

Localized bulk photo-response in a superlattice's high-field regime

Paul JAÏS

Riccardo Bertini, Julien Barrier, Xueqiao Wang, Pablo Jarillo-Herrero, Frank Koppens
ICFO, Av. Carl Friedrich Gauss, 3 - 08860, Castelldefels, Spain
paul.jais@icfo.eu

Abstract

Thanks to their small Brillouin zone with isolated flat minibands and reduced Fermi velocity, moiré superlattices allow to reach a current saturation regime under large in-plane electric fields. Sharp non-linearities in differential resistivity are expected [1], along with a large photo-response. This critical behavior was observed in graphene-based superlattices [2], enabling single photon detection by engineering negative differential conductivity [3].

Here, we align the crystallographic axes of Bernal bilayer graphene to those of hexagonal boron nitride to form an artificial moiré superlattice whose miniband width is tuneable using out-of-plane electric fields. Using scanning photocurrent microscopy in the visible range at 4K, we take advantage of the large photo-response to map the transport non-linearities across the device length. Our results suggest that the critical behaviour is a localized bulk response, strongly affected by the electrostatic configuration but independent of edge contacts. We also demonstrate that far-field photocurrent imaging through a top gate enables non-invasive and non-destructive mapping of current flow across the device.

References

- [1] R. Tsu, L. Esaki; IBM Journal of Research and Development 14(1), Superlattice and Negative Differential Conductivity in Semiconductors. (1970) : 61 - 65.
- [2] Alexey I. Berdyugin et al., Science 375, Out-of-equilibrium criticalities in graphene superlattices (2022) 430-433.
- [3] Krystian Nowakowski et al., Science 389, Single-photon detection enabled by negative differential conductivity in moiré superlattices (2025) 644-649.