





MPI Stuttgart

Atomic-scale control of graphene magnetism using hydrogen atoms

"HiMagGraphene"



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Magnetism in graphene: just remove a p_z orbital



Atomic Hydrogen on Monolayer Graphene

Relaxed Atomic structure



Calculated spin density



• Magnetic moment = $1\mu_B$

• spin density located on the opposite triangular sublattice.

Simulated STM image (Tersoff-Hamann)



DFT calculations: M. Moaied, J.J Palacios, Felix Yndurain • Spin Polarized – DFT SIESTA code // (DZP) basis set.

Experimental approach

Illustration by Julio Gómez-Herrero

UHV-STM

Starting point of the project!



Proposed experiments



The consortium (who we are)

Partner 2

Coordinator (P1)



P.I.

co-Investigator





- I. Brihuega
- J.M.Gómez-Rodríguez



J-Y Veuillen



P. Mallet





MPI Stuttgart co-Investigator **P.I.**



K. Kern



M.Ternes

Quasiparticle pseudospin

I Brihuega, P. Mallet, C. Bena, S. Bose, C. Michaelis, L. Vitali, F. Varchon, L.Magaud, K. Kern, J.Y. Veuillen Phys Rev. Lett. 101, 206802 (2008)







True variable Temperature experiments



Point defects in graphene









Preparation of graphene substrates





Neutral (thick) twisted multilayer





Max-Planck-Institute for Solid State Research Nanoscale Science Department











Chronogram of activities:

WP1. Substrate preparation and characterization (0-36)

SiC(000-1): from ML to multilayer graphene; SiC(0001): ML and BL; HOPG; ML on BN/SiO₂; ML on SiO₂; ML graphene on (Au, Cu, Ir, Pt); graphene islands and ribbons on SiC.

WP2. STS Characterization of H on undoped graphene (0-36)

- LDOS of single H for different substrates
- Spatial extension of the spin-split state

0

- Interaction between graphene magnetic moments induced by neighboring H atoms

WP3. Temperature dependent measurements (12-36) - Influence of thermal fluctuations in the magnetic moments - Dynamic evolution of H atoms. - Single and ensembles of H atoms WP4. Magnetic field dependence (6-36) - Proof of the magnetic origin of the peaks by using spin-sensitive tips - Observing the energy shifts due to the Zeeman energy - Determine the coupling strength and sign in ensembles of H atoms WP5. Spin manipulation (6-36)

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- Locally: using the STM tip to manipulate the H adsorption sites
- Externally: with doping (both by substrate and by gating)

12

- On a device: try to inject spin polarized current without magnetic electrodes.

time [months]

Role of the partners

(who does what)





WP1: Enabling Research

WP2: Spintronics







MPI Stuttgart

"HiMagGraphene"

Progress so far...











7 H atoms "up" 7 H atoms "down"







7 H atoms "up" 7 H atoms "down"











H. González-Herrero, J.M. Gómez-Rodríguez, P. Mallet, M. Moaied, J.J. Palacios, C. Salgado, M.M. Ugeda, J.Y. Veuillen, F. Ynduráin and I Brihuega, submitted









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Sublattice localization of the polarized peak







Sublattice localization of the polarized peak



Sublattice localization of the polarized peak



C. Salgado, M.M. Ugeda, J.Y. Veuillen, F. Ynduráin and I Brihuega, submitted





True variable Temperature experiments







