

Probing high-bias criticality via near-field photovoltage in a bilayer graphene moiré superlattice

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Abstract

Nonlinear transport regimes in graphene-based moiré superlattices expose physics far beyond equilibrium. At high current densities, these systems access extreme-field phenomena — including Schwinger-like electron–hole pair creation [1,2], negative differential conductance (NDC) [3], and Cherenkov phonon emission [4] — that are inaccessible in linear response. In bilayer graphene aligned to hexagonal boron nitride (BLG/hBN), the moiré-folded band structure enables a critical peak in differential resistance whose traversal unlocks a bistable electronic state with single-photon sensitivity [3].

We employ cryogenic scanning near-field optical microscopy (cryo-SNOM) at mid-infrared frequencies to study the spatially resolved photovoltage (PV) in BLG/hBN as the dc bias is tuned across this critical peak. Near criticality, the PV response is dominated by bulk bolometric contributions, while the spatial extent of the PV phase-reversal boundary broadens. These observations establish near-field optoelectronic microscopy as a nanoscale probe of photovoltage generation mechanisms under strong in-plane electric fields, complementing recent nano-infrared imaging of current-driven nonequilibrium electrodynamic in graphene [4]. Our results may enable spatially resolving the interplay between Schwinger pair creation, negative differential conductance, and bolometric heating in moiré superlattices.

References:

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