Magnetism in graphene nanoribbons

Nacho Pascual[1]

[1] CIC nanoGUNE, Donostia San Sebastián, Spain

Ji.pascual@nanogune.eu

Graphene can spontaneously develop intrinsic paramagnetism. Crucial examples are the magnetization of zig-zag edges in graphene, or the emergence of paramagnetism in open shell graphene nanostructures. I will show that graphene nanoribbons (GNR), fabricated with atomic precision on a metal surface exhibit fingerprints of pi-paramagnetism on a metal surface, which can be detected and spatially localized using low temperature scanning tunneling [1].

Single electron spins emerge localized at certain zigzag sites of the carbon backbone. Their presence could be detected and mapped by spatially resolving the zero-energy resonance due to the Kondo effect (see figure below). We found that near-by spins are coupled into a singlet ground state and quantify their exchange interaction via singlet-triplet inelastic electron excitations. Theoretical simulations picture how electron correlations result in spin-polarized radical states with the experimentally observed spatial distributions. Extra hydrogen atoms bound to radical sites quench their magnetic moment and switch the spin of the nanostructure in half-integer amounts.

I will also review other methods for activating magnetic ground states in graphene. The simplest one is to incorporate magnetic molecular species into a ribbon using on-surface synthesis routes (see included image of a Fe porphyrin contacted to chiral nanoribbons). We prove that the molecular spin survives in the ribbon by using spin-excitation inelastic spectroscopy [2]. By proper selecting the position of the halogen functionalization, we fabricated linear GNR-FeTPP-GNR structures and performed electronic transport measurements [3], detecting spin-excitation fingerprints in transport mode.

References

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[3] J. Li, N. Friedrich, N. Merino-Díez, D. G. de Oteyza, D. Peña, D. Jacob, and J.I. Pascual, "*Electrically Addressing the Spin of a Magnetic Porphyrin through Covalently Connected Graphene Electrodes*", Nano Letters 19, 3288 (2019).

Figures

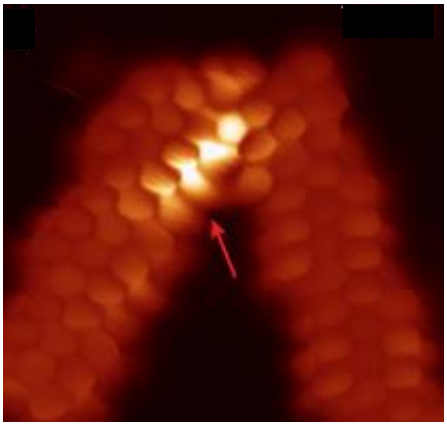

Figure 1. Single spin localization in a graphene nanostructure [1]

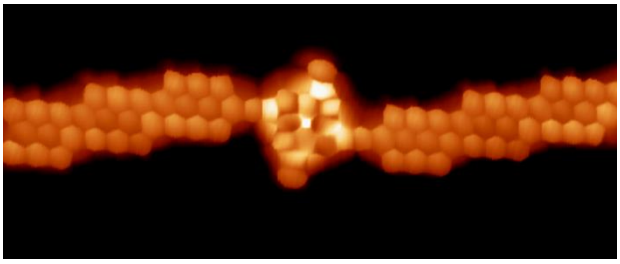

Figure 2. Two chiral GNRs contacting a single Iron Porphyrin molecule [3]