Quantum Coherent Control of Artificial Spin Structures Crafted Atom-by-Atom on Surfaces

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The desire to probe and control individual quantum systems has led to significant scientific and engineering advances in quantum information science. Single atoms and molecules on surfaces, on the other hand, have been extensively studied in search of novel electronic and magnetic functionalities. These two paths came together when it was clearly demonstrated that individual spins on a surface can be coherently controlled and read out in an all-electrical fashion [1]. The enabling technique is scanning tunneling microscopy (STM) combined with electron spin resonance (ESR) [2], which provides unprecedented coherent controllability at the Angstrom length scale.

In this talk, I present a new approach to coherently control multiple electron spins in a artificially built spin structures on surfaces. We found that remote spins, which are outside the tunnel junction, can be controlled by the local oscillating magnetic fields created by a single-atom magnet placed next to them in oscillating electric fields. The read-out of multiple spins is achieved by a sensor atom weakly coupled to them. The resonances of the sensor spin are separated in the frequency domain so that we can independently and simultaneously control the sensor and remote spins. Our work shows the enhanced coherent properties of the remote spins as well as fast controlled operations of multi-electrons in an all-electrical fashion. Our development widens the approaches to the multi-spin control in tailored spin structures on a surface.

[1] S. Baumann et al., Science 350, 417 (2015).

[2] Y. Chen et al., Adv. Mater. 2107534 (2022).

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