Scientists discover single atom defect in 2D material can hold quantum information at room temperature

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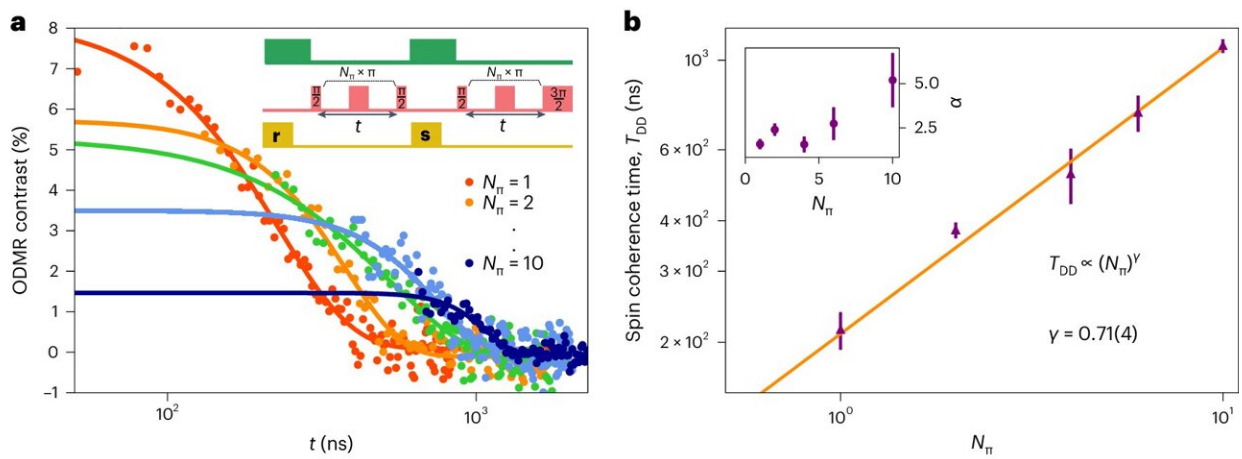

Scaling of spin coherence under dynamical decoupling. **a**, Dynamic decoupling measurements with N_π refocusing pulses, where each measurement is fit to $\exp[-(t/T_{DD})^{\alpha}]$. **b**, Spin coherence time T_{DD} (purple triangles) as a function of the number of refocusing pulses N_π. Credit: *Nature Materials* (2024). DOI: 10.1038/s41563-024-01887-z

Scientists have discovered that a "single atomic defect" in a layered 2D material can hold onto quantum information for microseconds at room temperature, underscoring the potential of 2D materials in advancing quantum technologies.

The defect, found by researchers from the Universities of Manchester and Cambridge using a thin material called hexagonal boron nitride (hBN), demonstrates spin coherence—a property where an electronic spin can retain quantum information—under ambient conditions. They also found that these spins can be controlled with light.

Up until now, only a few solid-state materials have been able to do this, marking a significant step forward in quantum technologies.

The findings, published in *Nature Materials*, further confirm that the accessible spin coherence at room temperature is longer than the researchers initially imagined it could be.

Carmem M. Gilardoni, co-author of the paper and postdoctoral fellow at the Cavendish Laboratory at the University of Cambridge, where the research was carried out, said, "The results show that once we write a certain quantum state onto the spin of these electrons, this information is stored for ~1 millionth of a second, making this system a very promising platform for quantum applications.

"This may seem short, but the interesting thing is that this system does not require special conditions—it can store the spin quantum state even at room temperature and with no requirement for large magnets."

Hexagonal boron nitride (hBN) is an ultra-thin material made up of stacked one-atom-thick layers, kind of like sheets of paper. These layers are held together by forces between molecules, but sometimes, there are tiny flaws between these layers called "atomic defects," similar to a crystal with molecules trapped inside it. These defects can absorb and emit light that we can see, and they can also act as local traps for electrons.

Because of the defects in hBN, scientists can now study how these trapped electrons behave, particularly the spin property, which allows electrons to interact with magnetic fields. They can also control and manipulate the electron spins using light within these defects at room temperature—something that has never been done before.

Dr. Hannah Stern, first author of the paper and Royal Society University Research Fellow and Lecturer at The University of Manchester, said, "Working with this system has highlighted to us the power of the fundamental investigation of new materials. As for the hBN system, as a field we can harness excited state dynamics in other new material platforms for use in future quantum technologies.

"Each new promising system will broaden the toolkit of available materials, and every new step in this direction will advance the scalable implementation of quantum technologies."

Prof Richard Curry added, "Research into materials for quantum technologies is critical to support the U.K.'s ambitions in this area. This work represents another leading breakthrough from a University of Manchester researcher in the area of materials for quantum technologies, further strengthening the international impact of our work in this field."

Although there is a lot to investigate before it is mature enough for technological applications, the finding paves the way for future technological applications, particularly in sensing technology.

The scientists are still figuring out how to make these defects even better and more reliable and are currently probing how far they can extend the spin storage time. They are also investigating whether they can optimize the system and material parameters that are important for quantum-technological applications, such as defect stability over time and the quality of the light emitted by this defect.

More information: Hannah L. Stern et al, A quantum coherent spin in hexagonal boron nitride at ambient conditions, *Nature Materials* (2024). DOI: 10.1038/s41563-024-01887-z

Provided by University of Manchester

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