2398131: Physics in Films
Oct 30, 2017

Topics to discuss

- Few physics points we will focus on "X-Men" (2000)
  - Quantum Mechanics

X-Men (2000)

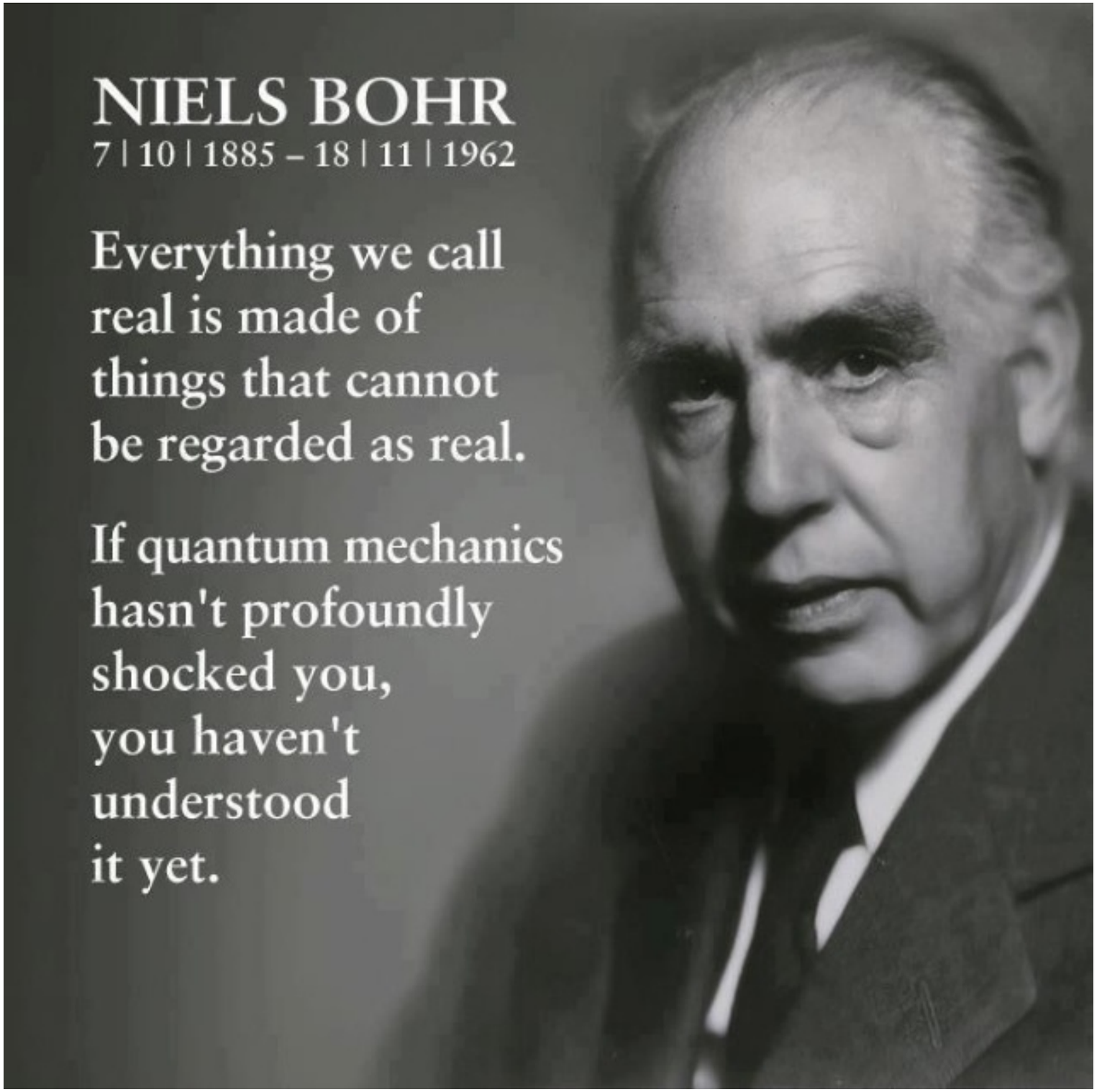
Two mutants come to a private academy for their kind whose resident superhero team must oppose a terrorist organization with similar powers.

We will now watch the opening scene (~25 min).

What is quantum mechanics?

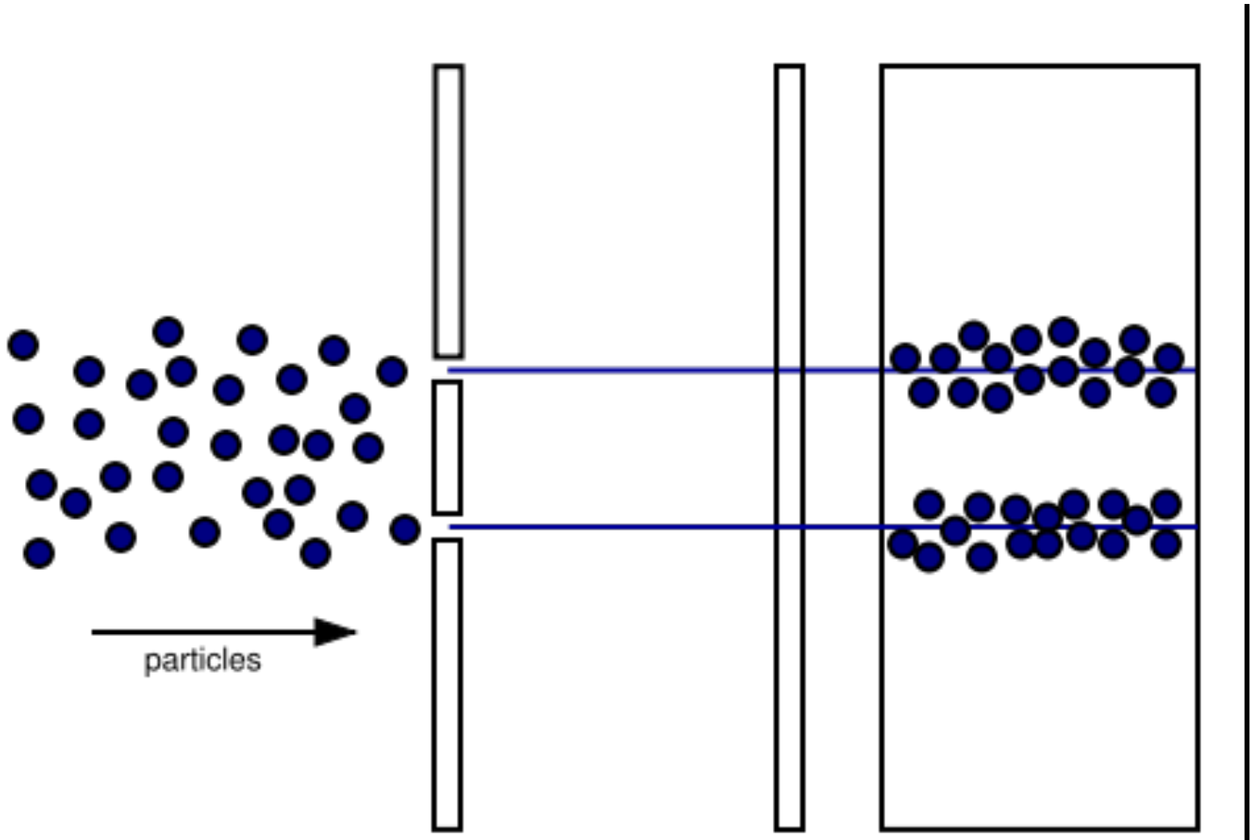
Ref: Wikipedia

It’s branch of physics which is the fundamental theory of nature at the smallest scales of energy levels of atoms and subatomic particles.

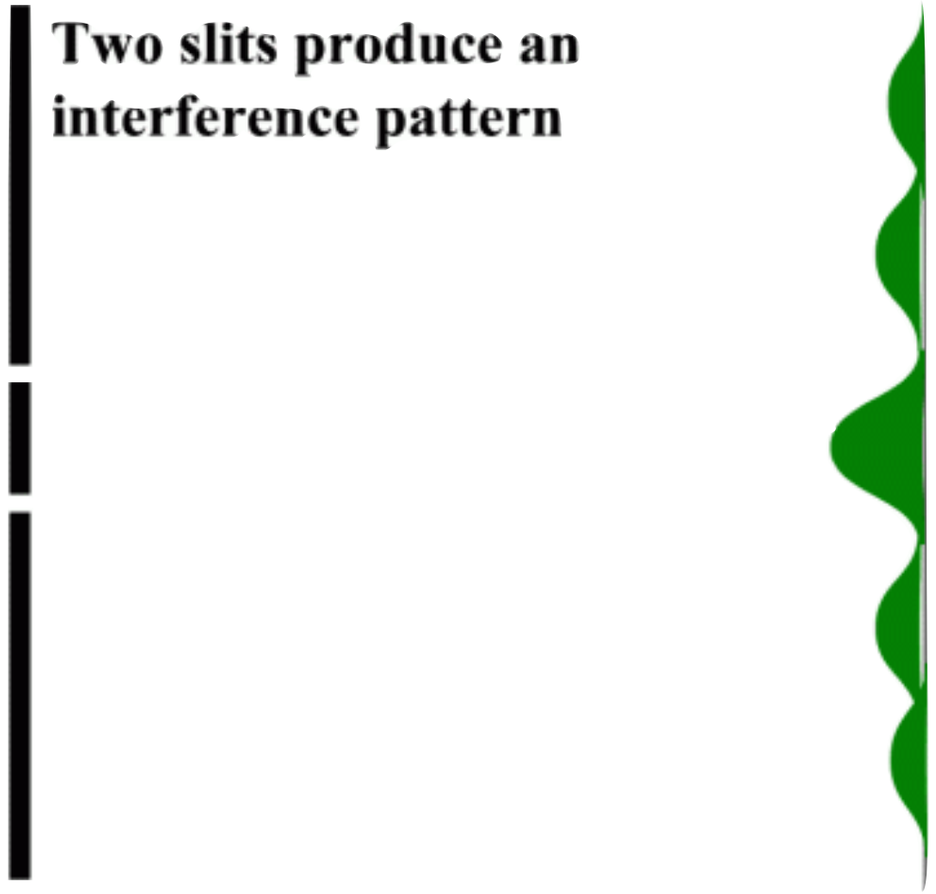


Double slit experiment

Imagine we have a wall with two slits — very close together but distinct — with a screen behind it. If we throw very small grains of sand at this wall, we can predict what's going to happen. And then if we shot waves, like light or waves of water through the two slits. What will happen?



World of particles

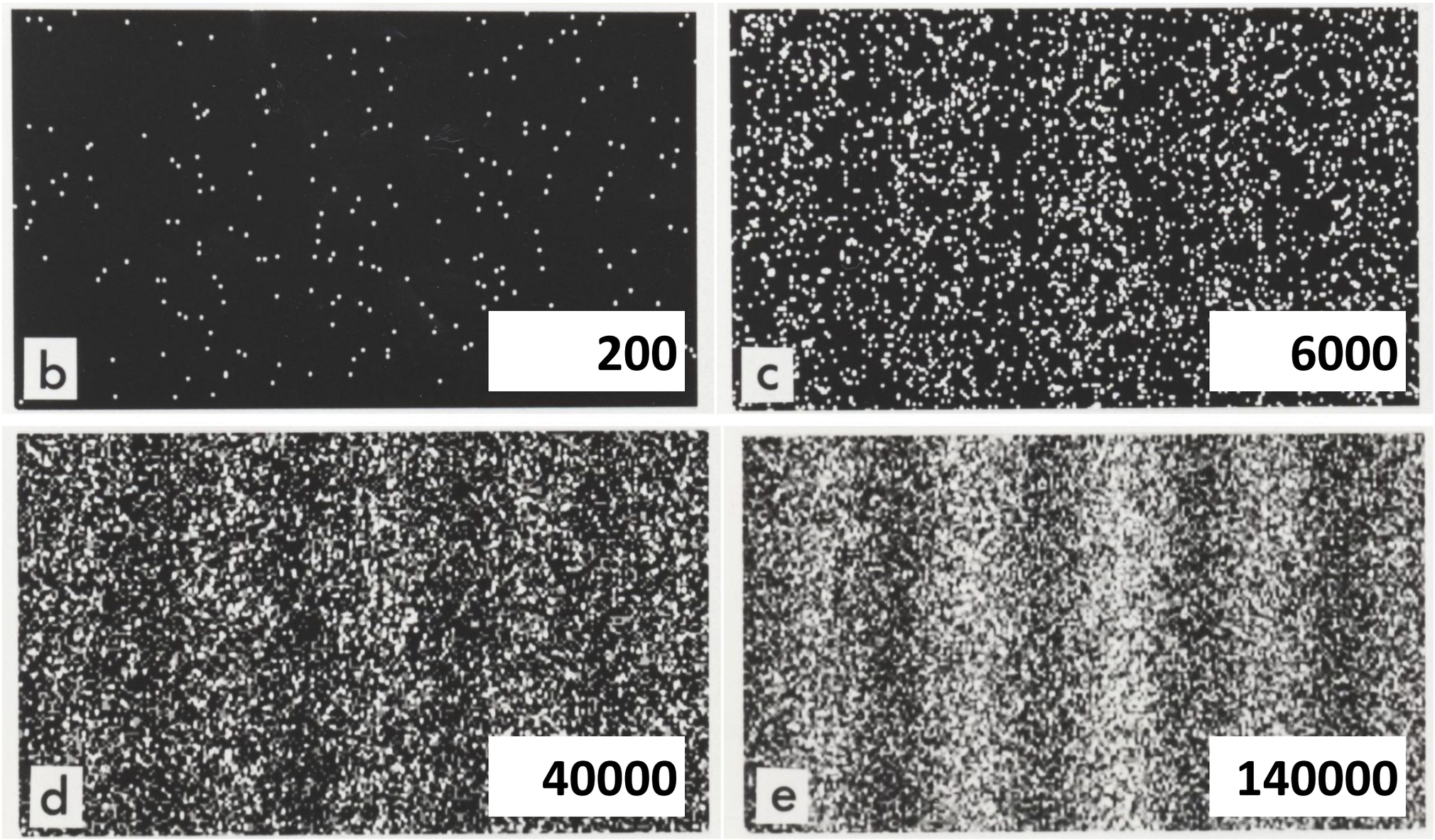


World of waves

What will happen if we shot electrons or photons?

Double slit experiment

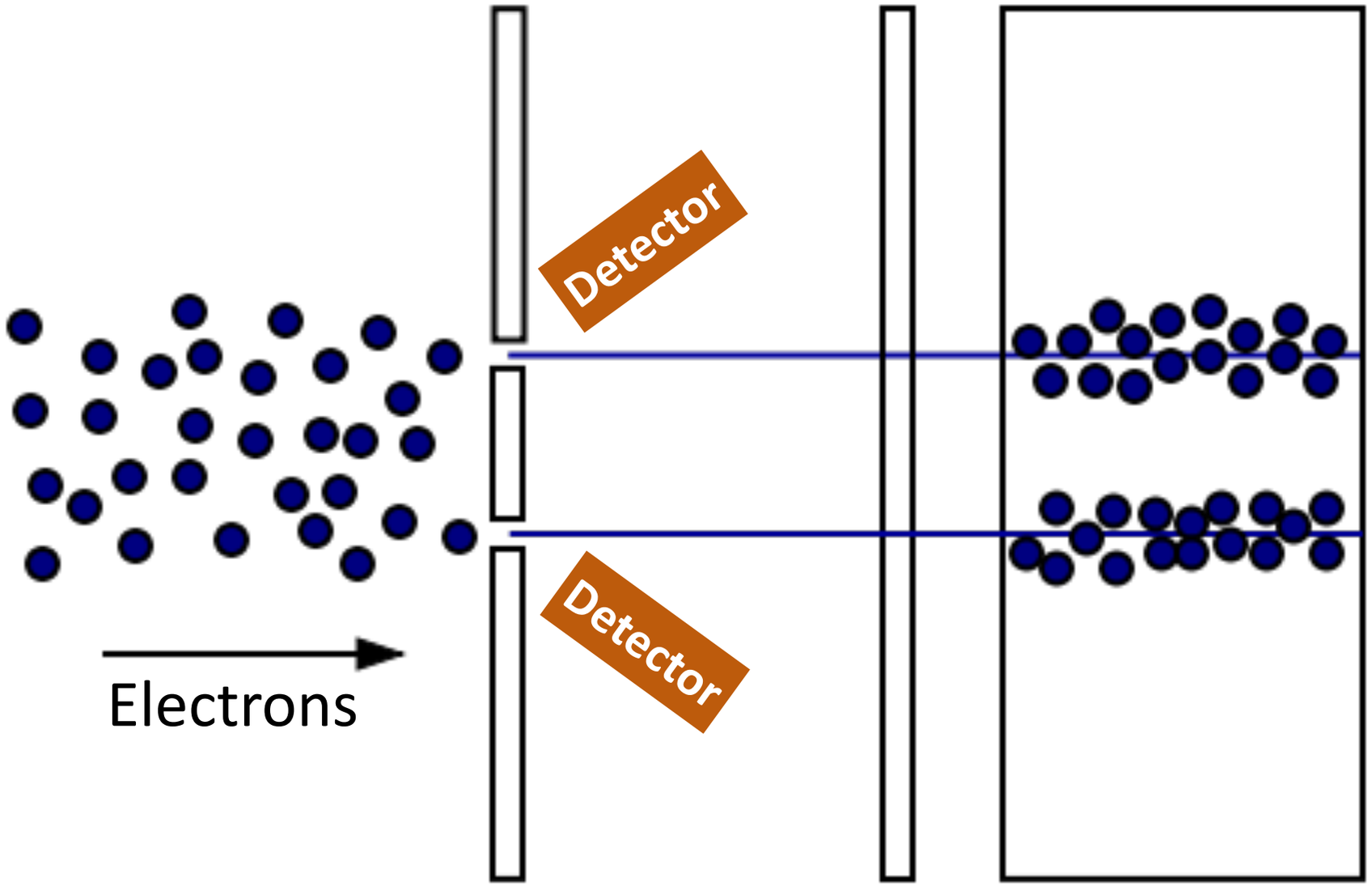
let's shoot the electrons one-at-a-time at these two slits. Most electrons that you fire smack against the wall, but a few make it through. After a few hundred electrons, you can't really tell what's happening, but after tens of thousands make it through, and you add up where they landed, here's what you find:



Ref: Wikipedia
Results of a double-slit-experiment performed by Dr. Tonomura

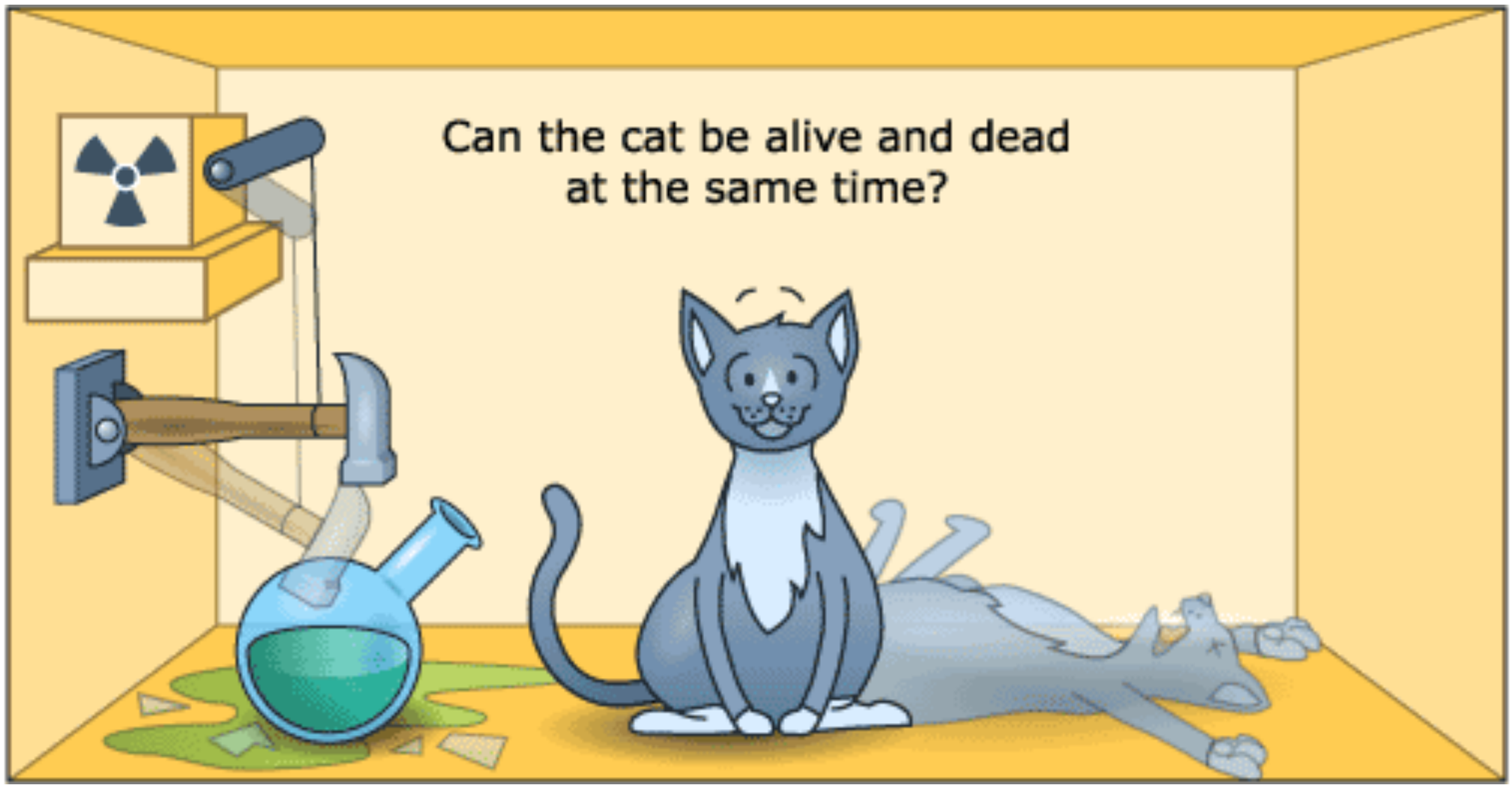
Double slit experiment

We can do one more experiment: this time, we shoot electrons one-at-a-time at this wall, but at each slit, we **put a detector** to show us which slit electron went through. But — *and here's the crazy part* — the pattern on the screen now shows no interference, and instead we just get two separate peaks corresponding to the two "classical", particle-like paths the electrons could have taken.



Schrodinger's cat

A cat, a flask of poison, and a radioactive source are placed in a sealed box. If an internal monitor detects radioactivity, the flask is shattered, releasing the poison, which kills the cat.



https://chillingcompetition.com/2016/09/13/gc-judgment-in-case-t-47213-lundbeck-v-commission-on-patents-and-schrodingers-cat/

Interpretations

There are various interpretations of quantum mechanics which attempt to explain how quantum mechanics informs our understanding of nature.

https://en.wikipedia.org/wiki/Interpretations_of_quantum_mechanics

For example,

Copenhagen interpretation

The measurement process randomly picks out exactly one of the many possibilities allowed for by the state's wave function in a manner consistent with the well-defined probabilities that are assigned to each possible state. According to the interpretation, the interaction of an observer or apparatus that is external to the quantum system is the cause of wave function collapse.

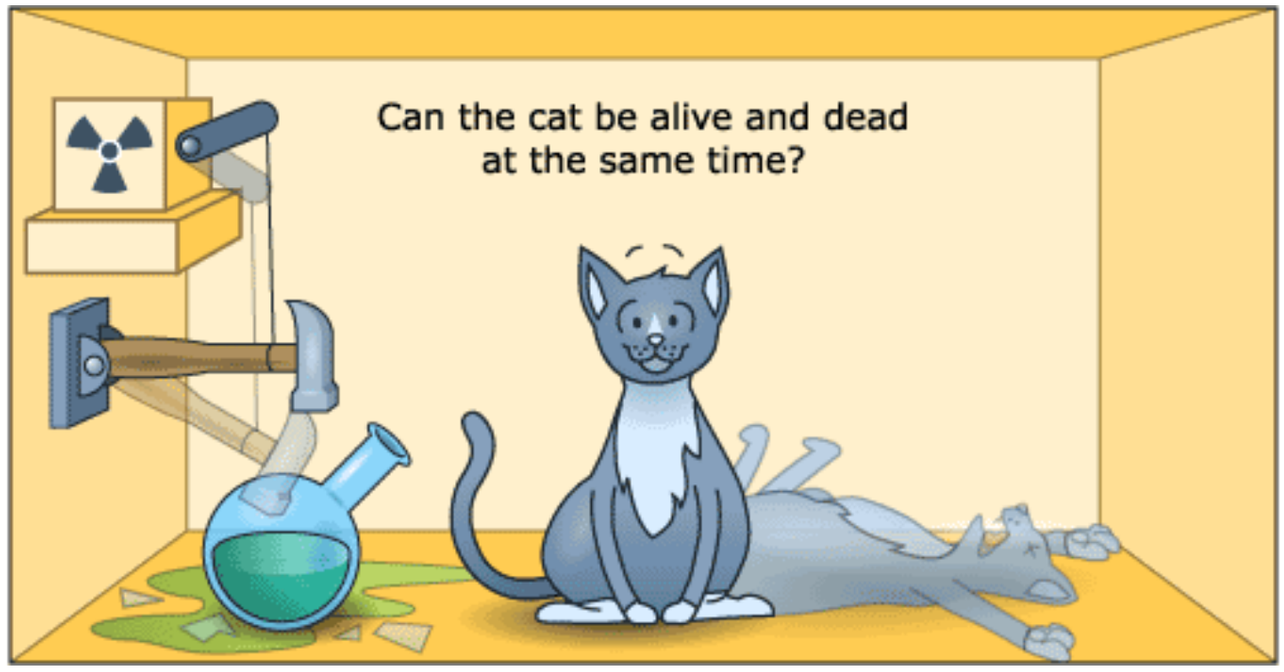
Many-worlds interpretation

Many-worlds implies that all possible alternate histories and futures are real, each representing an actual "world" (or "universe"). Everything that could possibly have happened in our past, but did not, has occurred in the past of some other universe or universes.

Interpretations of Schrodinger's cat

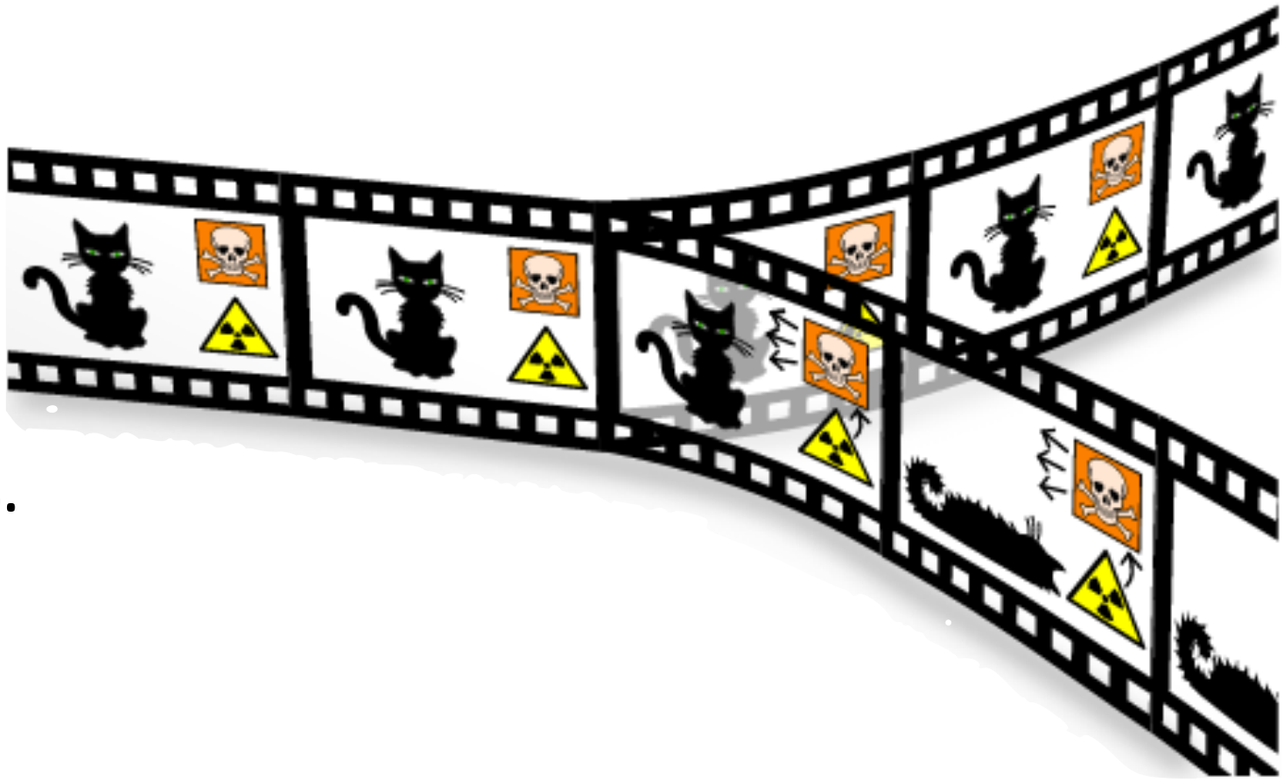
Copenhagen interpretation

When one looks in the box, one sees the cat either alive or dead not both alive and dead. This poses the question of when exactly quantum superposition ends and reality collapses into one possibility or the other.



Many-worlds interpretation

There are 2 universes (one that cat is alive and one that cat is dead). You (observer) stay in one of those universes.



Schrodinger's equation

Erwin Rudolf
Josef Alexander
Schrödinger

$$\left[\frac{-\hbar^2}{2m}\nabla^2 + V\right]\Psi = i\hbar\frac{\partial}{\partial t}\Psi$$

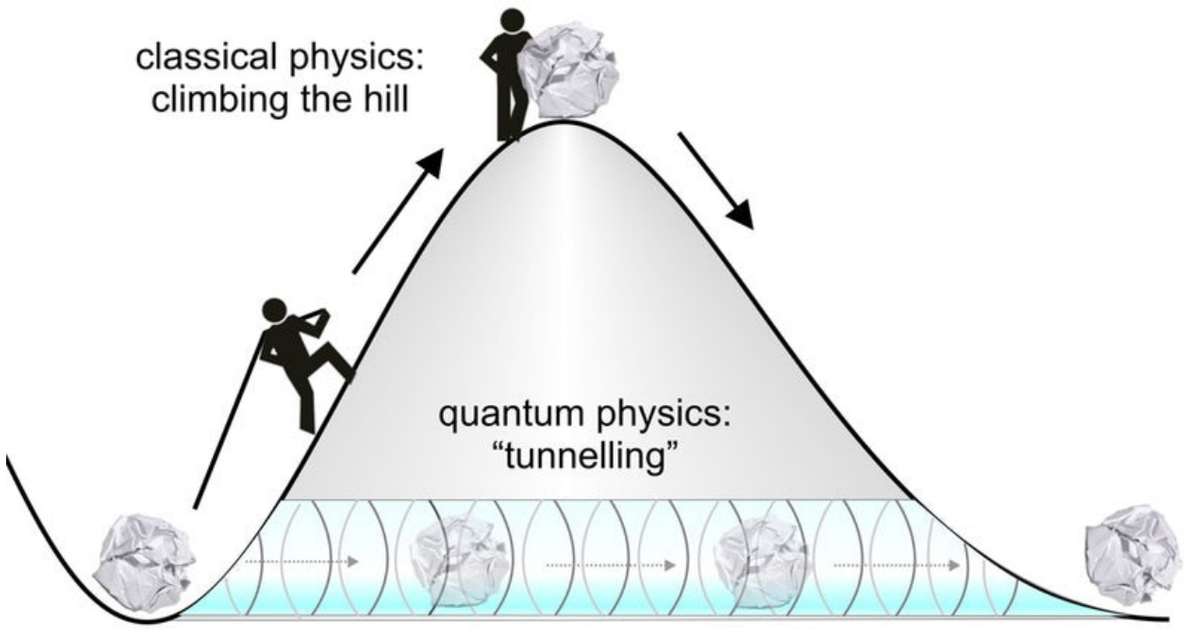
What does this equation tell us?

Schrodinger's equation

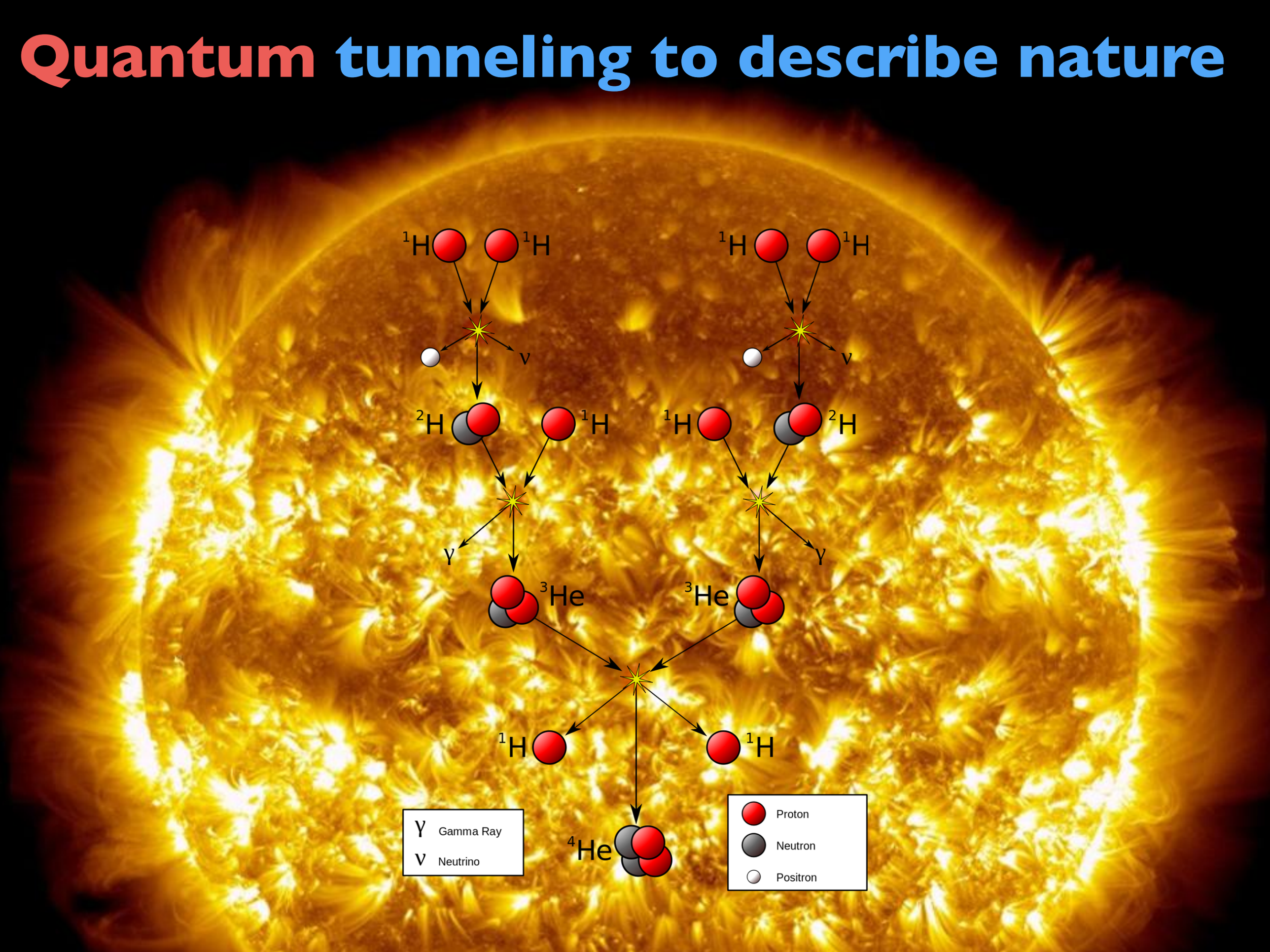
Erwin Rudolf Josef Alexander Schrödinger

$$[\frac{-\hbar^2}{2m}\nabla^2 + V]\Psi = i\hbar\frac{\partial}{\partial t}\Psi$$

Quantum mechanics can be used to describe several things (in nature, or in our technology) for example, **quantum tunneling.**



Quantum tunneling to describe nature



Question

(1)
What do you think Bohr meant?

(2)
Discussion about the quantum tunneling application in our technology.