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Realization of unusual electronic states via strain engineering

The ability to engineer the band structure and, more strikingly, to access new exotic phase of matter has been the cornerstone of the advance of science and technology. In this talk, I will present how we utilize the lithographically-patterned strain engineering to modify the band structures and consequently the electronic properties of van der Waals materials. We use this approach to realize an unusual electronic state in a corrugated bilayer graphene system in which strain and interlayer interactions are specially engineered to induce pseudo-magnetic fields and break the spatial inversion symmetry [1]. This creates tilted mini-Dirac cones with non-trivial and anisotropic energy dispersion and the momentum-space Berry curvature dipole, thereby giving rise to the nonlinear anomalous Hall effect [2-4] and a new type of planar Hall effect, namely, the pseudo-planar Hall effect without breaking the time reversal symmetry. Many interesting phenomena have also been found in this system due to the interplay between the pseudo-magnetic fields and interlayer interaction. For example, the anisotropy axis of the pseudo-planar Hall effect (i.e., pseudo-magnetoresistance) can be rotated by simply tuning the Fermi energy.

We have used both theoretical and experimental approaches to investigate this simple, but novel, artificial material system and the physics behind it, which will be discussed in details during the talk. In short, this artificial material system provides a unique platform to study novel geometrical and/or topological quantum phenomena when both the real-space and momentum-space pseudo-magnetic fields (Berry curvatures) exist. Moreover, the capability to artificially create nontrivial band structure and Berry curvatures from conventional two-dimensional materials such as graphene via lithographically-patterned lattice deformation provides an alternative route to exotic phases of matter on par with the discovery of novel materials or engineering the band structure with twistronics.

References

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