The Quantum Coherence of Metal-functionalized Graphene Nanoribbons

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There are many proposals to achieve states with long coherence times in graphene. The low spin-orbit coupling, due to the low curvature and light atoms [1], and the possibility of having topologically interesting states [2] may lead to sizeable coherence and make the material most appealing.

Most investigations into the quantum properties of graphene structures have been hindered by the lack of a clean, defined structure and clear-cut edges. Recent advances in the molecular shaping of graphene, with bottom-up synthetic methods [3], have recently opened the path to graphene nanostructures with perfectly defined morphology, which can be designed atom-by-atom. Magnetic edge states with long coherence times, as predicted by theory, could be detected [4]. On the other hand, most states that are theoretically interesting need another ingredient: spin orbit coupling, as possibly produced by metals.

Here we show the coherence properties of such metal-functionalized nanoribbons, demonstrating very long coherence in the μs range even at room temperature, and analysing the spin-spin interactions, as useful for quantum information processing purposes. We specifically investigate systems containing vanadyl and cyanide ions, as they are interesting for the production of topologically nontrivial states. We use pulsed Electron Paramagnetic Resonance at Q-Band Frequency (34 GHz), and by using different pulse sequences, we examine relaxation mechanisms, resolve couplings, and manipulate spin interactions.

Our results open up a myriad of opportunities for potential applications in quantum electronic devices and offer a novel platform for the investigation of topological states of matter.

References

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[4] M. Slota et al., Nature 557.7707 (2018): 691–695

Figures

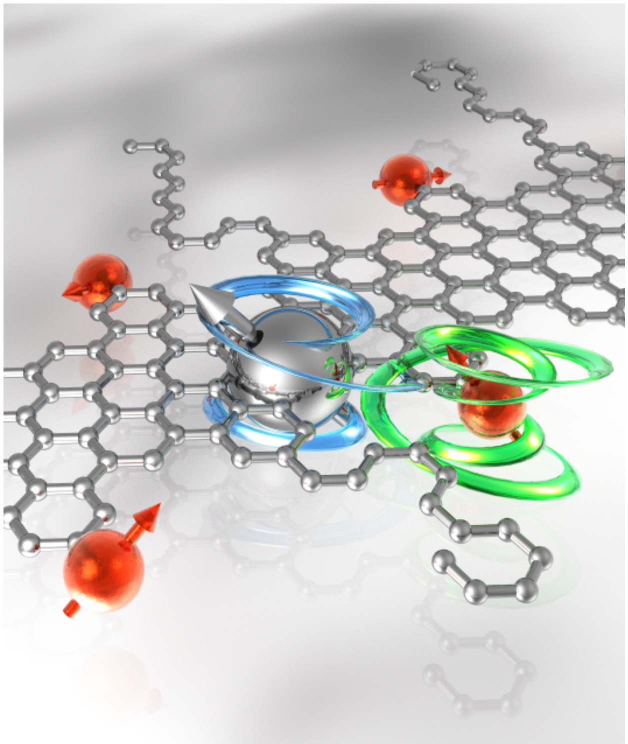

Figure 1: An illustration of a graphene nanoribbon functionalised with a vanadyl group (shown in red) and their associated quantum spin.