Twist-Angle-Controlled Anomalous Gating in Bilayer Graphene/BN Heterostructures

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Anomalous gating effects-such as gate ineffectiveness and pronounced hysteresis-have been observed in graphene-based systems encapsulated in boron nitride (BN) and linked to a possible ferroelectric state. However, their origin, stability, and reproducibility remain under debate. Here, we present charge transport experiments in dual-gated, dynamically rotatable van der Waals heterostructures based on bilayer graphene encapsulated in BN. Remarkably, the angular degree of freedom acts as an ON/OFF switch for the anomalous gating response. We show that the angular alignment between the two BN layers -- not the presence of a moiré superlattice with graphene -- is the key parameter governing these effects. The relevant alignment between the two BN layers, to observe the anomalous gating effect at room temperature, lies between 15 deg and 45 deg, with no evidence of the expected 60 deg periodicity. Both gate ineffectiveness and hysteresis are highly sensitive to small angular changes, which we classify into three distinct regimes. Our results clarify the conditions necessary to reproduce these phenomena and pave the way for theoretical investigation of their microscopic origins.