Layertronics of valley electrons in twisted bilayers

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Long wavelength moiré pattern in van der Waals stacked 2D materials has provided a powerful tool towards designer quantum materials that can extend the exotic properties of the building blocks. For band edge carriers located at the Brillouin zone corners (valleys), the interlayer coupling features sensitive dependence on the atomic registry between the constituting layers. In twisted TMDs homobilayers, such coupling in the moiré pattern manifests itself as a location-dependent Zeeman field acting on the active layer pseudospin. Berry curvature arising from such layer pseudospin texture corresponds to a pseudo-magnetic field that realizes fluxed honeycomb superlattices with layer-sublattice locking [1,2], underlying the recently observed gate-programmable magnetic states [3] and quantum anomalous Hall effect [4]. Ultrafast dynamic modulation of the layer pseudospin texture by bias pulse or Terahertz field further introduces pseudo-electric field for spin/valley manipulation [5]. In moiré patterns distorted by non-uniform strains, the interplay of moiré interlayer coupling and strain together leads to non-Abelian Berry phase effects [6]. I will also discuss novel Hall effects of band geometric origin arising from the layer pseudospin structures in twisted homobilayers [7,8].

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