Moiré-Engineered Graphene Systems for FIR and MM-Wave Detection

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Sensitive detection of far-infrared (FIR) and millimetre-wave (MM-wave) radiation is central to astronomy, spectroscopy, and emerging quantum technologies [1]. Graphene offers unique advantages for long-wavelength detection, including broadband absorption, ultrafast carrier dynamics, and low electronic heat capacity [2]; yet detectors based on pristine graphene typically suffer from limited sensitivity. This talk presents two graphene-based detector platforms in which moiré engineering overcomes this limitation. First, a bias-free photo-thermoelectric (PTE) detector based on graphene and bilayer graphene/hexagonal boron nitride moiré superlattices is discussed. Tuning the Fermi level to van Hove singularities near secondary neutrality points strongly enhances the terahertz PTE response, while a modest magnetic field further amplifies the signal via a THz-driven Nernst effect, thereby boosting the overall device sensitivity. Second, the bolometric performance of magic-angle twisted bilayer graphene (MATBG) is examined. This system hosts a plethora of correlated states that are exceptionally sensitive to electronic temperature. In particular, we show that irradiation-induced melting of the correlated insulator enables highly sensitive bolometric detection, supported by fast energy relaxation in flat bands [3]. Together, these results establish graphene-based moiré systems as a powerful and versatile platform for long-wavelength radiation detection.

References

[1] Li, Jing, et al., Research 8 (2025) 0586.
[2] Aamir, Mohammed Ali, et al., Nano Letters. 21.12 (2021) 5330-5337.
[3] Mehew, Jake Dudley, et al., Science advances, 10.6 (2024) eadj136.

Figures

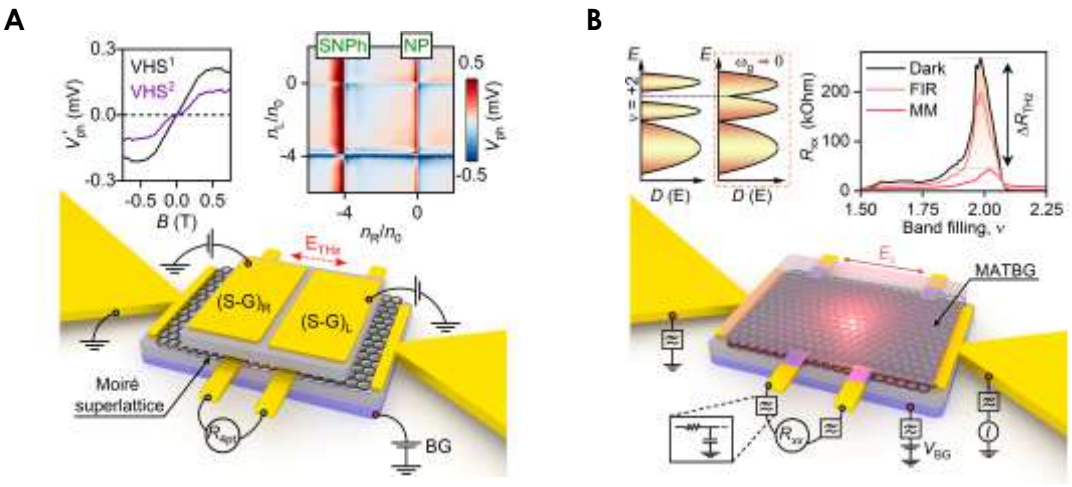

Figure 1: Graphical abstracts illustrating FIR and MM-wave detection techniques based on moire-engineered graphene. **A**. Moiré-based PTE detection. **B**. MATBG correlated insulator bolometer.