Gate-Tunable Fractional Chern Insulators in Moiré Superlattices

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In heterostructures with three mutually aligned layers, two distinct stacking configurations can exist, analogous to the Bernal and rhombohedral phases of graphite. To date, switching between them has been achieved only by mechanical means on exposed flakes, for instance through an AFM or STM tip with no equivalent in encapsulated electronic devices.

Here we show that in a doubly aligned hBN/graphene/hBN system the two configurations can be switched simply by applying a gate voltage. The two states adopt different structural reconstructions, triangular and hexagonal, and consequently display distinct electronic behaviour. In one stacking, low-field magnetotransport reveals the opening of an incipient topological energy gap at fractional filling factors - an incipient fractional Chern insulator - whereas this feature is absent in the other. A similar phenomenon also appears in single-aligned graphene–hBN superlattices, marking the first observation within genuinely dispersive monolayer graphene bands. We attribute this to the interplay between moiré potentials and weak magnetic fields, where van Hove singularities create extended open orbits that quench the kinetic energy of charge carriers in magnetic fields. Ultimately, this work demonstrates on-demand electrical control over structural phases and the dynamic emergence of exotic topological states.

Figures

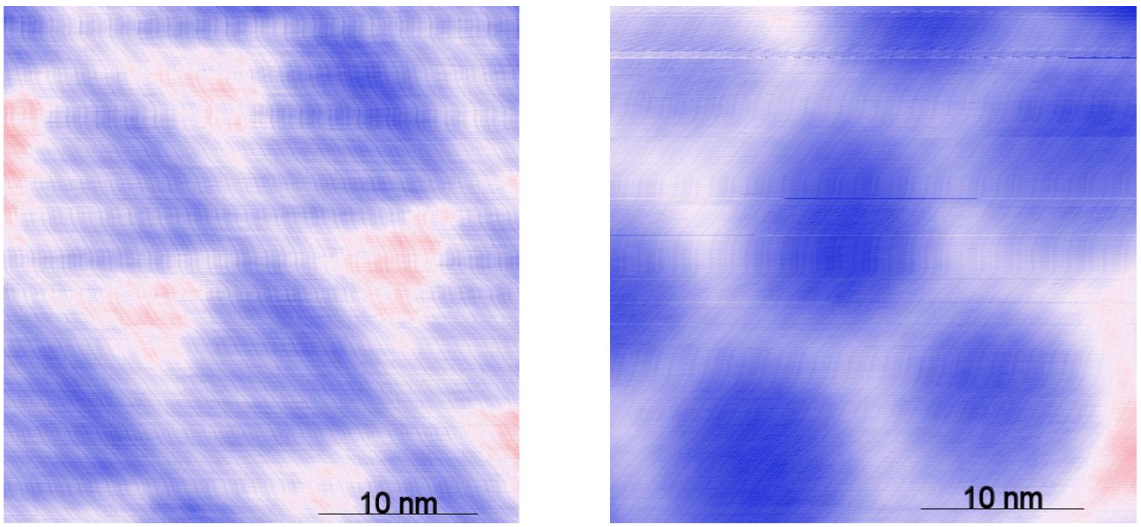

Figure 1: *STM images of the two stacking configurations, exhibiting triangular and hexagonal reconstructions respectively.*