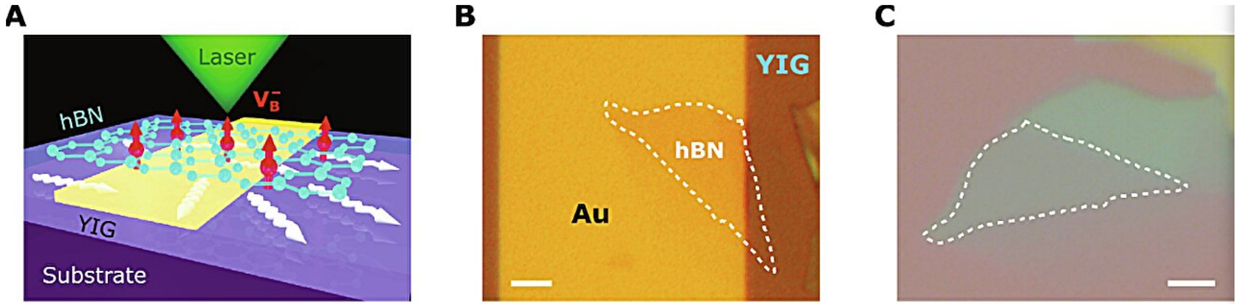
PHYS.ORG

Physicists pioneer new quantum sensing platform

May 3 2024, by Selena Langner



Measurement platform and mechanism.(A) Schematic of a hexagonal boron nitride (hBN) nanoflake transferred onto a Au microwave stripline patterned on magnetic insulator $Y_3Fe_5O_{12}$ (YIG) for quantum sensing measurements. (B and C) Optical microscope images of a prepared hBN-YIG device and the constituent hBN flake. The surveyed hBN flake area is outlined with white dashed lines; scale bar, 5 μm. Credit: *Science Advances* (2024). DOI: 10.1126/sciadv.adk8495

Quantum sensors detect the smallest of environmental changes—for example, an atom reacting to a magnetic field. As these sensors "read" the unique behaviors of subatomic particles, they also dramatically improve scientists' ability to measure and detect changes in our wider environment.

Monitoring these tiny changes results in a wide range of applications—from improving navigation and natural disaster forecasting, to smarter medical imaging and detection of biomarkers of disease, gravitational wave detection, and even better quantum communication for secure data sharing.

Georgia Tech physicists are pioneering new quantum sensing platforms to aid in these efforts. The research team's latest study, "Sensing spin wave excitations by spin defects in few-layer thick hexagonal boron nitride" was published in *Science Advances* this week.

The research team includes School of Physics Assistant Professors Chunhui (Rita) Du and Hailong Wang (corresponding authors) alongside fellow Georgia Tech researchers Jingcheng Zhou, Mengqi Huang, Faris Al-matouq, Jiu Chang, Dziga Djugba, and Professor Zhigang Jiang and their collaborators.

An ultra-sensitive platform

The new research investigates quantum sensing by leveraging color centers—small defects within crystals (Du's team uses diamonds and other 2D layered materials) that allow light to be absorbed and emitted, which also give the crystal unique electronic properties.

By embedding these color centers into a material called hexagonal boron nitride (hBN), the team hoped to create an extremely sensitive quantum sensor—a new resource for developing next-generation, transformative sensing devices.

For its part, hBN is particularly attractive for quantum sensing and computing because it could contain defects that can be manipulated with light—also known as "optically active spin qubits."

The quantum spin defects in hBN are also very magnetically sensitive, and allow scientists to "see" or "sense" in more detail than other conventional techniques. In addition, the sheet-like structure of hBN is compatible with ultra-sensitive tools like nanodevices, making it a particularly intriguing resource for investigation.

The team's research has resulted in a critical breakthrough in sensing spin waves, Du says, explaining that "in this study, we were able to detect spin excitations that were simply unattainable in previous studies."

Detecting spin waves is a fundamental component of quantum sensing, because these phenomena can travel for long distances, making them an ideal candidate for energy-efficient information control, communication, and processing.

"For the first time, we experimentally demonstrated two-dimensional van der Waals quantum sensing—using few-layer thick hBN in a real-world environment," Du explains, underscoring the potential the material holds for precise quantum sensing. "Further research could make it possible to sense electromagnetic features at the atomic scale using color centers in thin layers of hBN."

More information: Jingcheng Zhou et al, Sensing spin wave excitations by spin defects in few-layer-thick hexagonal boron nitride, *Science Advances* (2024). DOI: 10.1126/sciadv.adk8495

Provided by Georgia Institute of Technology

Citation: Physicists pioneer new quantum sensing platform (2024, May 3) retrieved 18 May 2024 from https://phys.org/news/2024-05-physicists-quantum-platform.html