

Towards van der Waals topological electronics: Twisting, gating and strain engineering of topological and transport properties of graphene-based heterostructures

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Van der Waals (vdW) crystals provide a unique platform for investigating a wide range of topological and magnetic states. By stacking various two-dimensional (2D) crystals, one can engineer novel heterostructures that exhibit various proximity effects and emergent magnetic and topological phases. Importantly, the transport properties of vdW structures can be controlled by electrical gating, mechanical strain, and the twist angle between layers.

I will focus on specific vdW structures consisting of graphene and other 2D crystals, such as transition metal halides and transition metal dichalcogenides. In the first part of the talk, I will review the most important concepts of vdW structures with highly tunable electronic properties by means of external fields, mechanical forces, twist-angle between graphene and other vdW crystals [1-3]. In the second part of my talk, I will present some of our recent results concerning graphene on transition metal trihalides CrX_3 ($X = \text{I}, \text{Cl}, \text{Br}$) [4,5] and graphene on semiconducting transition metal dichalcogenides (TMDCs) [6,7]. I will show, among others, that the twist angle leads to a shift of the graphene states into the energy band gap of CrI_3 2D crystal, whereas by tuning the strain in the system one can control the topological and valley-contrasting transport properties of the structures. The presented results can serve as a prototype for highly tunable devices in new topological electronics based on van der Waals materials.

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