University of Exeter | Centre for Metamaterial Research and Innovation

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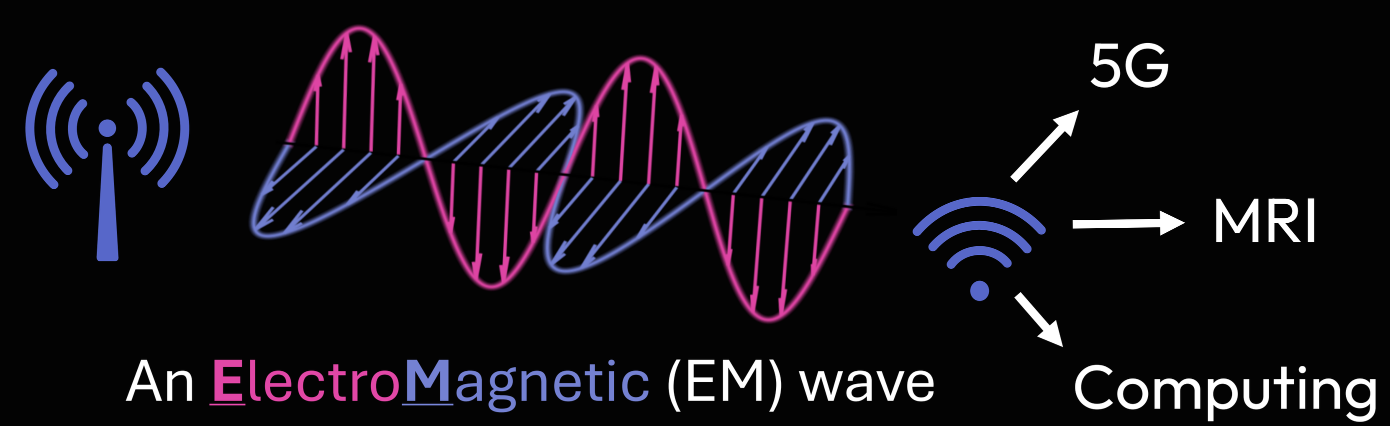
A Quantum Sensor of Microscopic Landscapes: Using Single Electrons to Detect Electromagnetic Waves

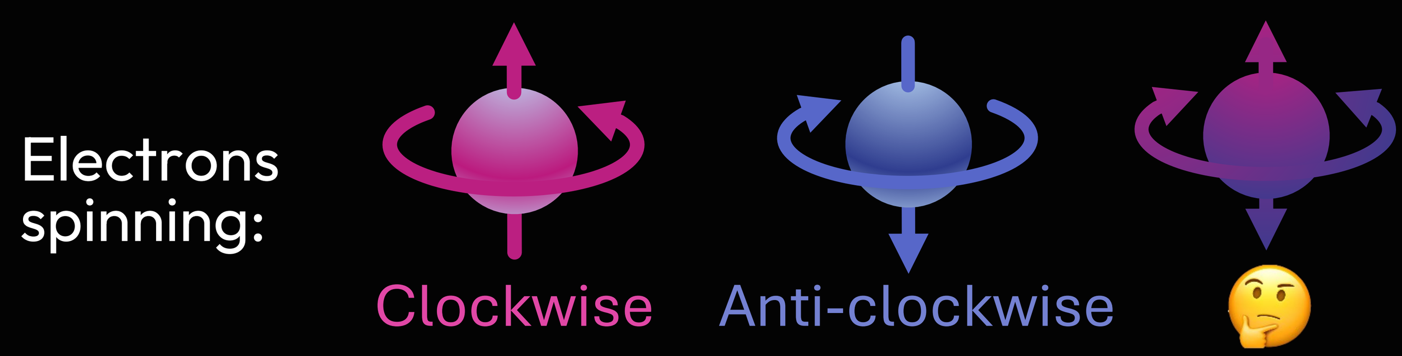
1. Motivation



- Our ability to control **ElectroMagnetic (EM) waves** has transformed the modern world.
- Novel approaches to sensing EM signals, e.g. by using quantum sensors, could revolutionise these technologies or enable completely new applications.

2. What is a Quantum Sensor?

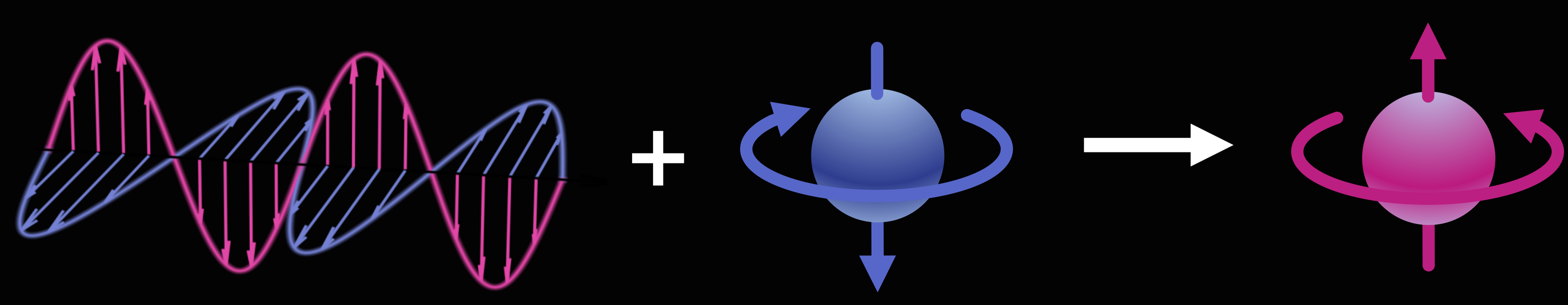
- Quantum sensors use quantum mechanics, which describes the behaviour of individual particles.
- Often these behaviours are unintuitive – a single light particle can exist in two places at once, and a single electron can spin clockwise and anti-clockwise at the same time.



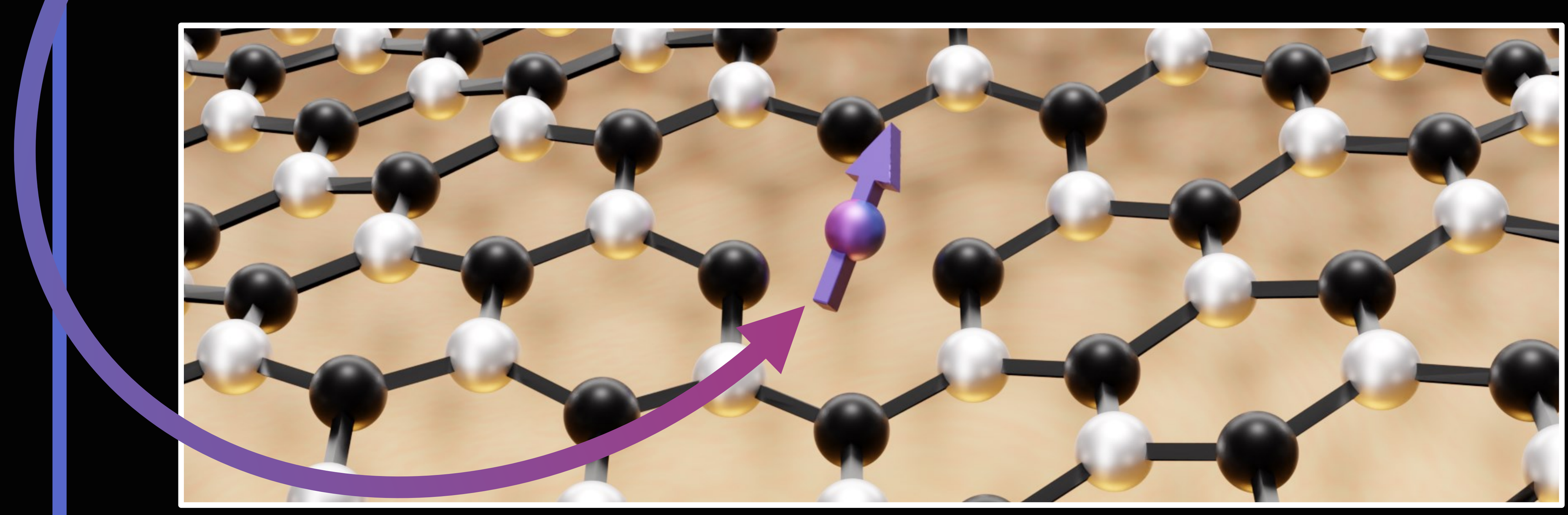
- These behaviours are incredibly delicate. **The goal of quantum sensing research is to use this sensitivity to detect local disturbances that are inaccessible to traditional technology.**

3. Our Approach to Quantum Sensing

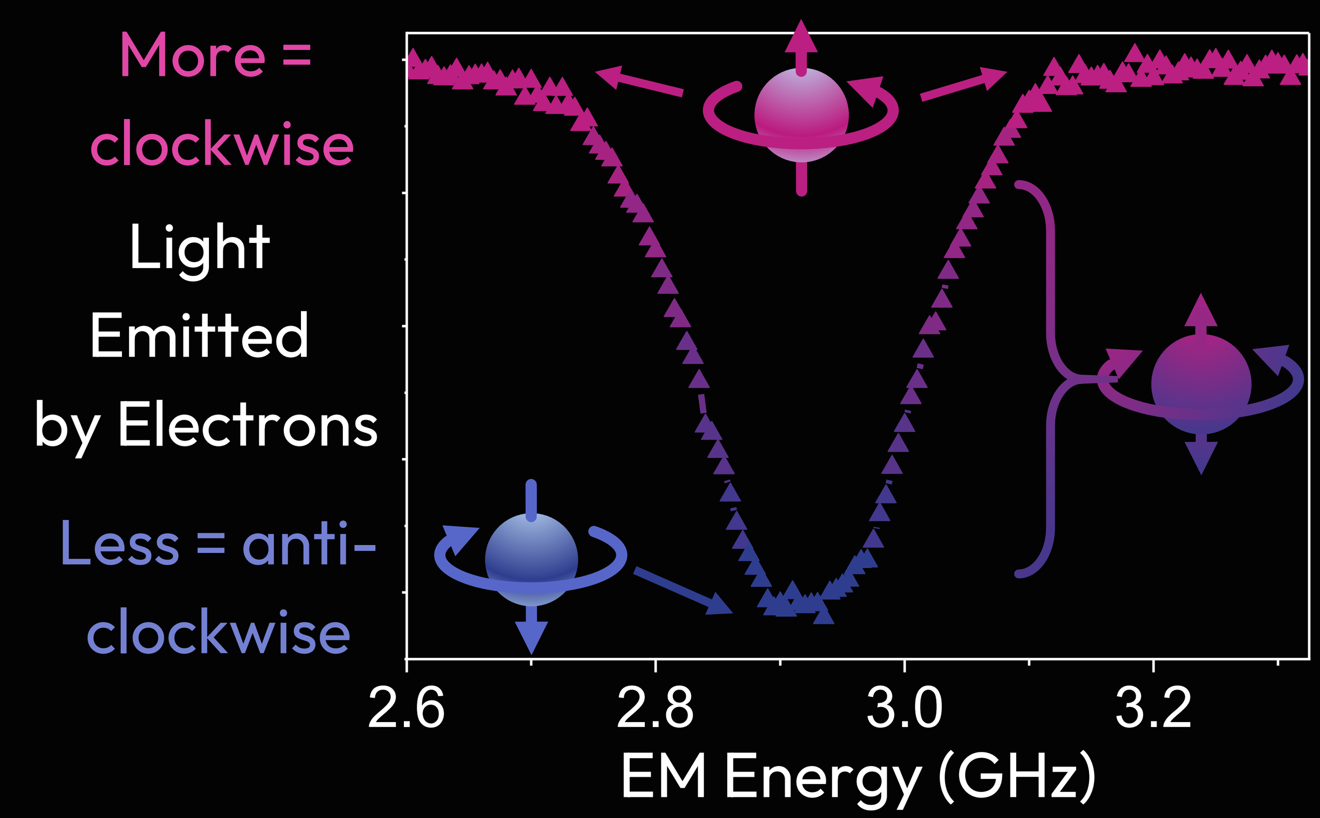
- An electron's quantum spin makes it act like a tiny bar magnet. This means the magnetic part of an EM wave can disturb its motion.



- We detect this interaction using **single electrons trapped at the sites of missing atoms in an electrical insulator**. The insulator, hexagonal boron nitride, is just a few atoms thick, so that we can detect EM waves from microscopic sources.

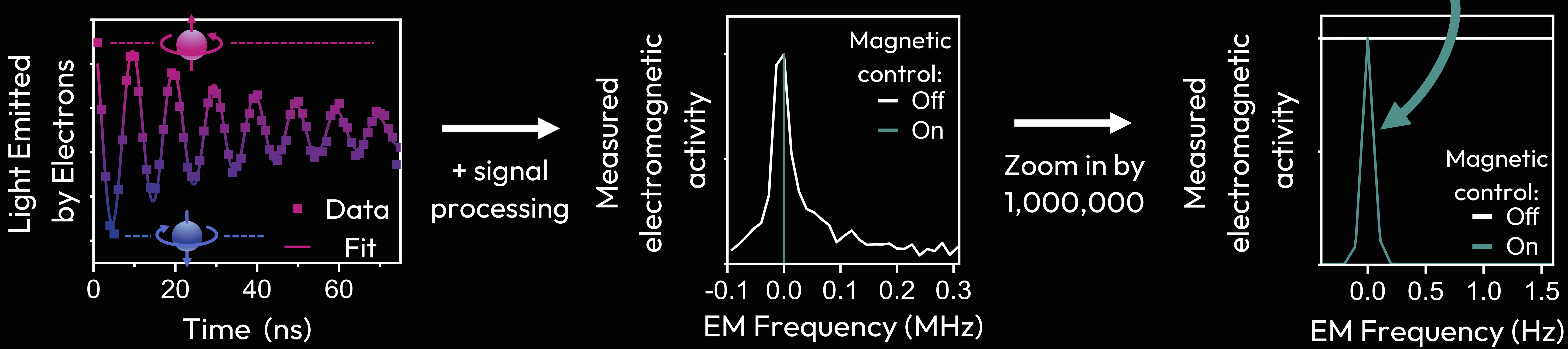


- To see if an EM wave has disturbed the quantum spin of these electrons, **we monitor the amount of light they emit.**



4. Quantum Detection of Electromagnetic Waves

- To measure an EM signal, we control the quantum spin of the electrons using our own customised EM wave. This improves the precision of our sensor by 1,000,000, **allowing us to detect the frequency of EM signals to an accuracy of 1 part in 1 billion.**



- **We're now using our quantum sensor to investigate novel magnetic materials for next generation computing.**

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