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Abstract for an Invited Paper
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Adding magnetic functionalities to epitaxial graphene by self assembly on or below its surface

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We show how to add magnetic functionalities to graphene's set of extraordinary electronic, mechanical or optical properties. We will discuss such two examples:

1. *Achieving long range magnetic order on a monolayer of TCNQ adsorbed on graphene /Ru(0001).*

Cryogenic STM and Spectroscopy and DFT simulations show that isolated TCNQ molecules deposited on gr/Ru(0001) [1-3] acquire charge from the substrate and develop a sizeable magnetic moment, which is revealed by a prominent Kondo resonance. The self-assembled molecular monolayer develops spatially extended spin-split electronic bands with only the majority band filled, thus becoming a 2D organic magnet whose predicted spin alignment in the ground state is visualized by spin-polarized STM at 4.6 K [4]. The long range magnetic order is originated by the charge transfer from graphene to TCNQ (which creates the magnetic moments) plus the self-assembly of the molecular adlayer on the graphene layer (which creates spin-polarized intermolecular bands where the added electrons partly delocalize). Examples will be shown where the adsorbed molecules accept charge and develop magnetic moments, but do nor form bands (F4-TCNQ on graphene/Ru(0001)), or where similar bands do form, but they are not populated, because there is no charge transfer to the molecules (TCNQ on gr/Ir(111)). ii) *Introducing a giant spin-orbit interaction on graphene/Ir(111) by intercalation of Pb.* The intercalation of an ordered array of Pb atoms below graphene results in the appearance a series of equally spaced, sharp peaks in the differential conductance, as revealed by STS at 4.6 K. The vicinity of Pb enhances the, usually negligible, spin-orbit interaction of graphene. The spatial variation of the spin-orbit coupling creates a gauge field that acts as an pseudo magnetic field opening a gap, confining electrons and originating pseudo Landau levels [5].

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[3] D. Stradi et al, Phys. Rev. Lett. 106, 186102 (2011);
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[5] F. Calleja et al, in preparation.