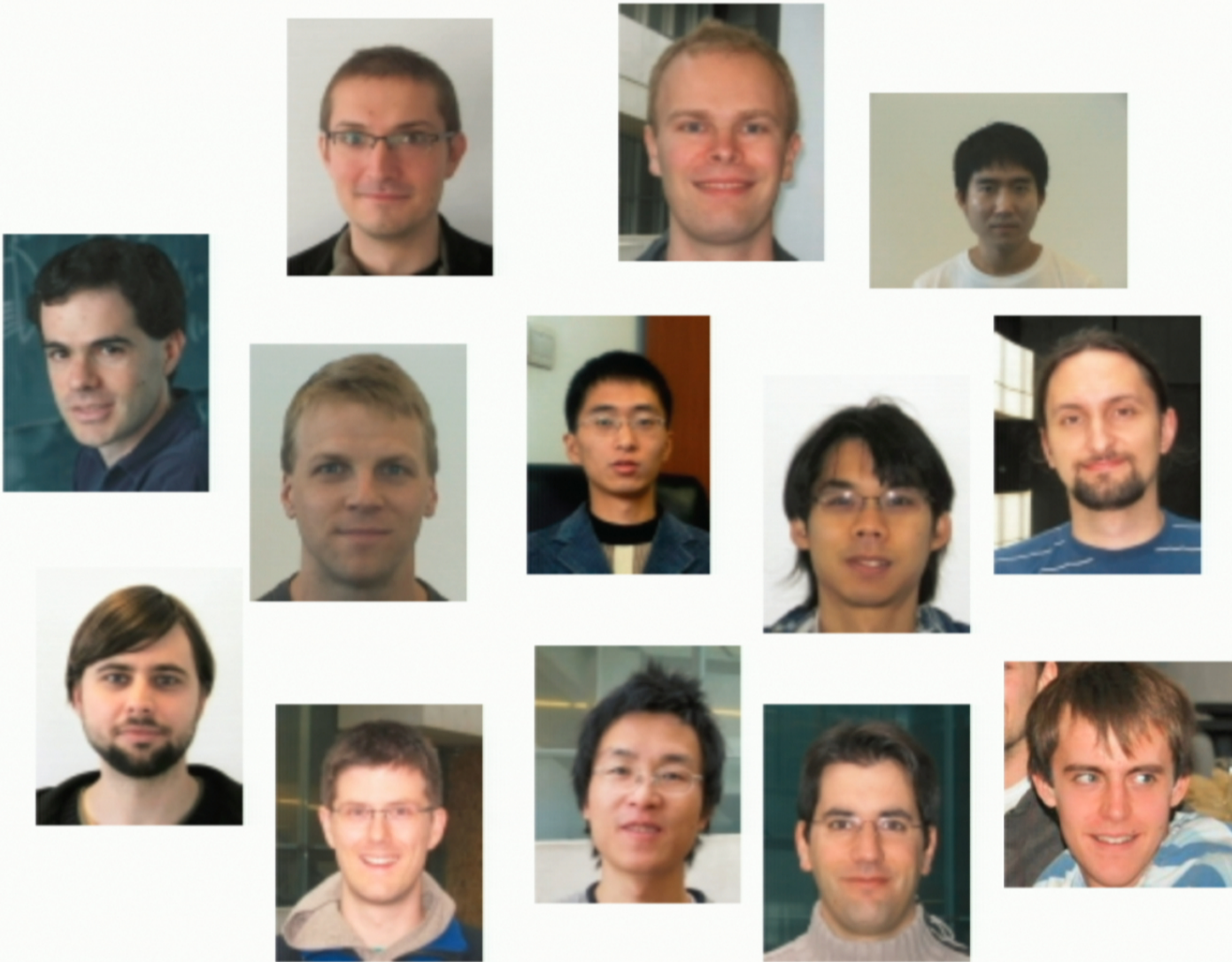
Date: Jan 30, 2014 10:15 AM

URL: <http://pirsa.org/14010109>

Abstract:

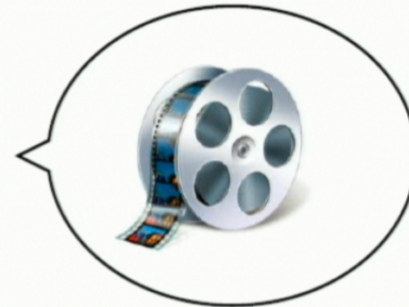
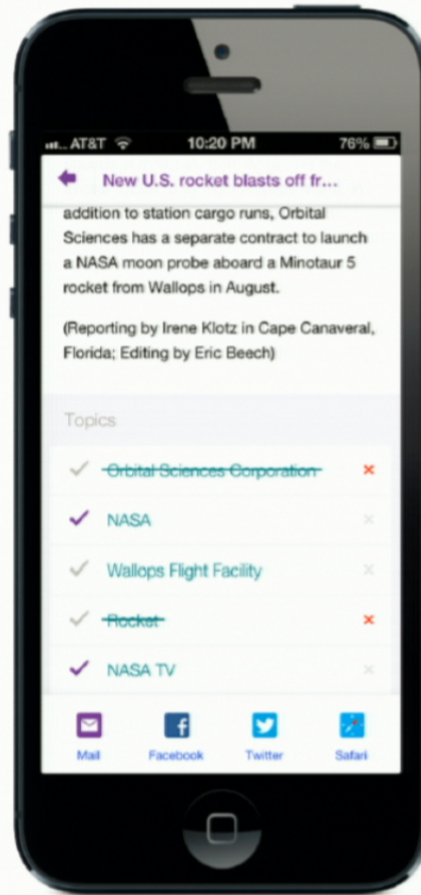
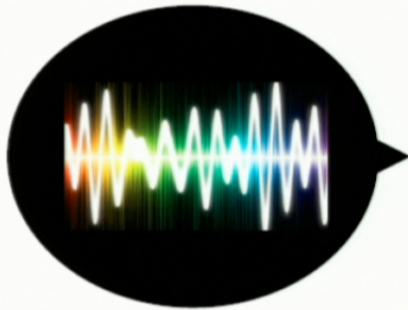
What a Quantumful World

PI day



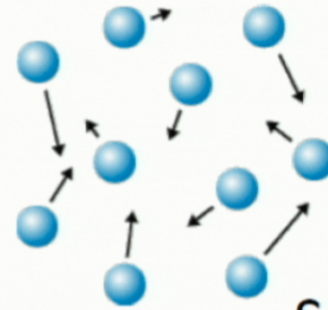
Outline

- WHY quantum information & computation?
- HOW to make it work?
- WHAT can we learn?

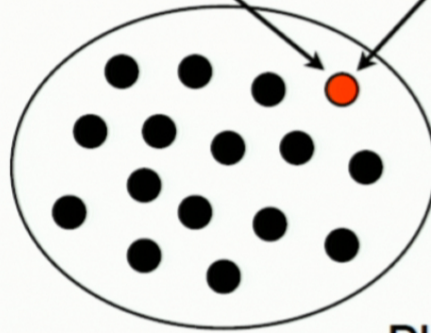


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010101010100110
100110011010100
101001101011010
111011110101001
100010110010010
001001000010001
```

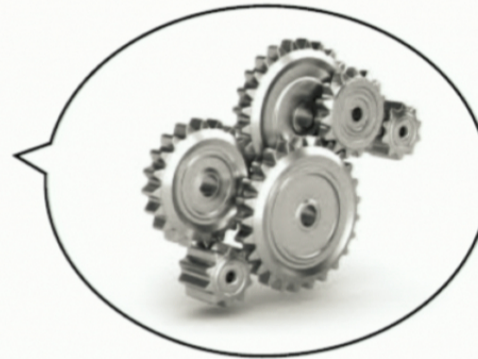
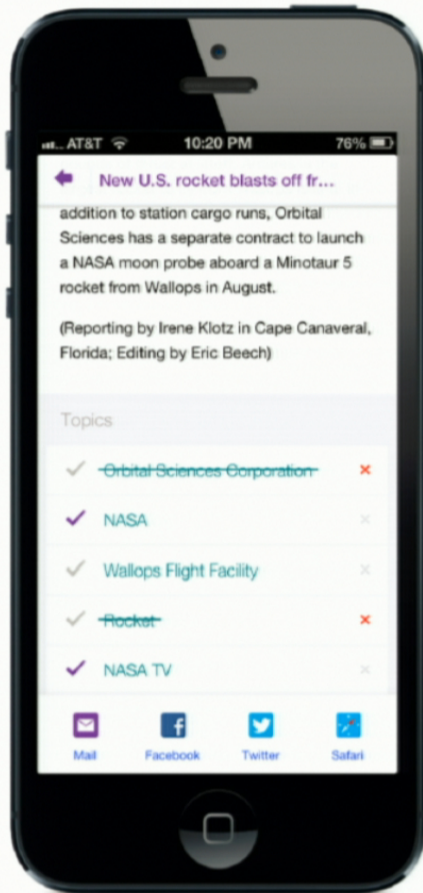
Binary string



System state



Phase space

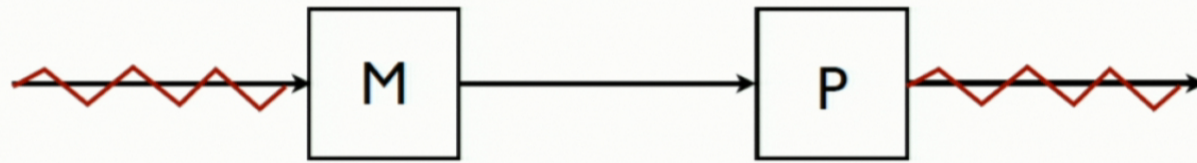




Information is physical



...and physics is quantum

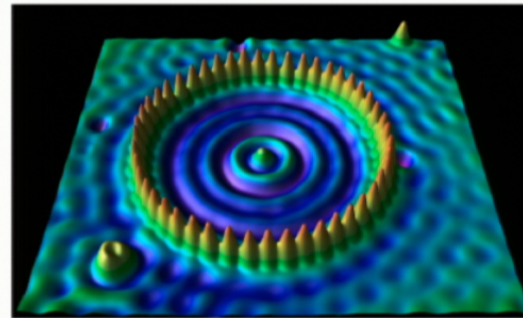


0 or 1
Bits

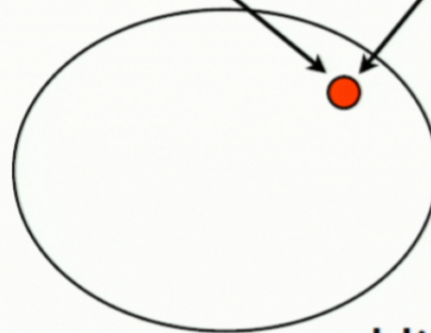
—————→ $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle,$
Qubits

$$\bigotimes_i H_{\text{qubit}}$$

Qubit 'string'



Pure state



Hilbert space

- How is QI&C different?

Cryptography, exponential speed-up...

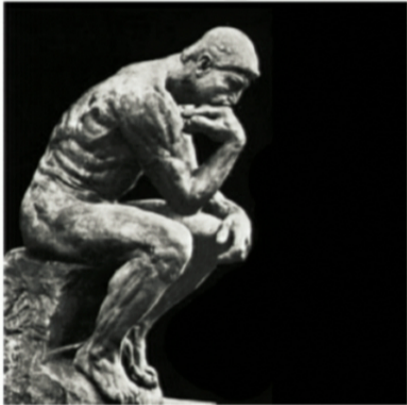
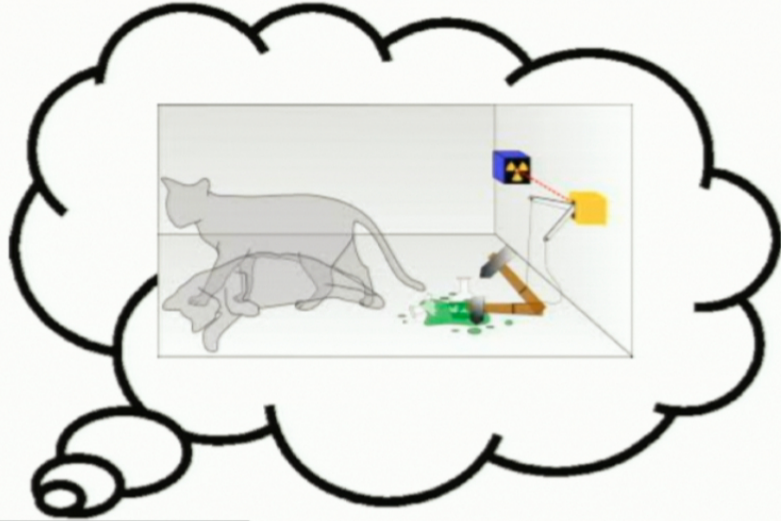


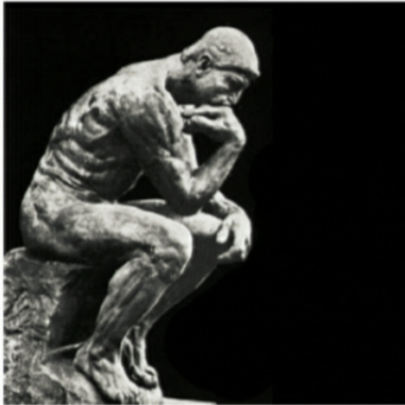
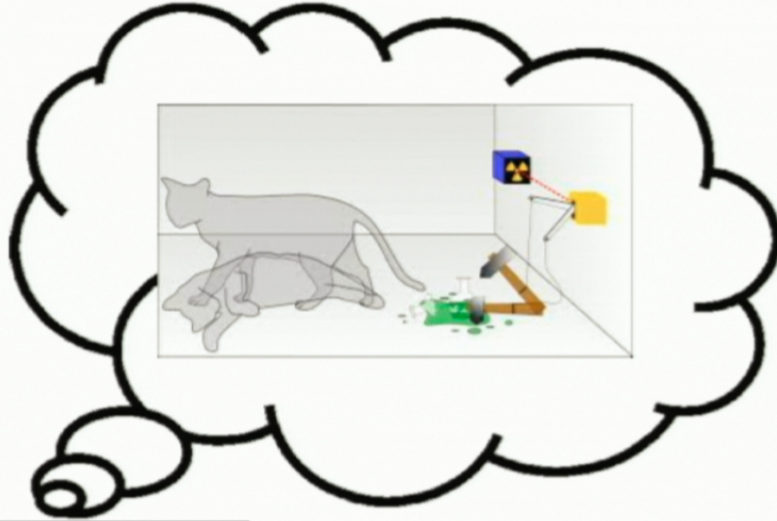
Abstract

Task oriented
computation, communication, cryptography



Resource theory

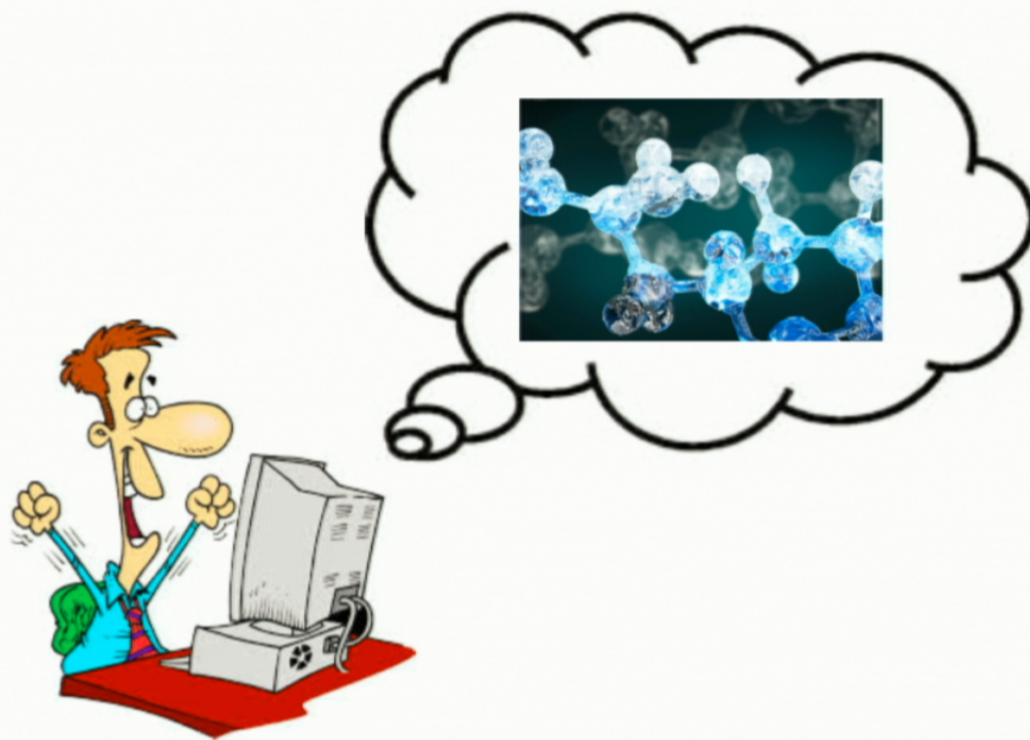




Does it catch mice?



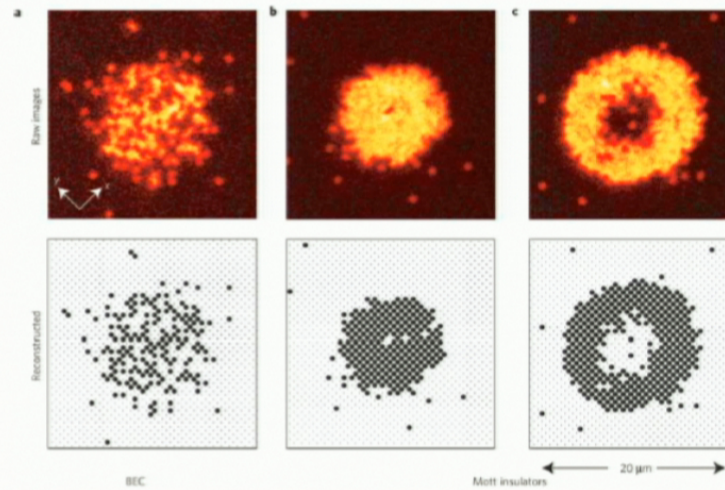
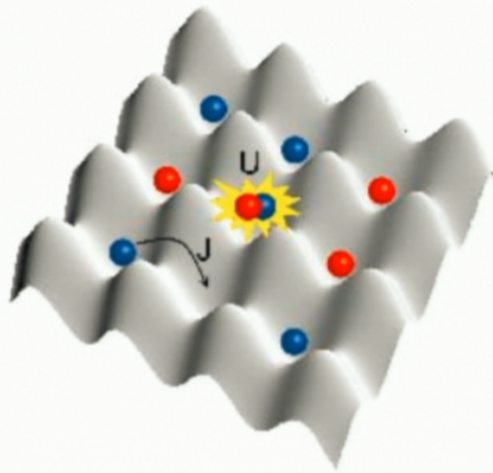
Simulating physics with computers



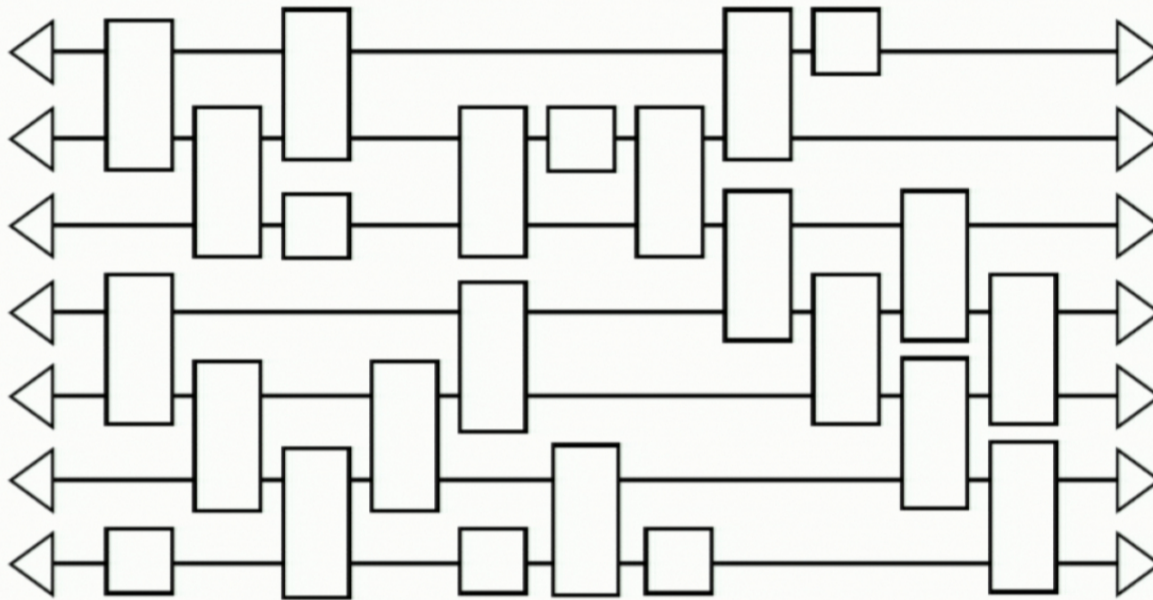
Analog computers



Analog quantum computers



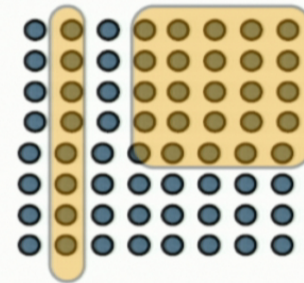
Quantum computers



- Want: isolation + control
- Have: decoherence + imprecision
- Need: error correction

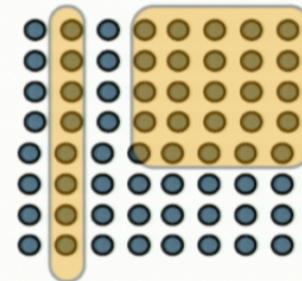
Error correction

- Errors are local
- Encode in collective degrees of freedom
- Good news: it works!
- Bad news: sort of

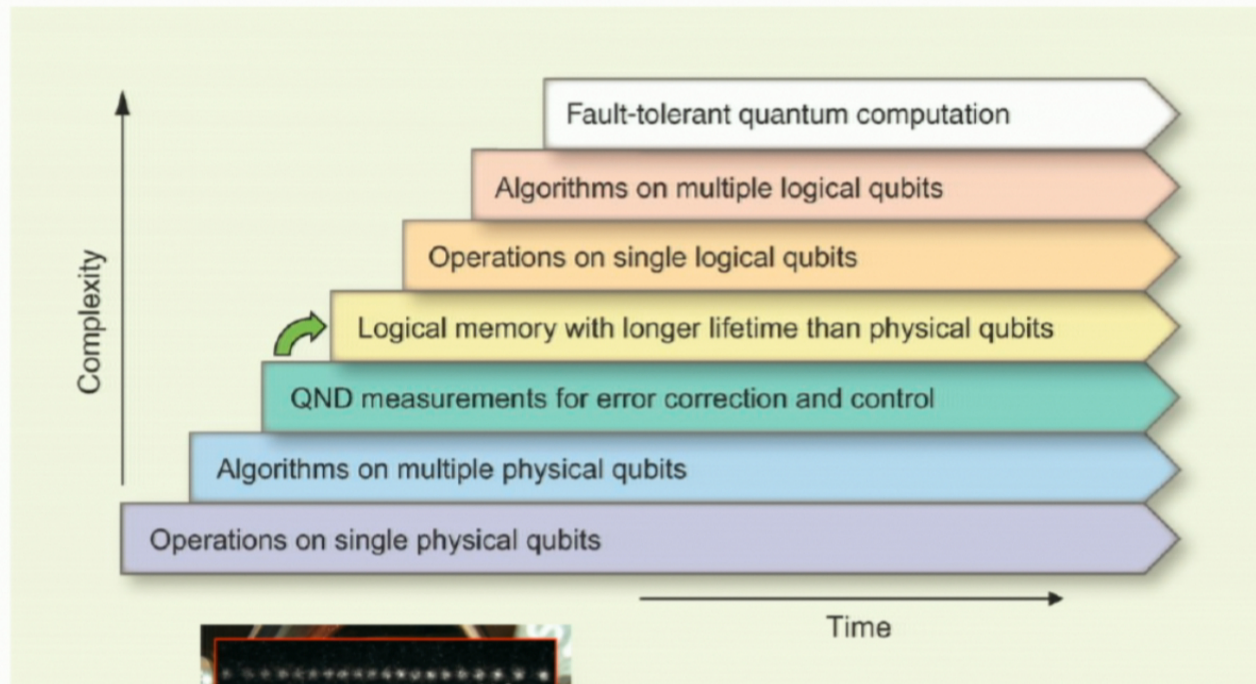


Error correction

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Roadmap

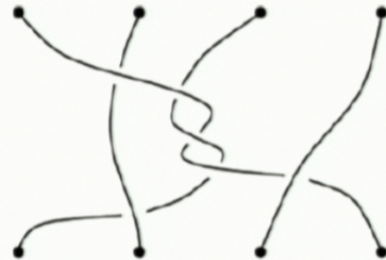


physical qubits \sim cnst # logical qubits



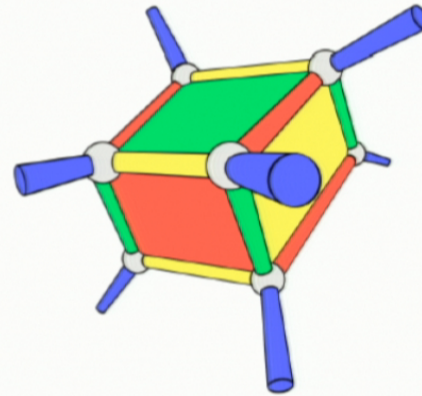
Deformation robustness

- Energy gap
- GS degeneracy
- Local indistinguishability



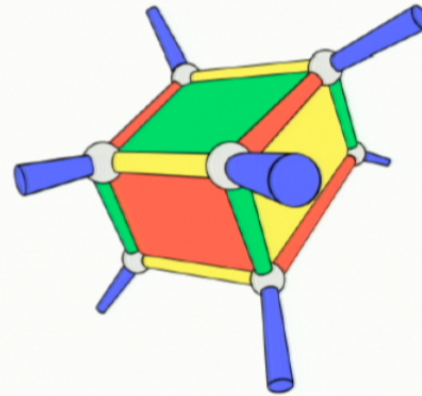
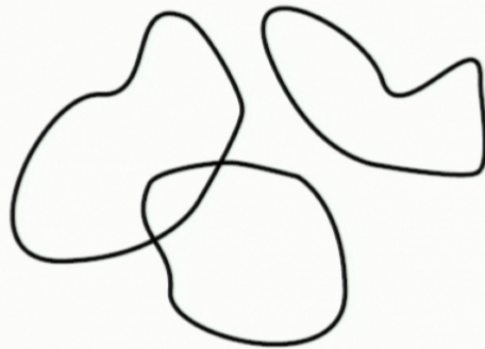
Thermal robustness

- Free energy wall
- High D needed?



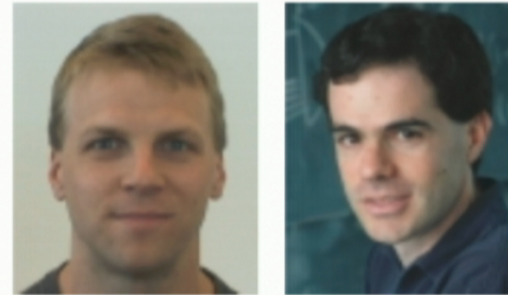
Thermal robustness

- Free energy wall
- High D needed?





- How do we verify a QC?



Entanglement

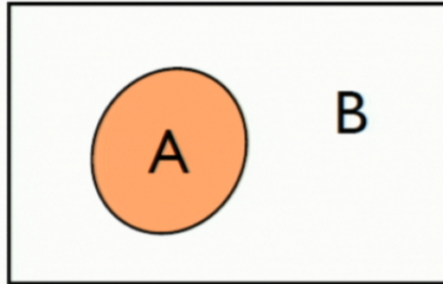
"the characteristic trait of quantum mechanics"



$$|\Phi^+\rangle = \frac{1}{\sqrt{2}}(|0\rangle_A \otimes |0\rangle_B + |1\rangle_A \otimes |1\rangle_B).$$

Bell state = 1 ebit

$$S = -\text{tr}(\rho \ln \rho),$$

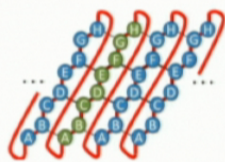
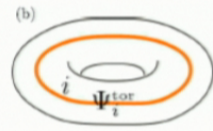
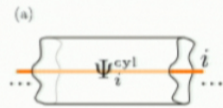
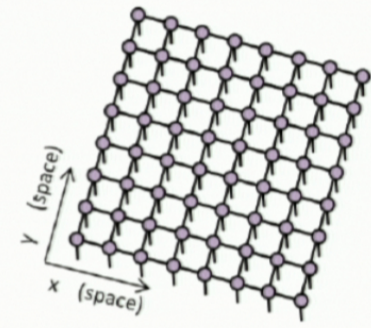
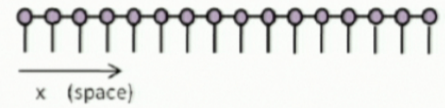
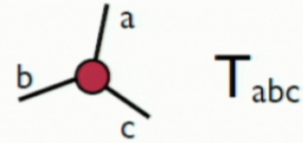
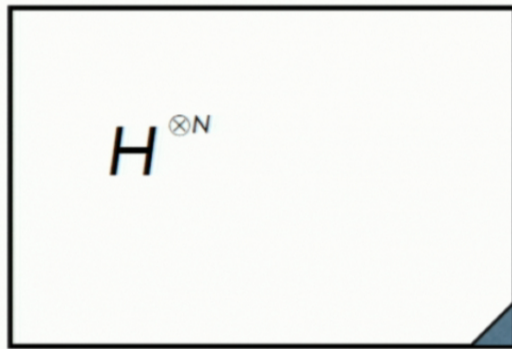


- What can entanglement tell about many-body systems?

$$\log_2 N \leq O(L^{D-2})$$



Tensor networks



- What is the ultimate computer?

