Exotic electronic states in borylated graphene nanoribbons on a metallic substrate

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Graphene nanoribbons (GNRs) have emerged as promising platforms for π-magnetism [1], with recent findings revealing the presence of uncompensated spin-polarized states at ribbon edges or interiors due to non-conventional band topology effects. Additionally, advancements in bottom-up growth techniques have enabled the synthesis of GNRs directly on surfaces [2], further enhancing their potential for applications in spintronics and quantum computing.

Here, we investigate the induction of spin polarization in topologically trivial, densely 2B-doped 7AGNRs [3,4] when detached from a metal support. Utilizing a combination of density functional theory (DFT) [5], mean-field Hubbard calculations and topological band theory, as well as low-temperature scanning tunneling microscopy (STM) transport experiments and simulations [6] on borylated GNRs, we demonstrate and study the presence of a Kondo resonance for specific tip-substrate distances while slowly lifting a 2B-7AGNR from an Au(111) substrate using the tip of an STM. Additionally, we observe the emergence of a low-energy electronic state (Fig. 1) at the terminal of an asymmetric 2B-7AGNR, with an additional anthracene unit on one end. Due to asymmetry, a topological classification based on the bulk-boundary correspondence isn't possible for this structure. However, our theoretical analysis of the electronic structure underscores the potential for substrate-mediated charge transfer effects and hopping processes, enabling the emergence of topological edge states. This discovery provides a compelling basis for exploring complex spin physics and exotic quantum phases in low-dimensional organic materials.

References

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Figures

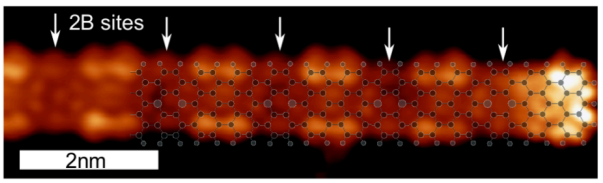

Figure 1: constant-height STM image of the edge state of a densely 2B-doped 7AGNR (V_b = 5 mV).