we4u Insights

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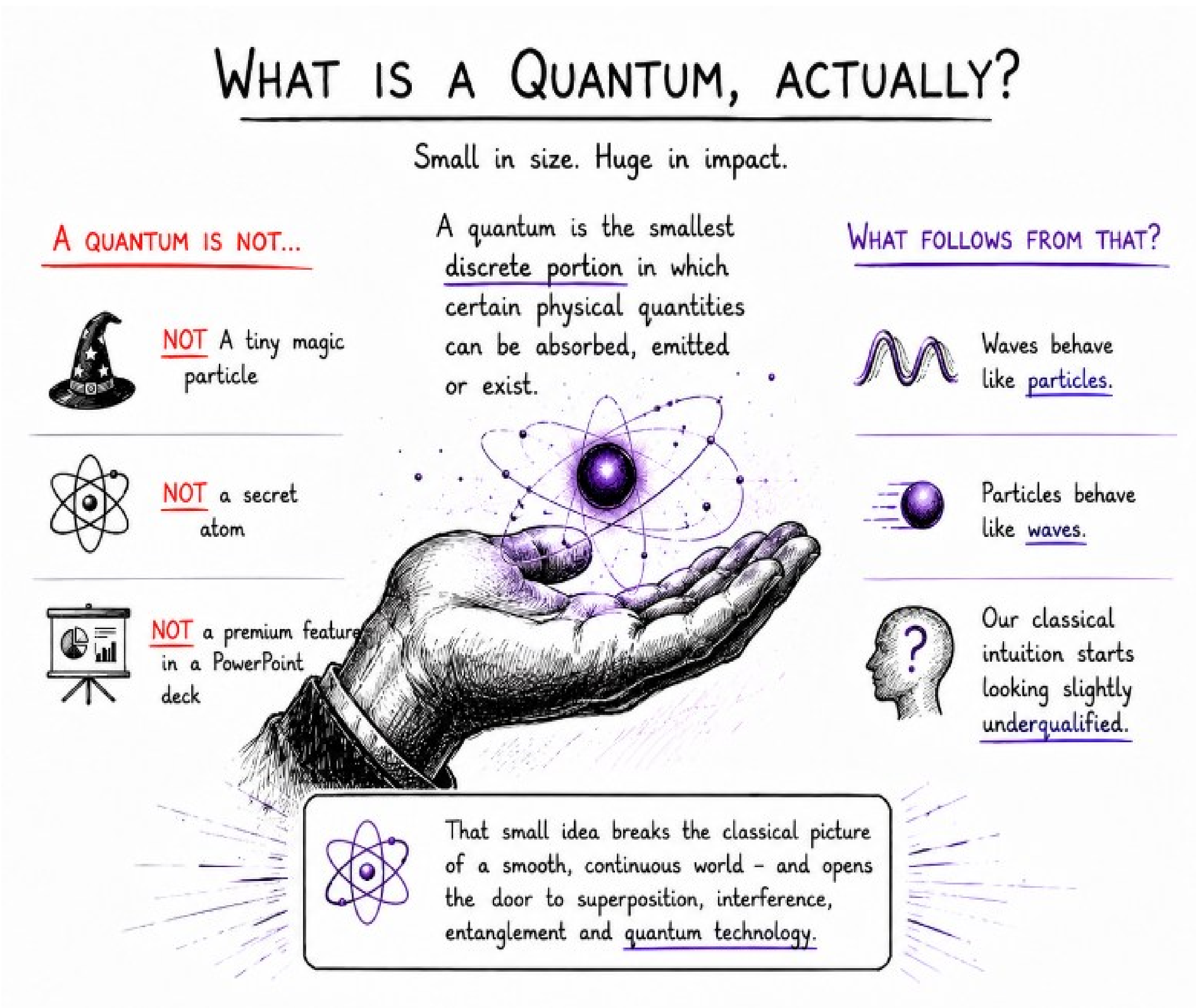
Quantum technology

What exactly is a quantum?

A quantum is not a tiny magic particle, not a secret atom, and definitely not something hiding between "AI strategy" and "blockchain" on the tech buzzword bingo card.



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Here is the short answer:

A quantum is the smallest discrete unit in which a physical quantity can, under certain conditions, occur, be absorbed or be emitted. In other words: nature does not always behave as if everything could be divided smoothly and continuously into ever smaller amounts. At the microscopic level, certain quantities appear only in specific portions.

This idea emerged from one of the great crises of classical physics. As described in the chapter of our **we4u Insights "The second crisis: Light, heat and atoms do not fit with classical physics"**, classical physics could not correctly explain blackbody radiation, the photoelectric effect, the stability of atoms or the spectral lines of gases. The problem became especially visible in blackbody radiation, where classical theory predicted physically absurd results at high frequencies.

Max Planck solved this problem in 1900 by assuming that **energy is exchanged not continuously, but in discrete packets**. This was the beginning of quantization. Einstein then went one step further in 1905 when he explained the photoelectric effect by treating light itself as consisting of discrete energy packets, later called photons.

This was deeply disruptive because light had already been very successfully described as a wave. Quantum physics showed that the classical distinction between wave and particle is not fundamental enough. Depending on the experiment, light and matter can display both wave-like and particle-like behaviour.

That is why the **we4u Insights** chapter **"What is a quantum?"** is so important for understanding quantum technology. Quantum physics is not about the world being made of "quanta as little things". It is about a deeper insight: nature does not always behave as a smooth continuum. Certain physical properties, such as light energy, atomic energy levels or measurement outcomes, can appear only in specific allowed portions or states. From this radical break with classical physics, almost everything else follows.

The **double-slit experiment**, discussed in the **we4u Insights** chapter **"The quantum paradox"**, shows how strange this becomes. A single photon or electron is detected as a local event, almost like a particle. But if many such individual events are accumulated, they form an interference pattern, which is typical of waves. As long as the experiment gives us no information about which path the photon or electron has taken, the quantum system behaves as if multiple possibilities jointly contribute to the outcome. If the path is measured, the interference disappears.

This is where quantum physics starts to challenge our classical intuition. A photon or electron is not simply a tiny object moving along a definite path that we have not yet discovered. Before measurement, the quantum state describes a range of possible outcomes that are not yet defined. Measurement turns this open set of possibilities into one defined outcome, because the system interacts with a detector or its environment. In this process, the coherence between the different possibilities is lost. This loss of coherence is called decoherence.

The **we4u Insights** chapter **“Quantum state”** then explains why this matters for technology. Strictly speaking, our entire material world is governed by quantum-mechanical laws. Yet the objects around us appear classical because they are constantly interacting with their environment. These interactions destroy observable quantum coherence extremely quickly. To use quantum effects technologically, we therefore need to isolate, initialize and control relevant degrees of freedom before decoherence destroys the fragile quantum behaviour.

This is why quantum technologies are so difficult and so powerful at the same time. They are based on creating, preserving, manipulating and measuring quantum states in a controlled way. Superposition, interference and entanglement are no longer only strange features of microscopic physics. They become technological resources.

When we ask “What exactly is a quantum?”, we are asking why nature’s microscopic rules are so different from our everyday world, and why those rules can now be turned into technology.

The answer is the starting point for everything that follows in quantum technology: quantum computing, quantum sensing, quantum communication, quantum key distribution and the long-term vision of a quantum internet.

If this has caught your interest, read the full we4u Insights and follow us for more strange questions from the quantum world in our coming posts.

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