Quantum Explainers 04

QUANTUM PRINCIPLES

MEASUREMENT

Imagine if looking at something changed what it looked like.

This doesn't happen in the world we see around us, but in quantum physics, measuring something 'forces' it to become one thing or another.

Measuring something is a way of observing it, like looking at it.

This can happen with particles where, by measuring them, you force one of their properties to be fixed.

Even more strangely, forcing one property to become fixed forces another property to become unknowable. This is described by the **'Heisenberg uncertainty principle'**.

Before looking, the object is all the things it can be.

Looking at the object forces it to be one thing or another.

HEISENBERG UNCERTAINTY PRINCIPLE

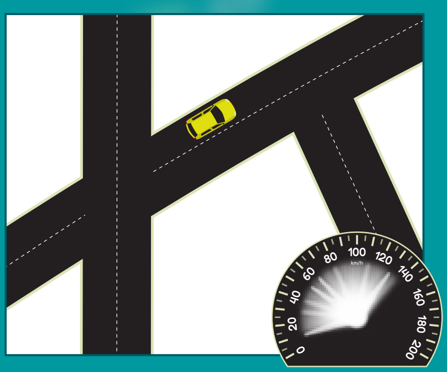
When we drive a car, we can know its speed (from the speedometer) and where it is (from GPS or Google Maps) at the same time.

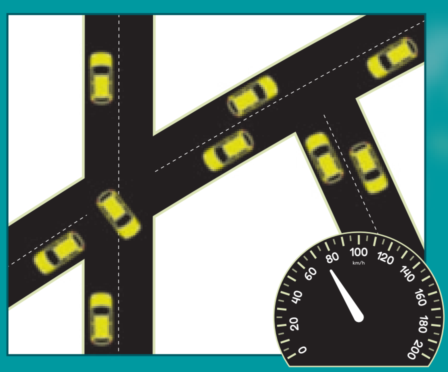
That's not true when we try to accurately measure really small things like particles.

By measuring either speed or location, you can know its value, but it also means you can't know the value of the other one.

The Heisenberg uncertainty principle states that you can never accurately know both the momentum of something and its position at the same time, or how much energy it has at a particular time. How accurately you can measure these things is set by Planck's constant.

Momentum is how heavy something is times its speed.





If we measure the location we can't know the speed, but if we measure the speed we can't know it's location.

TUNNELLING

'Quantum tunnelling' is something completely unlike classical physics.

If you have a ball and try to roll it over a high hill from the bottom with a small push, you won't be able to.

Quantum tunnelling is a bit of a 'cheat', as if there was a tunnel to the other side of the hill that you could roll the ball through.

Amazingly, particles can do something like this all by themselves at a quantum scale. They turn up in places where we wouldn't expect them to be able to get to.

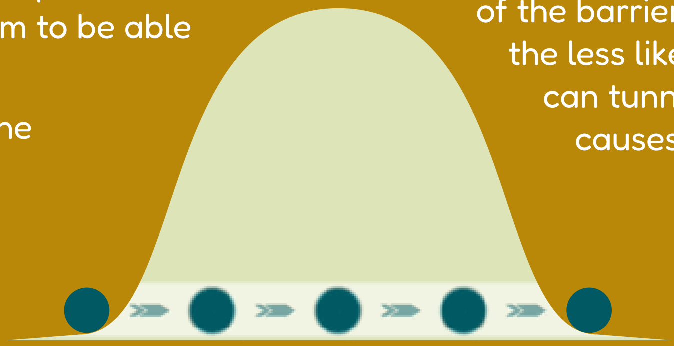
This is because, in the quantum world, the exact energy and position of a particle can't ever be fully known. There's a chance they could end up with either enough energy to go over the hill or to be positioned on the other side of the hill to start with.

We're always uncertain about either the energy or the position

This means that sometimes these particles can 'tunnel' across barriers that we wouldn't expect them to be able to cross.

The chances of the particle tunnelling through the barrier depends on the size of the barrier: the higher it is, the less likely that the particle can tunnel. This is what causes radioactive decay.

Radioactive decay is the way radioactive elements gradually break down by losing energy.



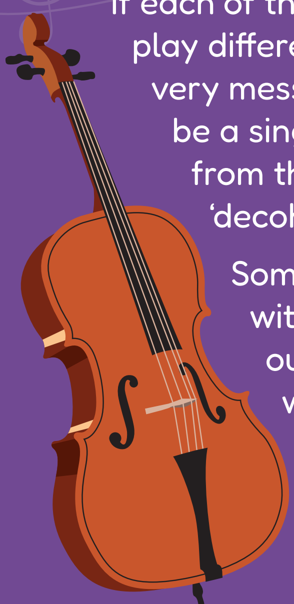
COHERENCE

Musicians in an orchestra sound good because they play the same tune, in time with each other. Physicists call this kind of agreement between different things 'coherence'.

Coherence means that different things behave in the same way.

If each of the musicians started to play different tunes, it would sound very messy and there would not be a single coherent tune coming from the orchestra. This is called 'decoherence'.

Something similar can happen with waves when they spread out, and different parts of the wave 'decohere'.



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