KIT-Fakultät für Physik

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Einladung zum Physikalischen Kolloquium

27.01.2023 **Roman Fasel, EMPA Dübendorf**

**»Atomically precise graphene nanomaterials:
From ribbons to spin chains«**

Einführung: W. Wulfhekel

Der Vortrag findet um **15:45 Uhr im Otto-Lehmann-Hörsaal**, Physik-Flachbau (Geb. 30.22), statt.

Zusätzlich wird der Vortrag im Livestream angeboten:

https://kit-lecture.zoom.us/j/66234967643
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Atomically precise graphene nanomaterials: From ribbons to spin chains

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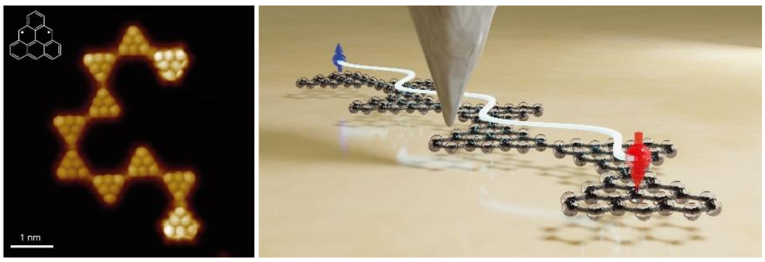
Graphene nanoribbons (GNRs) – narrow stripes of graphene – have attracted much interest due to their versatile electronic properties, including width-dependent bandgaps for armchair GNRs[1] and spin-polarized edge states for GNRs with zigzag edges[2]. Manifestation of these properties requires atomically precise GNRs which can be achieved through a bottom-up on-surface synthesis approach[3] that will be reviewed in the first part of this talk. As an example, I will discuss width-modulated GNRs hosting topological electronic quantum phases that emerge from localized zero-energy modes at the junctions of topologically dissimilar graphene nanoribbons[4]. The realization of 1D topological quantum phases in GNRs enables a novel route to bandgap and effective mass control in GNRs, which can be readily integrated in CMOS-type electronic devices[5].

The topology of the edge bonds and the π-electron network are not only critically important for 1D GNRs, but also for the electronic structure of 0D graphene fragments called "nanographenes" (NGs). Among various properties that arise in graphene nanomaterials, intrinsic magnetism is a particularly attractive one [6]. 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 for spintronic and quantum applications.

In the second part of this presentation, I will thus discuss the on-surface synthesis and scanning probe microscopy & spectroscopy characterization of NGs with structural topologies entailing intrinsic π-electron magnetism. I will present NGs with different spin ground states and with exchange couplings covering a wide range of energies [7]. Collective magnetism in covalently bonded NG dimers [8] will be demonstrated, and the emergence of the Haldane symmetry-protected topological phase in NG quantum spin-1 chains shall be highlighted [9]. Finally, I will discuss recent data for a 1D quantum spin system based on bowtie-shaped NGs, which is a realization of the antiferromagnetic dimerized Heisenberg spin-½ chain.

[1] J. Cai et al., *Nature* **466**, 470 (2010); L. Talirz et al., *ACS Nano* **11**, 1380 (2017).
[2] P. Ruffieux et al., *Nature* **531**, 489 (2016).
[3] L. Talirz et al., *Adv. Mater*. **28**, 6222 (2016); Q. Sun et al., *Adv. Mater*. **30**, 1705630 (2018).
[4] O. Gröning et al., *Nature* **560**, 209 (2018); D. Rizzo et al., *Nature* **560**, 204 (2018).
[5] J.P. Llinas et al., *Nat. Commun*. **8**, 633 (2017); Q. Sun et al., *Adv. Mat*. **32**, 1906054 (2020).
[6] O.V. Yazyev, *Rep. Prog. Phys*. **73**, 056501 (2010).
[7] S. Mishra et al., *J. Am. Chem. Soc*. **141**, 10621 (2019); S. Mishra et al., *Nat. Nanotechnol.* **15**, 22 (2020).
[8] S. Mishra et al., *Angew. Chem. Int. Ed*. **59**, 12041 (2020).
[9] S. Mishra et al., *Nature* **598,** 287 (2021).



Fractional edge excitations in nanographene 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.