Pb intercalation in epigraphene: Charge neutral graphene, 2D interlayer bands, and spin textures

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Intercalation of epitaxial graphene is a robust approach for stabilizing two-dimensional (2D) interlayers confined at the graphene/SiC interface. Among the various elements explored as intercalants, Pb has attracted particular interest due to two key properties: it is a well-established superconductor, even in the form of ultrathin epitaxial films approaching the ultimate 2D limit [1], and it exhibits strong intrinsic spin-orbit coupling (SOC), with pronounced SOC effects persisting down to monolayer thickness [2,3]. These characteristics make Pb an excellent candidate for inducing both superconductivity and enhanced SOC in graphene via proximity coupling.

In this work, we present a detailed investigation of the electronic band structure of Pb-intercalated quasi-freestanding monolayer graphene (Pb-QFMLG) on SiC using angle-resolved photoelectron spectroscopy (ARPES). The graphene π bands show near charge-neutrality [4-6], involving a combined charge transfer from both the interlayer Pb and the SiC substrate [6]. The Pb-derived interlayer bands exhibit a metallic nature with a (1×1) registry with respect to the SiC substrate, corroborated by ARPES measurements within the repeated Brillouin zone of Pb [5,6]. Light polarization-dependent ARPES measurements reveal a predominantly out-of-plane orbital character for the Pb bands, suggesting potential interactions between the p_z orbitals of the interlayer Pb and graphene, potentially contributing to proximity-induced effects in graphene [6]. Density functional theory (DFT) calculations for a (1×1) Pb monolayer on SiC qualitatively agree with both the observed interlayer band structure and the light-polarization dependence [6].

Motivated by the prospect of SOC-driven effects, spin-resolved ARPES measurements were performed. These measurements reveal pronounced spin polarization in the Pb interlayer, reaching values up to about 50%, along with a tangential spin texture at the Fermi surface. Notably, the graphene π bands also exhibit measurable spin polarization, which may be attributed to Rashba-type spin splitting induced by the Pb interlayer. Spin-resolved DFT calculations support these findings.

References:
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