PICO

PHYSICS FOR ALL

Funded by the European Union
under Grant Agreement n. 101162413

THE QUANTUM WORLD PLAYS BY DIFFERENT RULES

QUANTUM RULES
REALITY — REWRITTEN

UNCERTAINTY

Why can an atom never stand still?

CLASSICAL WORLD

Knowing the exact position of an object does not affect its motion. We can know both where something is and how fast it is moving at the same time.

There is a fundamental limit to what we can know about a quantum object: the more precisely we know position, the less we know about motion —and vice versa.

QUANTUM WORLD

Knowing precisely where a quantum object, such as an atom, is limits our knowledge of how fast it is moving. We cannot know both exactly where something is and how fast it is moving at the same time.

This isn't a flaw in our measurements; it's how the universe works. We call it **the Uncertainty Principle.**

WHERE DO WE FIND IT?

UNCERTAINTY LIMITS HOW COLD YOU CAN GET

Temperature is a measurement of motion. At absolute zero particles should stop moving but no matter how cold we make something, the particles keep jiggling.

HOW DO WE USE IT?

UNCERTAINTY CAN BE USED TO INCREASE PRECISION

- Quantum sensors enable us to detect disease much earlier.
- Gravitational wave detectors are able to measure infinitesimal vibrations of spacetime.

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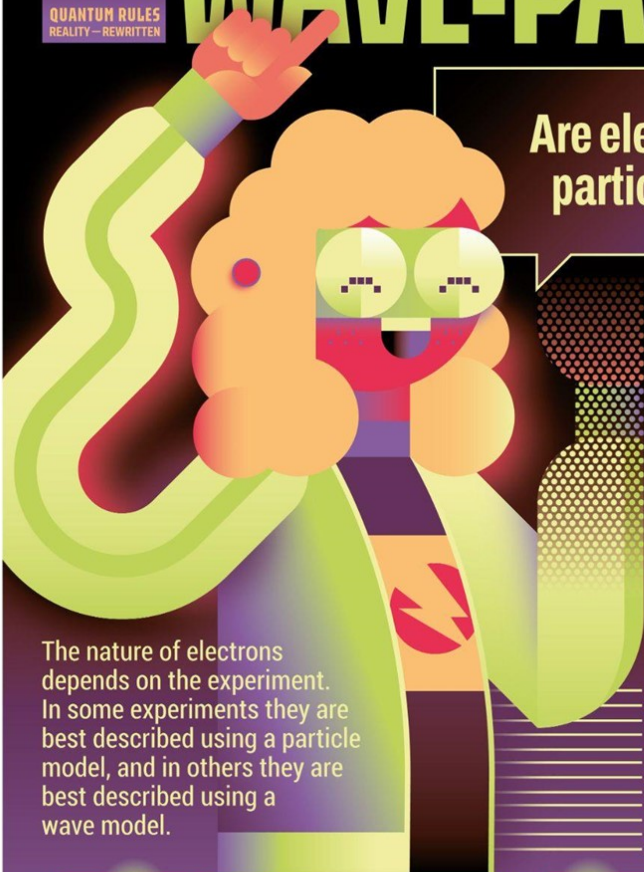
WAVE-PARTICLE



Are electrons waves, particles, or both?

The nature of electrons depends on the experiment. In some experiments they are best described using a particle model, and in others they are best described using a wave model.

CLASSICAL WORLD

Particles, like a grain of sand, are found in one definite location and when two particles arrive at the same location they collide. Waves, like in water, spread out and interfere when they overlap.

QUANTUM WORLD

Electrons are detected in one definite location, but after many detections an interference pattern emerges that can only be explained using a wave model.

WHERE DO WE FIND IT?

ULTRAVIOLET (UV) LIGHT DAMAGES YOUR SKIN AND EYES

Light behaves like billions of particles called photons. Shorter wavelength light, such as blue and UV, have photons with more energy that can do more damage to tissue.

HOW DO WE USE IT?

WAVE-PARTICLE DUALITY IMPROVES OUR ABILITY TO SEE

Our ability to see small things is limited by wavelength. The wave-length of fast-moving electrons is shorter than light, so electron microscopes show more detail than light microscopes.

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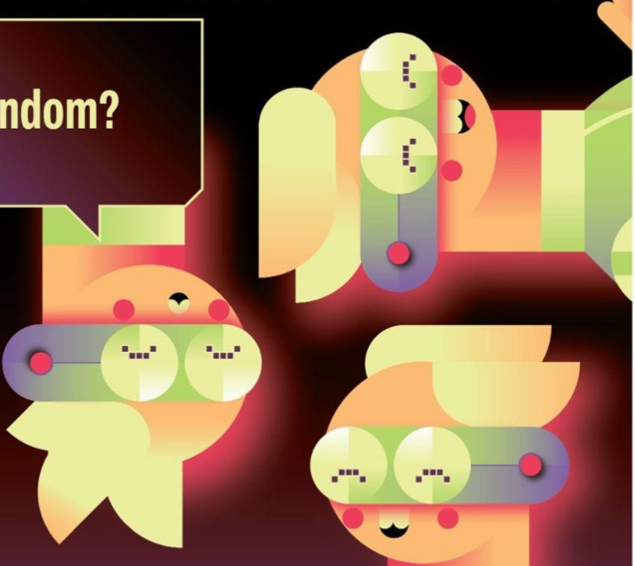
PROBABILITY

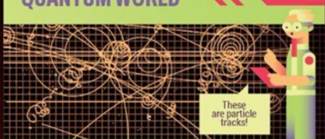
Is everything random?



CLASSICAL WORLD

A dice roll seems random. But with full knowledge of all initial conditions (ex. the force and angle of the roll), we could predict the outcome with absolute certainty. Randomness is only apparent.

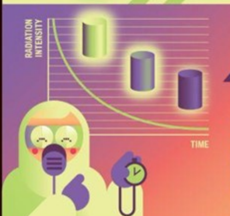
QUANTUM WORLD



Even with full knowledge of the initial conditions, the results of individual measurements are unpredictable — randomness is real. Yet repeated trials reveal patterns that follow probability rules.

Probability is a mathematical tool that we use to describe how likely or unlikely something is to happen.

WHERE DO WE FIND IT?



RADIOACTIVE ATOMS EMIT PARTICLES WHEN THEY DECAY.

While individual atomic decays happen at random times, the overall decay rate becomes predictable when observing a large sample of identical atoms.

HOW DO WE USE IT?

TO DATE ARCHEOLOGICAL OR BIOLOGICAL SAMPLES

Radioactive isotopes, like Carbon-14, can be used to date samples because the rate of decay for a sample is predictable.

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SUPERPOSITION

Is the cat dead or alive?

The principle of superposition describes quantum objects as existing in all possible states until they are measured.

SCHRÖDINGER'S CAT

Schrödinger's Cat is a thought experiment that emphasizes how the quantum world is different from the classical world.
A cat in a box is considered to be both alive and dead at the same time because its fate depends on a random quantum event (like a radioactive decay). Only when we open the box (observe the system) does the cat become definitely alive or dead. It's a way to highlight how strange and counterintuitive quantum mechanics can be.

WHERE DO WE FIND IT?

PLANTS CONVERT SUNLIGHT TO ENERGY VERY EFFICIENTLY

Plants use photosynthesis to transfer light energy to stored energy. The process is almost 100% efficient, best explained by the superposition of multiple energy pathways.

HOW DO WE USE IT?

WE PUSH PAST THE LIMITS OF CLASSICAL COMPUTING

Quantum computers can solve problems that classical computers cannot because they use quantum bits. Classical bits can only be a 0 or 1, while quantum bits can also be in a superposition of both.

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ENTANGLEMENT

What is spooky action at a distance?

Entangled quantum objects behave as a single system. Their properties are deeply linked, even when the objects are far apart. Albert Einstein called it "spooky action at a distance".

CLASSICAL WORLD

Objects are often independent. Measuring a property of one object does not affect the other. If two dice are shaken in separate cups, observing one dice does not change the other.

QUANTUM WORLD

Quantum objects can be entangled. Measuring a property of one entangled particle determines the state of the other instantaneously (regardless of the distance between them).

WHERE DO WE FIND IT?

ELECTRICITY FLOWING WITHOUT RESISTANCE!

When some materials are cooled to extremely low temperatures, their electrons form entangled pairs, which act as one and flow without resistance. This is how superconductivity works.

HOW DO WE USE IT?

WE CAN KEEP OUR COMMUNICATIONS SECRET

We can secure sensitive data using entangled photons. Any attempt to intercept the transmission will be detected, letting us to abort communication before it is too late.

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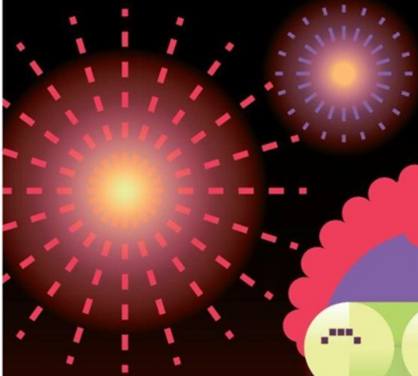
QUANTIZATION

What makes fireworks colourful?



In quantum physics, each atom has its own specific energy levels. This is called quantization. When the energy of an atom decreases, it releases packets of energy as unique colours of light, like what we see in fireworks.

CLASSICAL WORLD

Energy is continuous. The speed and kinetic energy of a person increases smoothly as they go down a slope.

QUANTUM WORLD

Energy is discrete. Electrons in an atom occupy specific energy levels, like steps on a staircase. They transition from one level to another by absorbing or emitting energy packets called photons.

WHERE DO WE FIND IT?

FIREWORKS ARE COLOURFUL BECAUSE OF QUANTIZATION

The colours of fireworks come from different elements, each with unique energy levels. Electrons transition between levels and emit specific coloured light depending on the energy gap.

HOW DO WE USE IT?

TO PRODUCE POWERFUL, PRECISE BEAMS OF LIGHT

Lasers increase the energy of many identical atoms so they can only produce photons with the exact same colour and direction to form a powerful, narrow beam of light.

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