Engineering intrinsic π-electron magnetism in atomically-precise carbon nanostructures

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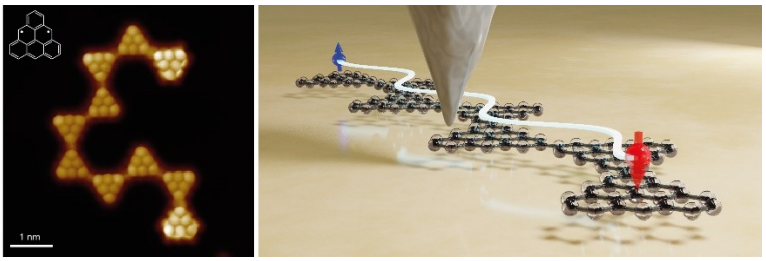
Topologies of the edge bonds and π-electron network critically influence the electronic structure of finite size graphene fragments such as nanographenes (NGs) and graphene nanoribbons (GNRs). Among various properties that arise in such carbon nanomaterials, intrinsic magnetism is a particularly attractive one [1]. Given the weak spin-orbit and hyperfine couplings in carbon and the possibility of electric-field control of spin transport, realization of magnetic carbon nanomaterials may offer unique opportunities in spintronic applications.

In this presentation, I will discuss the on-surface synthesis and scanning probe microscopy / spectroscopy characterization of atomically-precise carbon nanostructures with structural topologies entailing intrinsic π-magnetism. After a brief introduction to the on-surface synthesis of atomically precise GNRs [2], I will present NGs in which magnetism arises due to sublattice imbalance [3], topological frustration of the π-electron network [4], or polarization of low-energy states [5]. In the second part, two complementary approaches to the bottom-up fabrication of spin chains will be discussed. While the first approach is based on the covalent interlinking of triangular NGs [6], a promising alternative builds on topological electronic quantum phases in edge-extended GNRs [7].

[1] O.V. Yazyev, *Rep. Prog. Phys*. **73**, 056501 (2010).
[2] J. Cai et al., *Nature* **466**, 470 (2010); L. Talirz et al., *ACS Nano* **11**, 1380 (2017).
[3] S. Mishra et al., *J. Am. Chem. Soc*. **141**, 10621 (2019).
[4] S. Mishra et al., *Nat. Nanotechnol.* **15**, 22 (2020).
[5] S. Mishra et al., *Nat. Chem.* **13**, 581 (2021).
[6] S. Mishra et al., *Angew. Chem. Int. Ed*. **59**, 12041 (2020); S. Mishra et al., *Nature* **598,** 287 (2021).
[7] O. Gröning et al., *Nature* **560**, 209 (2018); Q. Sun et al., *Nano Lett.* **20**, 6429 (2020).



Fractional edge excitations in nanographenes spin chains: Scanning tunneling spectroscopy detects gapped magnetic excitations in the bulk of the chain and spin fractionalization at the chain termini, confirming the predictions of one of the cornerstone models of quantum magnetism first proposed by F. D. M. Haldane.