

# Researchers Achieve Atomic-Scale Control of Quantum Interference

A research team led by Prof. YANG Kai at the Institute of Physics (IOP), Chinese Academy of Sciences, in collaboration with Prof. FERNÁNDEZ-ROSSIER Joaquín from International Iberian Nanotechnology Laboratory, has demonstrated all-electrical control of quantum interference in individual atomic spins on a surface, opening new possibilities for fast and robust quantum-state manipulation at the atomic scale.

Quantum interference is a hallmark of the wave-like behavior of quantum particles. It arises when a system exists in a superposition of states, with the relative phases producing constructive or destructive interference. A prominent example is Landau-Zener-Stückelberg-Majorana (LZSM) interference, which occurs when a two-level system is repeatedly driven through an

energy-level anticrossing, leading to multiple non-adiabatic transitions and controllable interference patterns. This mechanism is a powerful tool for fast and reliable quantum control, but it remains a significant challenge to achieve tunable LZSM interference in an atomic-scale quantum architecture—where multiple spins can be precisely assembled and controllably coupled on demand.

Using a custom-built advanced microscope known as Electron Spin Resonance-Scanning Tunneling Microscope (ESR-STM), the team developed an all-electrical method to control LZSM quantum interference in individual and coupled atomic spins on insulating films (Figure). By modulating atomically confined tip-atom interactions with strong electric fields, they rapidly drove spin states through anti-

crossings and observed rich interference patterns, including multiphoton resonances and signatures of spin-transfer torque. Multi-level LZSM spectra of coupled spins revealed how many-body energy landscapes shaped quantum dynamics. These results open new avenues for all-electrical quantum manipulation in spin-based quantum processors in the strongly driven regime.

This study entitled “Electrically tunable quantum interference of atomic spins on surfaces” was published in *Nature Communications* (<https://doi.org/10.1038/s41467-025-64022-9>).

This work was supported by the National Natural Science Foundation of China, the Beijing Natural Science Foundation, the National Key R&D Program of China, and the Chinese Academy of Sciences.

(Source: IOP)

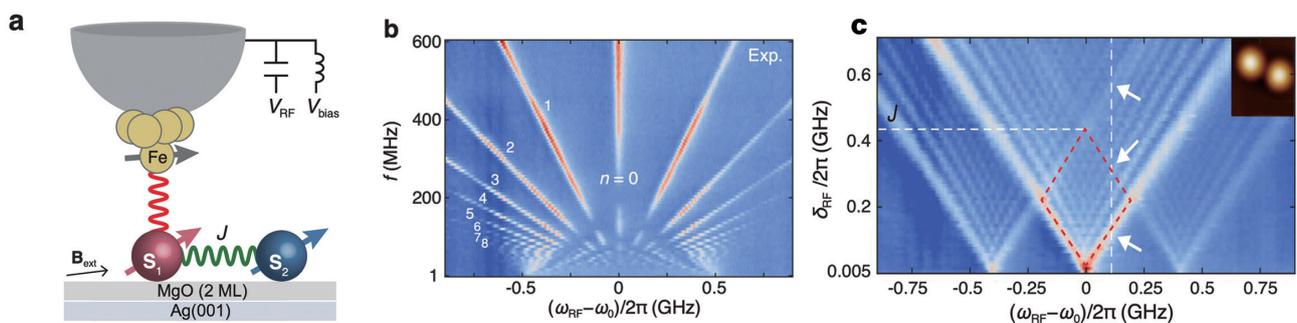


Figure: Quantum interference observed in a single spin and a pair of interacting spins. (Image by IOP)