Designing Moiré Patterns by Strain

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Experiments conducted on two-dimensional twisted materials have revealed a plethora of moiré patterns with different forms and shapes. Typically, the formation of these patterns is attributed to the presence of small strains in the samples, which usually arise during the fabrication process. In this work, we find that the superlattice structure of such systems critically depends on the interplay between twist and strain. Specifically, for systems composed of honeycomb lattices, we demonstrate that this interplay can lead to the formation of almost any moiré geometry, even when each lattice experiences only slight distortion. Consequently, we illustrate that under strain, the moiré Brillouin zone assumes the form of a primitive cell that adjusts according to the geometry of the strained moiré vectors. Furthermore, we elucidate the formation of nearly perfect one-dimensional moiré patterns in twisted bilayer systems. As a criterion for such a transition, we establish a simple relationship between twist, strain, and the material-specific Poisson ratio. This induced one-dimensional behavior is characterized by two periodicities, which are typically incommensurate. Our results provide explanations for the complex patterns of one-dimensional channels observed in low angle twisted bilayer graphene systems and twisted bilayer dichalcogenides. We also identify the conditions that allows the formation of hexagonal moiré patterns arising solely from shear or biaxial strain, thus presenting the possibility of engineering moiré patterns exclusively through strain. Moreover, we investigate the electronic properties within these moiré patterns and observe that strain tends to suppress the formation of flat moiré bands, even in strain-induced hexagonal patterns analogous to those obtained through only twist.