Quantum Effects in Atomically-tailored Carbon

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Graphene nanostructures, and nanoribbons in particular, are predicted to display a plethora of interesting phenomena, including topological states and coherent properties. They have thus undergone intense theoretical scrutiny, and their coherent manipulation would be a milestone for nanoelectronics and quantum devices. However, most nanoscale carbon units are not atomically-precise, hampering experimental investigations.

We show here how quantum carbon systems can be created by bottom-up shaping of the graphene lattice. We show how magnetic states emerge, and how the quantum spin dynamics and associated selection rules are modulated by the carbon lattice [1,2]. Even without any optimization, the spin coherence time can reach hundreds of μs at room temperature, and we perform quantum inversion operations between edge and radical spins. The examination of the spin decoherence channels allows for optimization of the quantum properties, while integration in quantum electronic devices allows exploring quantum thermodynamics at the single-molecule level [4], vibrational and spintronic effects,[5,6]. Eventually we show how the quantum admixture of modulated edge states makes them excellent emitting systems for carbon-based optical and optoelectronic devices [7].

References

[1] M. Slota et al., Nature, 2018.
[2] F. Lombardi et al., Science 2019
[3] P. Gehring et al. Nature Nano 2021
[4] T. Pei et al. Nature Comms 2022
[5] S. Sopp et al. Nature Materials 2023
[6] Q. Chen et al. Nature Chemistry 2024
[7] B. Sturza et al. Nature Comms 2024

Figures

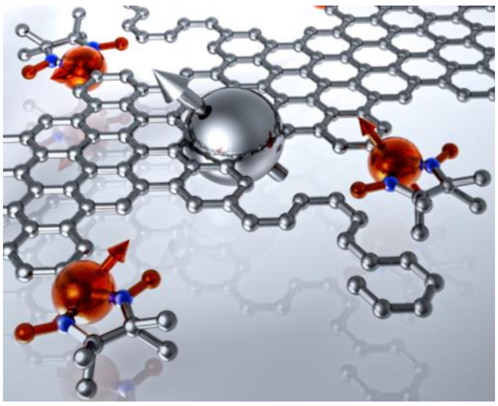

Figure 1: Insert caption to place caption below figure (Century Gothic 10)

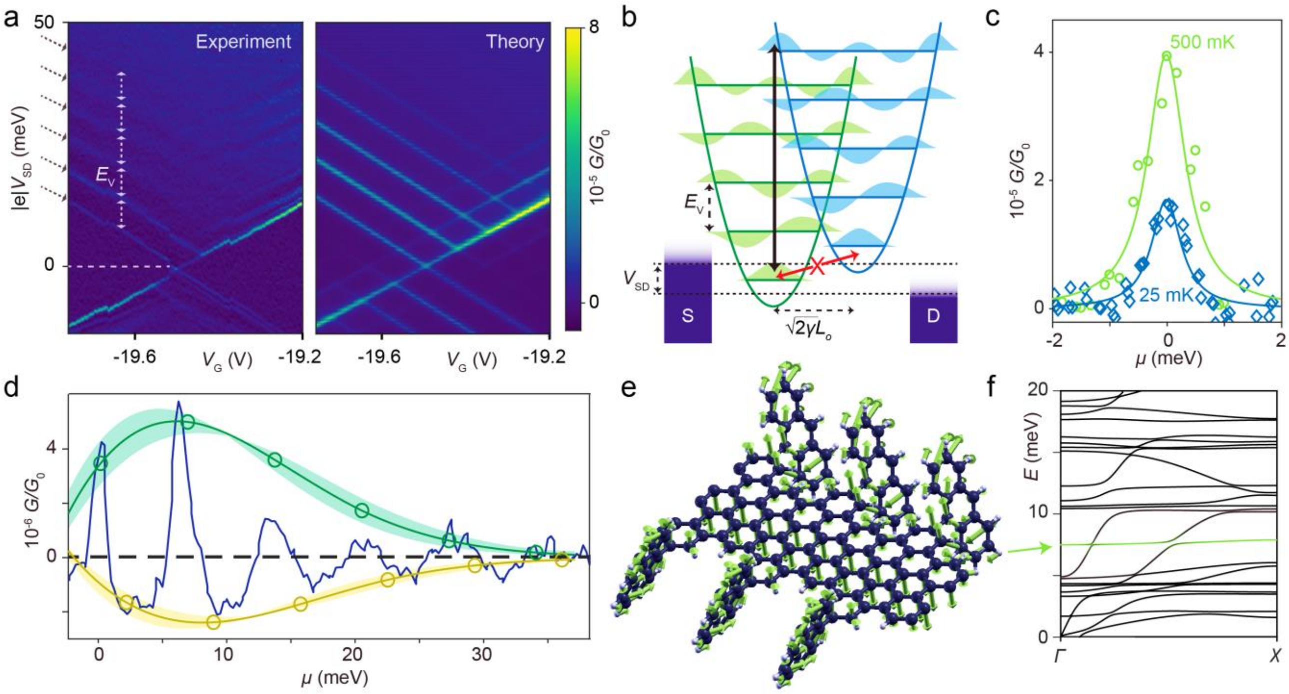

Figure 2: Insert caption to place caption below figure (Century Gothic 109