Ultrafast Photodetectors for Quantum Circuitry Using Moiré Materials

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Twisted bilayer graphene has emerged as a versatile quantum material. By applying an electric field, conducting, insulating, superconducting and ferromagnetic phases are induced in the material. Electronic devices that exploit these phases include Josephson junctions [1,2] and single electron transistors [3], which are the building blocks for quantum circuitry. However, the optical and optoelectronic properties are not fully understood. In particular, the energy relaxation pathways remain unknown.

Here we study the relaxation of photoexcited carriers in twisted bilayer graphene. We report on a dramatic speed up in carrier relaxation for twist angles close the magic angle, which results in a picosecond response time from ambient to cryogenic (5 K) temperatures. [4] This enhanced response is due to a novel Umklapp-assisted electron-phonon scattering mechanism that is enabled by the moiré superlattice.

This work could give important insights into the role of phonons in superconductivity and lead to the development of ultrafast photodetectors for sensing applications that span the visible, infrared and terahertz spectra.

Figures

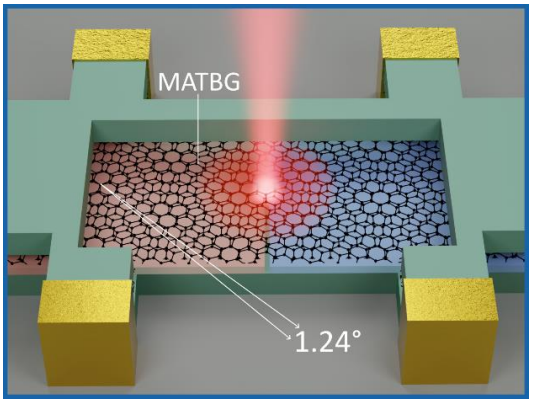

Figure 1: Illustration of the hBN-encapsulated MATBG device with twist angle 1.24°. We generate a photovoltage by illuminating the electrically defined pn-junction (±V, red/blue regions).

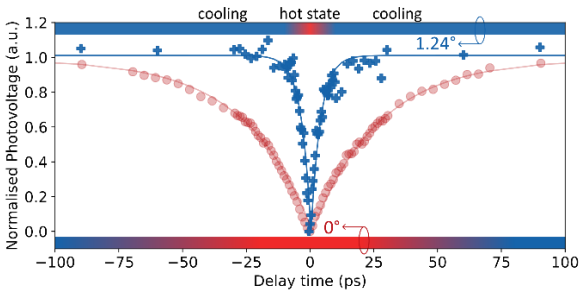

Figure 2: Controlling the time delay between two ultrafast pulses reveals the hot carrier cooling dynamics. At low temperatures, these are significantly faster in the case of MATBG (1.24°) than non-twisted BLG (0°).

References

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