3D twistronics of mixing moiré-surface and bulk states in graphite

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Van der Waals twistronics enables designing two-dimensional (2D) electronic states by using moiré superlattices. This approach resulted in many new phenomena, including, among other, strong correlations and superconductivity in magic-angle twisted bilayer graphene[1,2], charge ordering and Wigner crystallisation in transition metal chalcogenide moiré structures[3-6], Hofstadter's butterfly spectra and Brown-Zak quantum oscillations in graphene superlattices[7-9]. In this work we show that both surface and bulk electronic states in three-dimensional (3D) graphite can be tuned by a superlattice potential occurring at the interface with crystallographically aligned hexagonal boron nitride[10]. Such alignment results in numerous Lifshitz transitions and Brown-Zak oscillations arising from near-surface states whereas, in high magnetic fields, fractal states of Hofstadter's butterfly penetrate deep into the bulk of graphite. Our work provides novel control of 3D spectra using the approach of 2D twistronics.

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