

# QUANTUM COMPUTING LECTURE 0

## WHAT DOES "QUANTUM" MEAN?

**QUANTUM MECHANICS** describes how objects behave at small scale

- ★ Describes physics at the microscopic level
- ★ Seemingly incompatible with the types of observations in everyday
- ★ Leads to counter-intuitive effects
- ★ Used for describing the behavior of an atom

**QUANTUM COMPUTING** uses quantum phenomena to perform computation

- ★ Quantum mechanics is an additional tool used by quantum computers
- ★ Solve certain computational problems that normal computers cannot

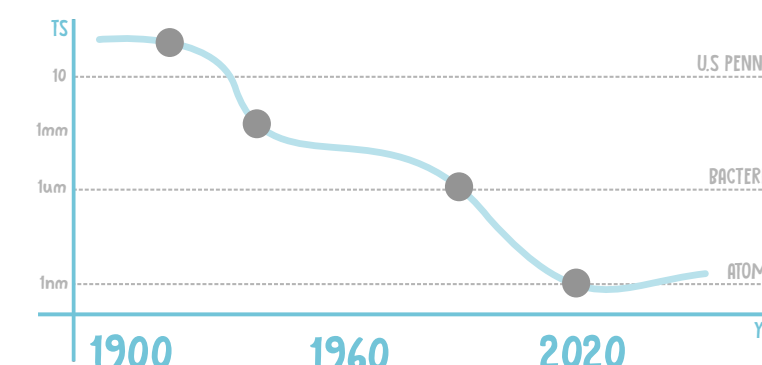
"Quantum computing is an application of Quantum Mechanics"

## WHY GO QUANTUM?

Some problems are just too hard for a classical computer to solve

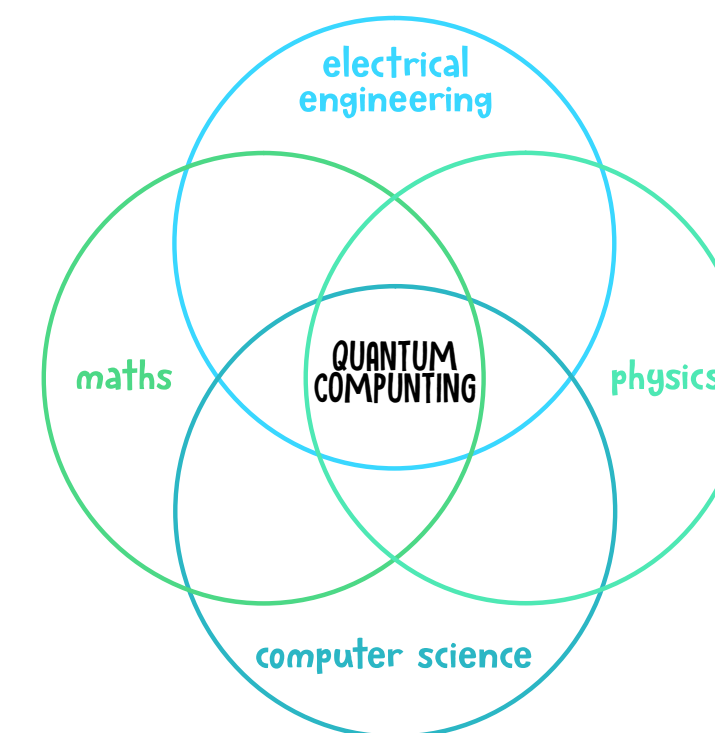
### MOORE'S LAW

"Computational power gets doubled every 18 months"



## WHAT IS IT?

It's interdisciplinary



### AMIR'S COCKTAIL PARTY DEFINITION

"In quantum computing we use the weirdness of quantum mechanics to solve problems that normal computers cannot"

### BIT (Classical computing)



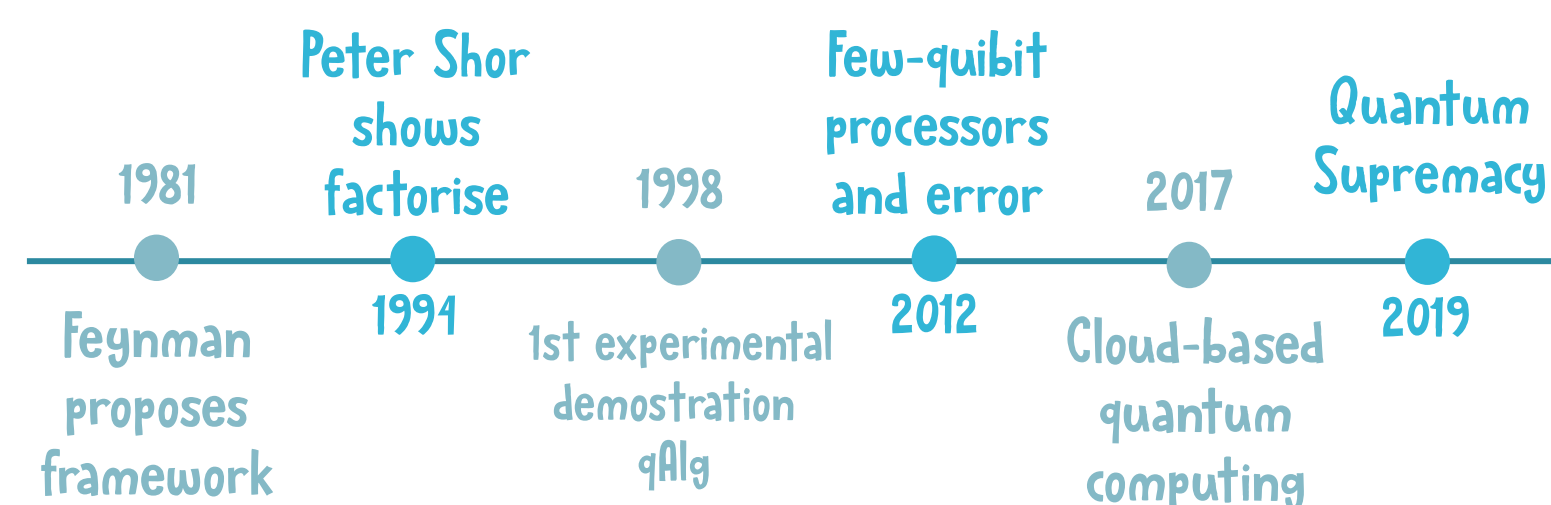
Basic unit of information processes

### QUBIT (Quantum computing)



It can be a combination of 0 and 1 simultaneously

## [QU]BIT OF QUANT HIST



## QUAN HARDWARE PLAT

- ★ Nuclear magnetic resonance
- ★ Trapped Ions
- ★ Majorana/Topological
- ★ Neutral Atoms
- ★ Diamond NV Cent
- ★ Superconducting
- ★ Photonics

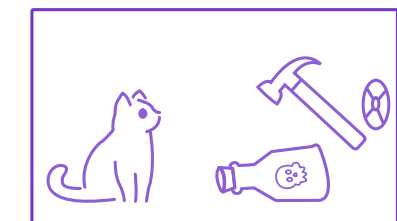
## CURRENT STATE QCM

"fifty-four qubit superconducting quantum computers"

- IBM, Google, Intel, Rigetti...

## SUPERPOSITION quantum systems can exist in two states at once

Our qubit can be in 0 and 1 at the same time, but then, when we as humans observe it or perform a measurement, this qubit collapses to be either zero or one

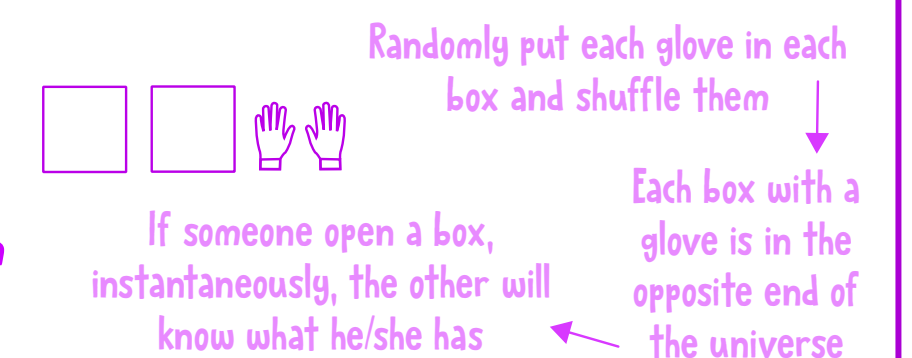


### SCHRÖDINGER'S CAT

The cat is dead but alive, and alive but dead

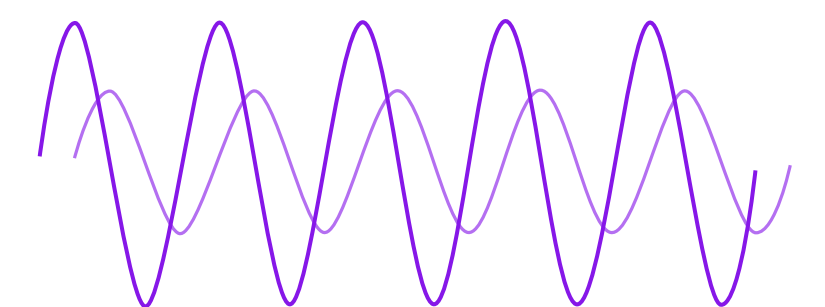
## ENTANGLEMENT spooky action at a distance

The idea that if you have an entangled pair of particles or more, one of the states of one of the cubic bits or quantum particles cannot be described without the other's state



## INTERFERENCE quantum objects can interact like waves

Essentially: the probability amplitudes of particles in quantum states can constructively interfere to create peaks and crests that we call quantum interference



These three weird properties enable the design of quantum algorithms which can compute in ways classical computers cannot.



## APPLICATIONS

- ★ Chemistry
- ★ ML
- ★ Finance
- ★ Cryptography
- ★ Agriculture
- ★ Biology
- ★ Physics
- ★ Medicine...