Critical Transport in Flat-Band Graphene Moiré Superlattices at High Bias

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Abstract

Electron transport in metals is usually described by slight perturbations of Fermi surface as a response to weak electric fields. However, this picture alone is no longer valid when the field shifts distribution of carriers far away from the equilibrium. The Schwinger-like production of charge carriers leads to critical behaviour of current density. Here, we investigate this critical transport behavior in graphene-based moiré superlattices exposed to high in-plane electric fields. We show that field necessary to reach supercritical behavior can be reduced by reducing the bandwidth of moiré materials. While the observed non-linear transport exhibits similarities with superconducting transitions, we emphasize that these effects arise from distinct mechanisms unrelated to conventional superconductivity. Our findings extend previous observations in graphene superlattices [1] and provide new insights into high-field transport in engineered low-dimensional materials, highlighting the role of band structure engineering in non-linear transport

References

[1] Berdyugin, Alexey I., et al. *Science* 375.6579 (2022): 430-433.

Figures

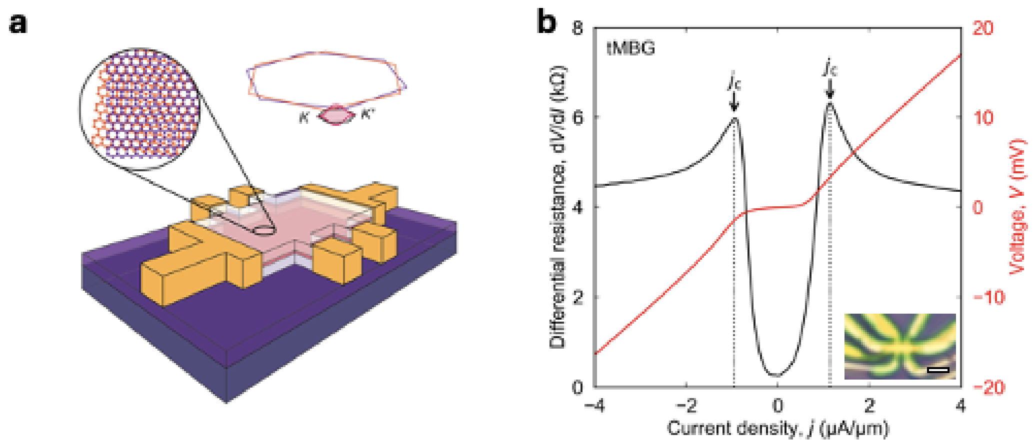

Figure 1: High-current transport in graphene moiré materials. (a) Schematic of the moiré device. Inset: flat band created from band-folding. (b) Differential resistance and voltage as a function of the current density. Black arrows indicate the critical current j_c. Inset: device micrograph.