

# Terahertz Photocurrent Probes Quantum Geometry in Moiré Superlattices

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Quantum geometry, encoded in the Berry curvature and quantum metric of Bloch states, underlie radically new electronic behaviours in multi-orbital quantum materials. Moiré superlattices are a unique quantum material with simultaneously large quantum geometry and strong electron-electron interactions. Yet, accessing quantum geometric responses remains challenging. Here, we show that terahertz (THz) photocurrent experiments unveil these hidden wavefunction properties in magic-angle twisted bilayer graphene (MATBG). We report the observation of THz shift currents—a nonlinear optical response governed by the geometric shift vector of the Bloch eigenstates—and demonstrate that this signal directly encodes the quantum geometry of moiré flat bands, including interaction-induced renormalizations [1]. We further present experimental data showing that these polarization-sensitive THz responses persist to temperatures of 77 K, providing a robust experimental fingerprint across a broad temperature range. This robustness opens unique directions for THz polarimetry – photodetectors capable of decoding the polarization state of light—exploiting the geometric sensitivity of the bulk photovoltaic effect. THz photocurrent constitutes a powerful and broadly applicable tool for probing quantum geometry in quantum materials, with immediate relevance to moiré platforms and topological systems.

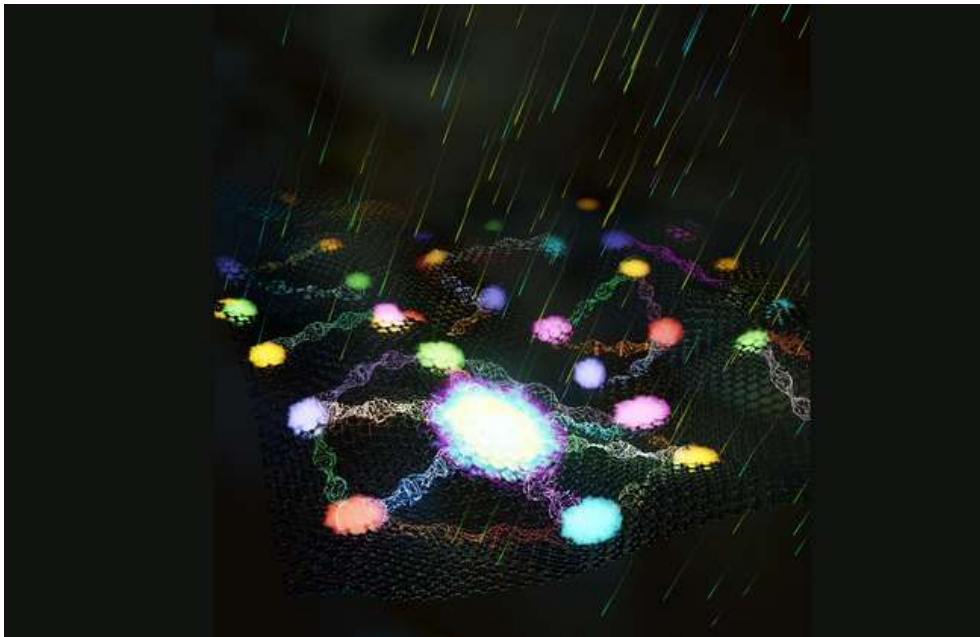


Figure 1: Artistic impression of terahertz photons interacting with magic-angle twisted bilayer graphene, whose quantum geometry is reshaped by many-body interaction effects. Artwork by David Alcaraz (ICFO).

## References

[1] R. Krishna Kumar, G. Li, R. Bertini, S. Chaudhary, K. Nowakowski, J.M. Park, S. Castilla, Z. Zhan, P.A. Pantaleón, H. Agarwal, S. Battle-Porro, E. Icking, M. Ceccanti, A. Reserbat-Plantey, G. Piccinini, J. Barrier, E. Khestanova, T. Taniguchi, K. Watanabe, C. Stampfer, G. Refael, F. Guinea, P. Jarillo-Herrero, J.C.W. Song, P. Stepanov, C. Lewandowski, F.H.L. Koppens, *Nature Materials* 24, 1034–1041 (2025). <https://doi.org/10.1038/s41563-025-02180-3>