Evidence of large spin-orbit coupling effects in quasi-free-standing graphene on Pb/Ir(111)

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A combined scanning tunneling microscopy, angle- and spin-resolved photoemission spectroscopy and density functional theory study of graphene on Ir(111) intercalated with a well-ordered, full Pb monolayer is presented. Lead intercalation between graphene and Ir(111) reduces the coupling to the metallic substrate in such a way that its corrugation becomes negligible and distortions of the linear dispersion largely disappear, while graphene's sublattice symmetry is maintained and it turns out to be *n*-doped. Remarkably, the spin-orbit splittings induced by the proximity of the Ir(111) surface are preserved after Pb intercalation in a wide energy range. We further show that the Pb interlayer induces a complex spin texture with both in-plane and out-of-plane components. Our calculations reveal the origin of the out-of-plane spin components in graphene to trace back to the out-of-plane spin-polarized surface and resonance states of Ir(111), while the Pb interlayer on its own does not induce any vertical spin polarization in the carbon sheet. However, the Brillouin zone folding imposed by the rectangular symmetry of the intercalated Pb layer plays an instrumental role in the spin-orbit coupling (SOC) transfer to graphene, as well as in the linearization of its bands. Finally, since no sizeable gap is observed at the Dirac point, we suggest that an intrinsic (Kane and Mele type) SOC does not exceed the extrinsic (Rashba) SOC for graphene on Pb/Ir(111).