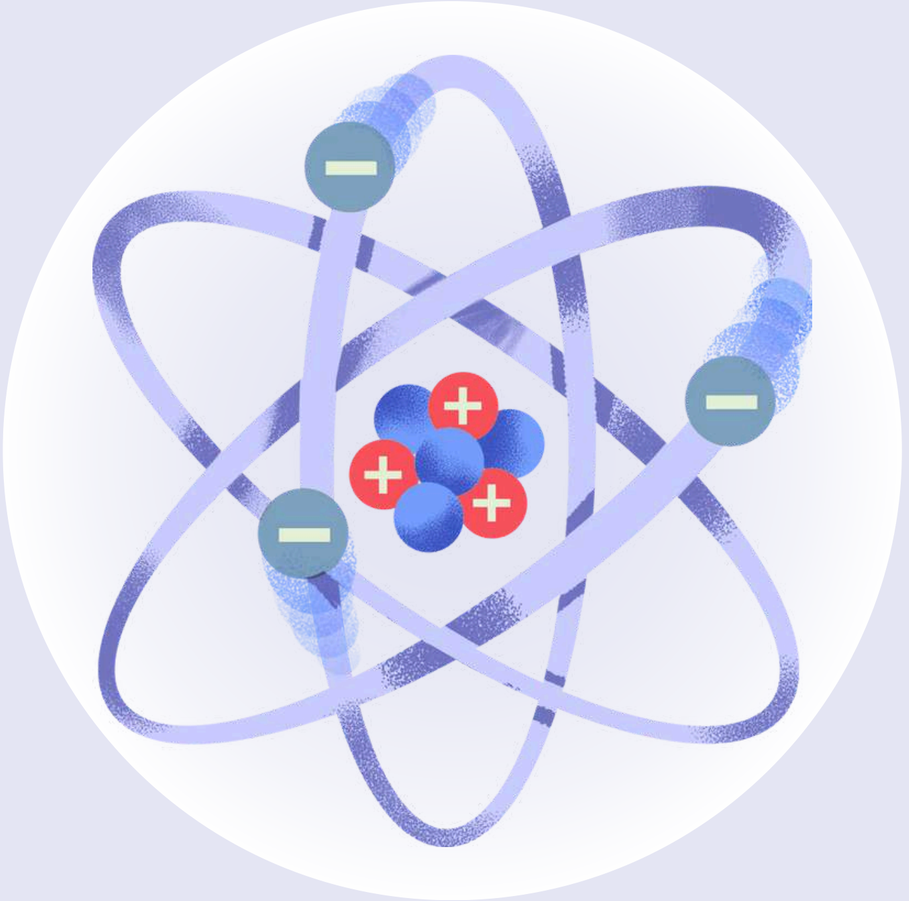
CYQCI
safe communications

QUANTUM MECHANICS

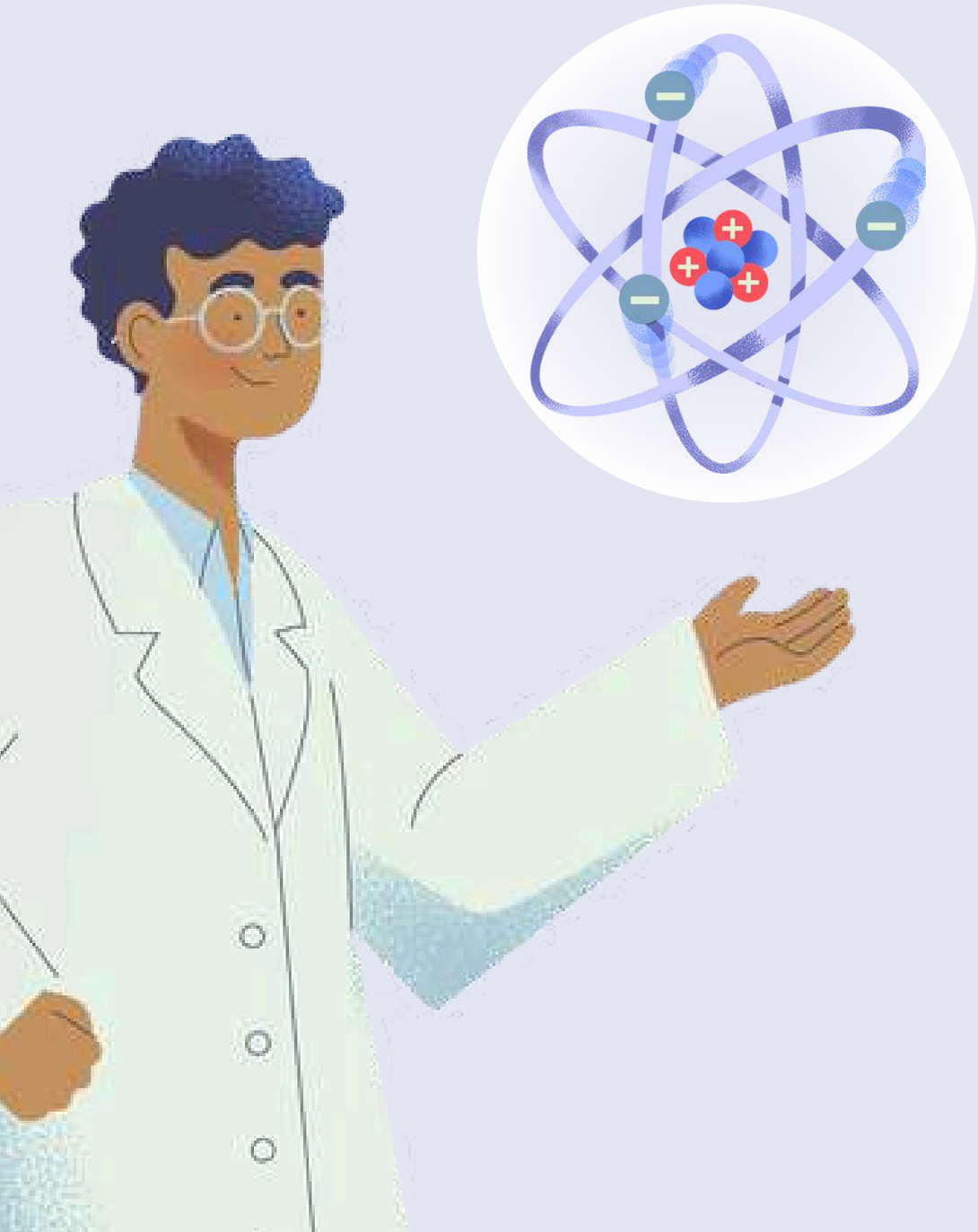
A Gentle Introduction



LEARNING OUTCOMES

By the end of this unit, you will be able to:

- Explain what quantum mechanics studies
- Describe wave-particle duality and interference
- Understand superposition and entanglement in simple terms
- Distinguish between a classical bit and a qubit



WHAT IS QUANTUM MECHANICS?

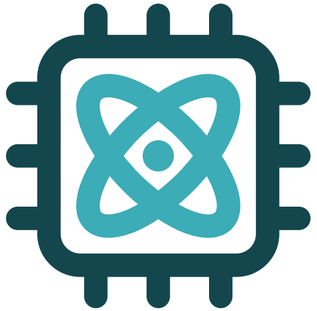
Quantum mechanics is the branch of physics that explains how matter and energy behave at the scale of atoms and subatomic particles e.g.

Electron

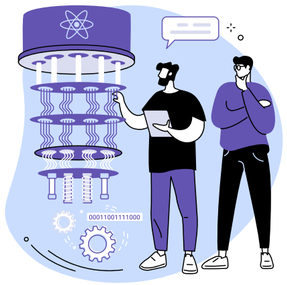
Photon

WHY IT MATTERS

Understanding how these quantum particles behave allows us to develop revolutionary technologies that have implications in computing, security, and the internet.



QUANTUM TECHNOLOGIES

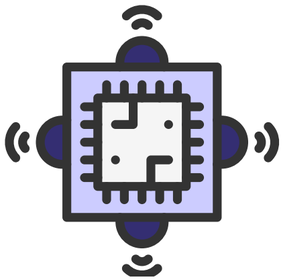


Quantum computing

Faster problem-solving

Quantum communication

Unhackable security



Quantum sensing

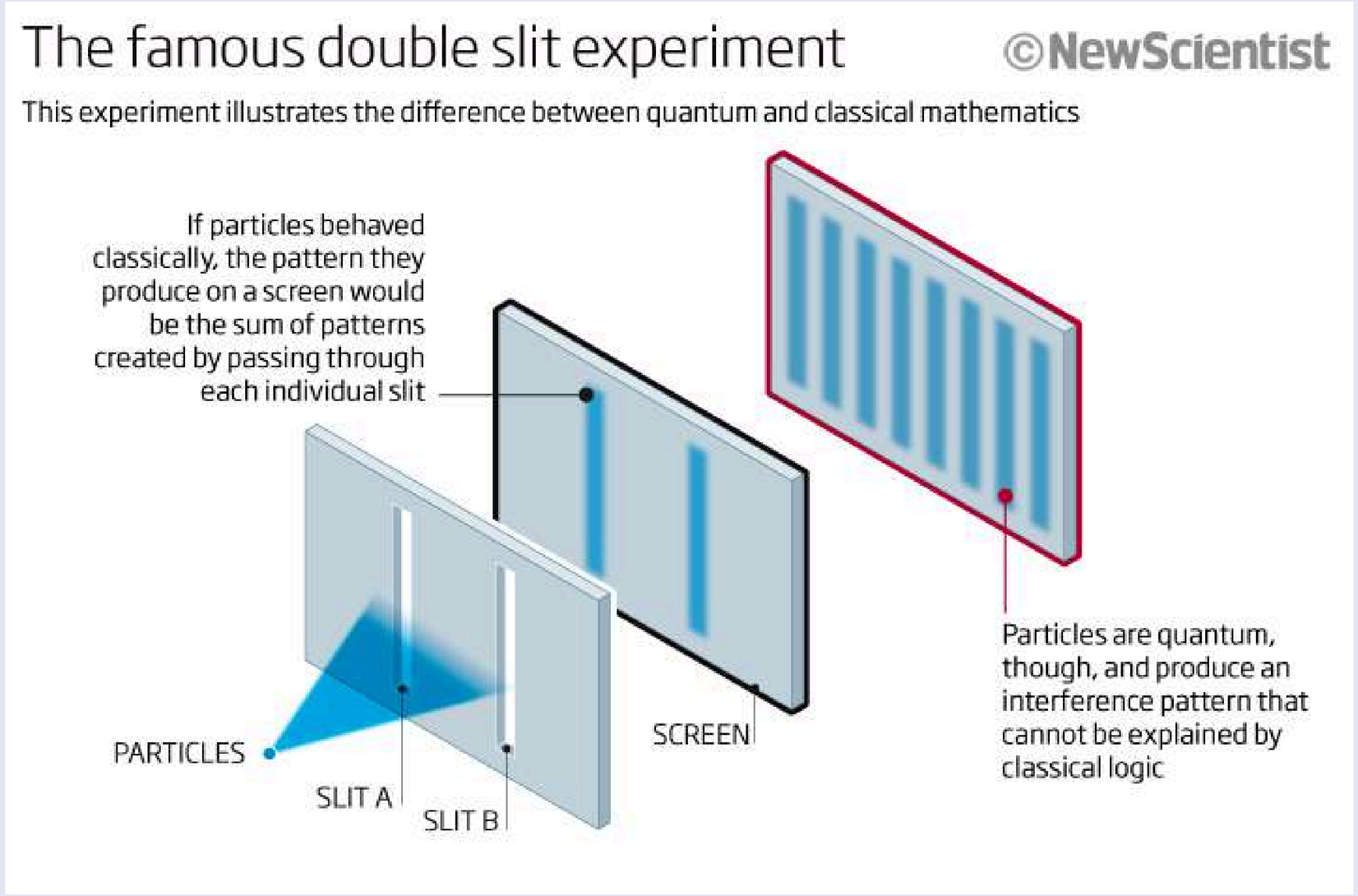
Ultraprecise measurements

WHAT ENABLES THESE TECHNOLOGIES?

Quantum technologies are built on the fundamental rules of **quantum mechanics**.

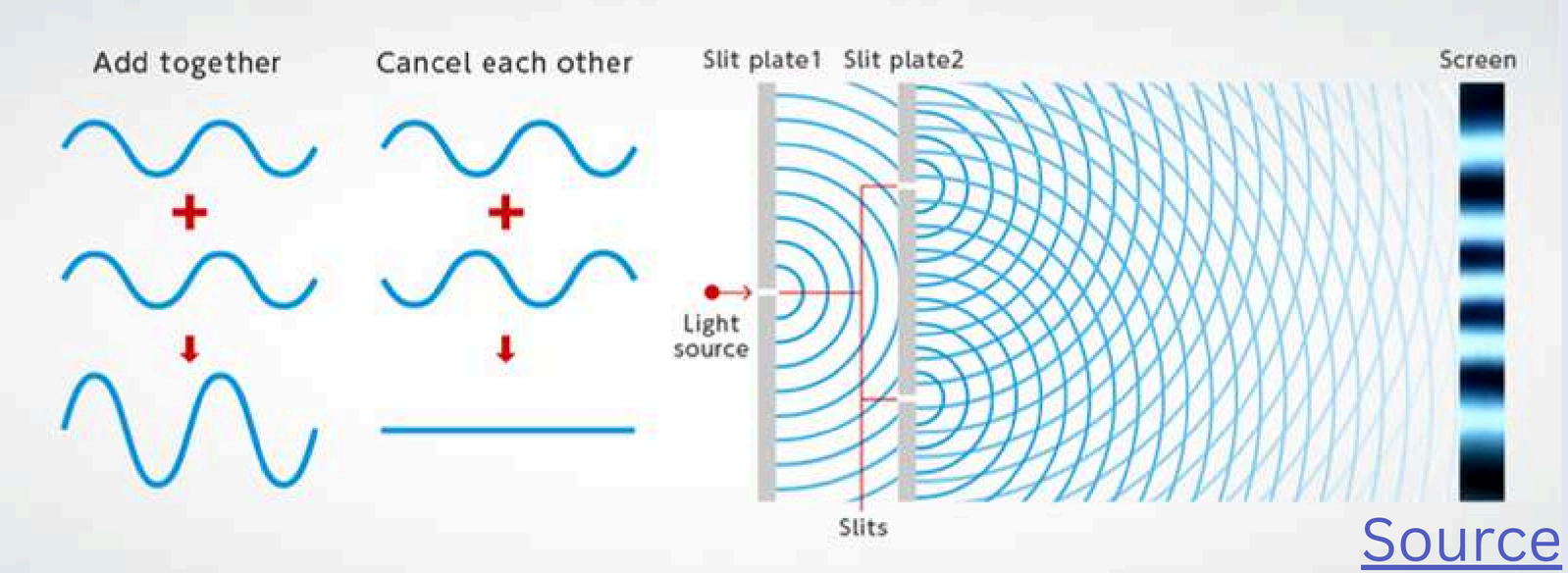
The next slides introduce the key quantum phenomena that make these technologies possible.

WAVE–PARTICLE DUALITY



Light (photons) and other quantum particles, e.g., electrons, can behave as both particles and waves, depending on the type of measurement we make.

INTERFERENCE



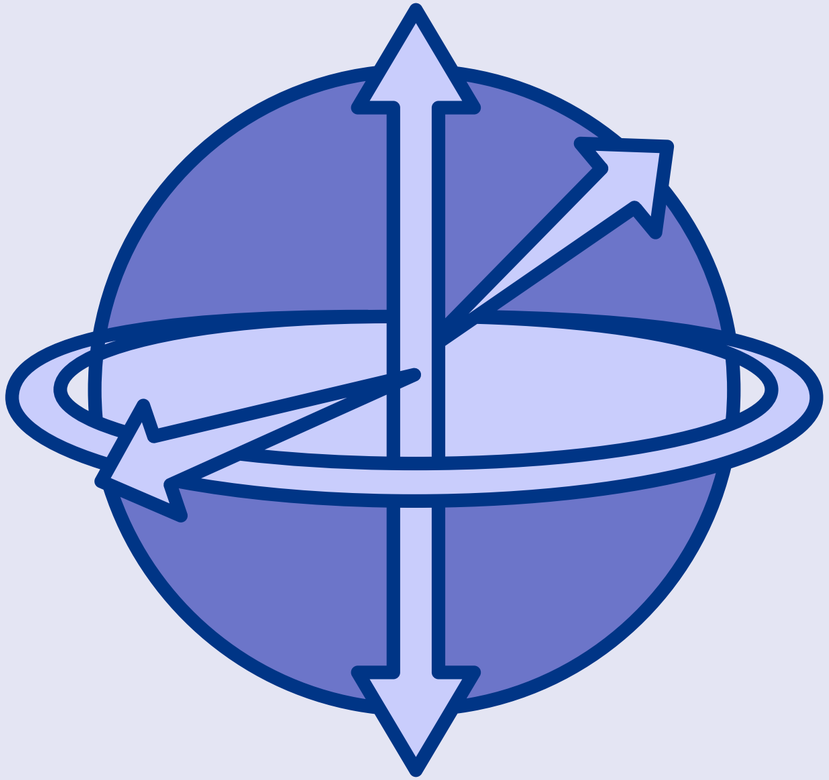
Source

When photons or electrons behave like waves, the waves can add up or cancel out depending on how they overlap.

- Constructive interference → the waves add up and make the signal stronger.
- Destructive interference → the waves cancel each other and make the signal weaker or disappear.

CLASSICAL VS QUANTUM

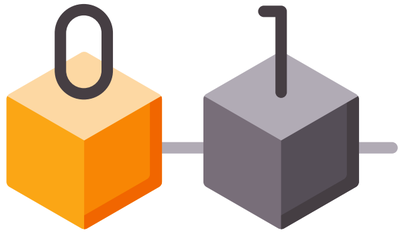
In classical computing and digital communication, the **bit** serves as the smallest unit of information. In the same way, a **qubit** (quantum bit) is the fundamental unit of information in quantum technologies.



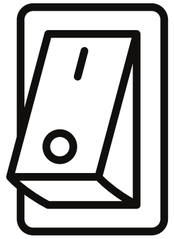
CLASSICAL VS QUANTUM

CLASSCAL BIT

Binary system: It can only take two values (0 or 1)



Just like a switch can be on or off at a time



QUANTUM BIT (QUBIT)

It can be 0, 1, or both at the same time due to a property called superposition.

SUPERPOSITION

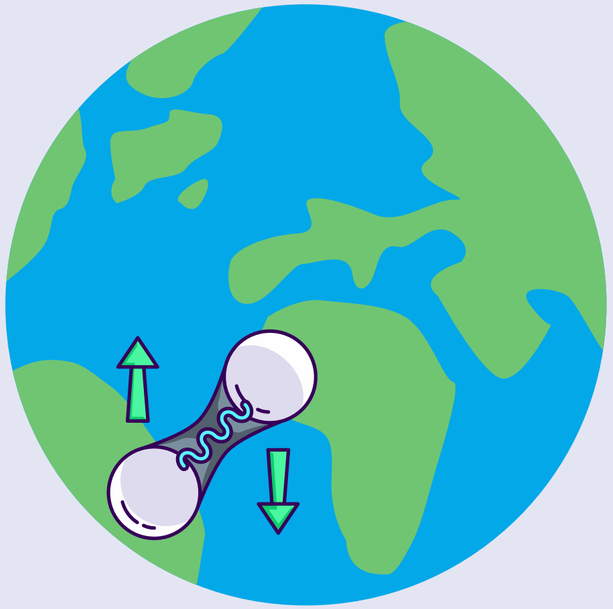
A qubit can be in multiple states (0 and 1) at once.

Analogy: A coin spinning in the air is in two states simultaneously (heads and tails or 0 and 1). When we observe (measure) the qubit it collapses to either 0 or 1 – just like a coin landing as heads or tails.

ENTANGLEMENT

Quantum entanglement is a phenomenon where two or more particles become linked in such a way that their quantum states are correlated, regardless of the distance separating them.

Measuring one immediately tells us something about the other even if they are on opposite sides of the planet



ENTANGLEMENT

Analogy:
Imagine you and a friend each take a pair of mystery gloves from a sealed box.

You fly to different continents. When you open your box and find the right-hand glove, you instantly know your friend has the left-hand glove, even before they look!

The gloves were correlated from the start, just like entangled particles.