Quantum Algorithms

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Power of quantum computing

- The obvious advantage of quantum computers over the classical computers is the ability to perform operations in **parallel**

- What does that **parallelism** mean?

Let's say we want to have an input, x, apply some operations to it and get an output.

Let the operations represented by an unknown function f(x), which takes x as input.

On a classical computer, we need to apply f(x) to each input consecutively to have a mapping of the function and this increases the complexity.

On a quantum computer, the input (qubit) is already in more than one state – **superposition**

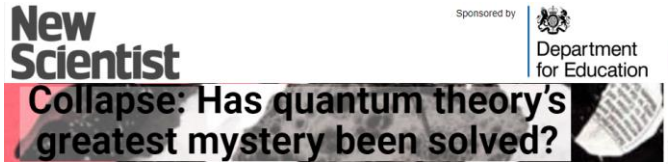
We can apply one operation f(x) to one qubit and have different outputs!

Does this mean we can carry out multiple calculations in parallel such that four players can play Crysis, Doom, PUBG, Half-Life simultaneously on a single quantum computer?

Not quite…

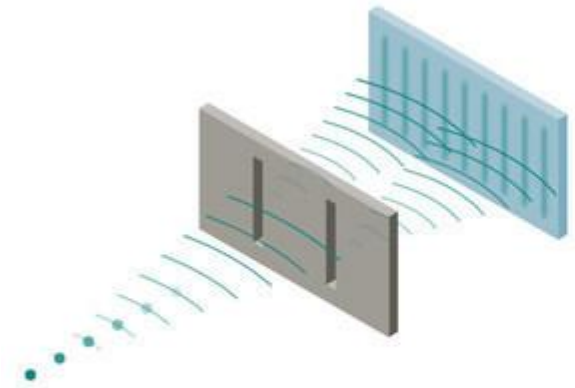
When a measurement is made on multiple qubit system, you have information on only one state.

We can measure only one state and the other information is lost.

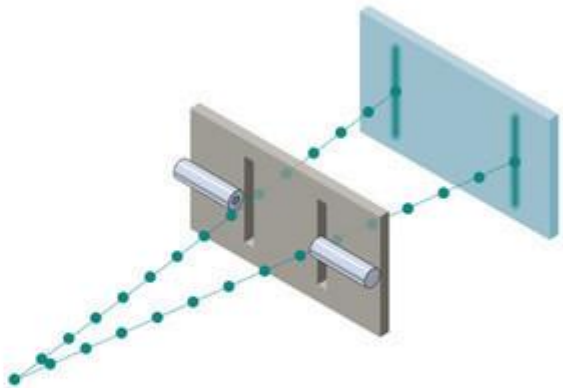


A central mystery

The classic double slit experiment seems to suggest quantum objects such as electrons are sometimes **particles**, sometimes **waves** – and we decide which guise they take



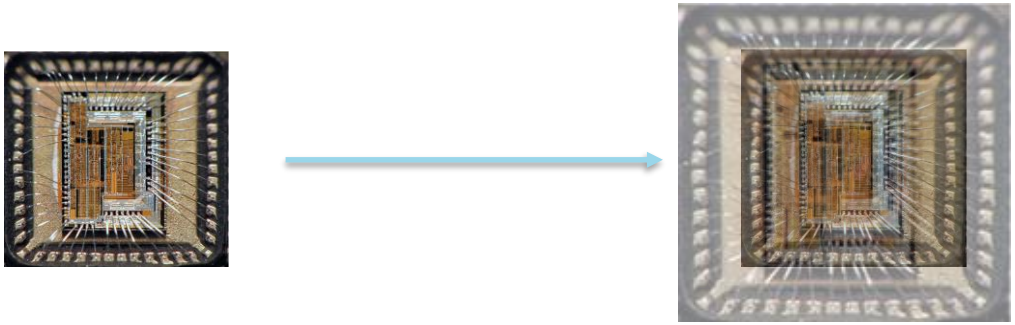
A stream of single electrons is fired at two slits and measured on a screen behind. An interference pattern forms, as if each electron were a **wave** that passed through both slits at once



Measure the electrons first at the slits, however, and you see individual **particles** passing through one slit or the other – and the interference pattern on the screen disappears

Fermilab

In order to multiply the processing power of a CPU, you need to double the wires inside the CPU.



In order to multiply the processing power of a QPU, you just need one more qubit!

Deutsch – Jozsa Algorithm

- Not a practical algorithm, but a good demonstration of exponential speed up over classical computers.

Problem statement:

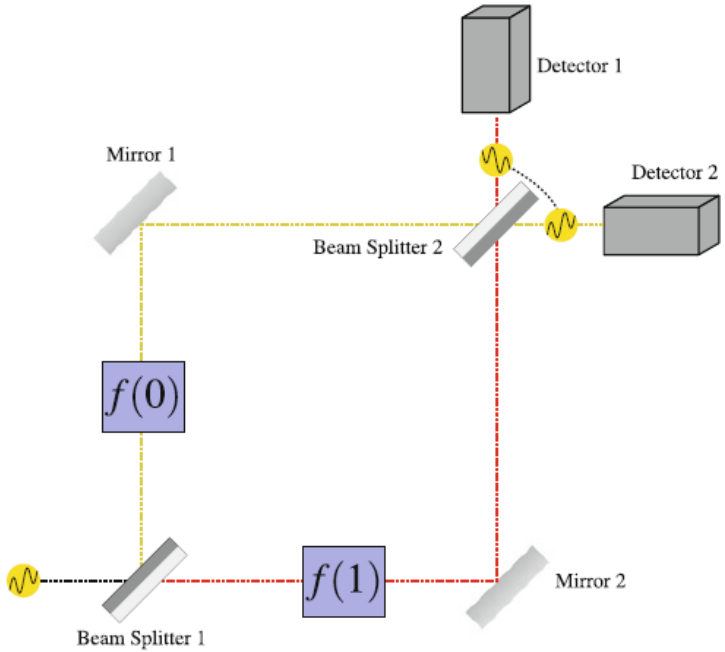
"You are given an unknown function f(x). With the least number of operations, find if this function is balanced or constant"

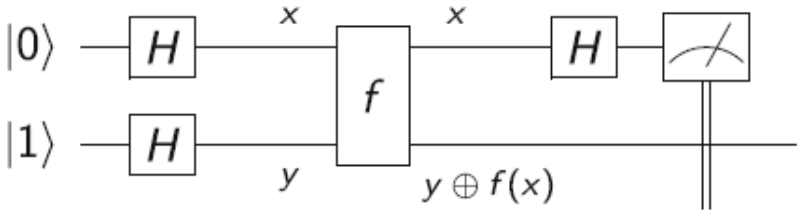
f(0) = 0	**f(0) = 1**	**f(0) = 1**	**f(0) = 0**
f(1) = 0	**f(1) = 1**	**f(1) = 0**	**f(1) = 1**
constant	**constant**	**balanced**	**balanced**

We just need to check if f(0) = f(1) on one qubit

Deutsch – Jozsa Algorithm

Mach-Zehnder realization





Fermilab