Steering the Current Flow in Twisted Bilayer Graphene

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A nanoelectronic device made of twisted bilayer graphene (TBLG) is proposed to steer the direction of the current flow. The ballistic electron current, injected at one edge of the bottom layer, can be guided predominantly to one of the lateral edges of the top layer. The current is steered to the opposite lateral edge, if either the twist angle is reversed or the electrons are injected in the valence band instead of the conduction band, making it possible to control the current flow by electric gates. When both graphene layers are aligned, the current passes straight through the system without changing its initial direction. The observed steering angle exceeds well the twist angle and emerges for a broad range of experimentally accessible parameters. It is explained by the twist angle and the trigonal shape of the energy bands beyond the van Hove singularity due to the Moiré interference pattern. As the shape of the energy bands depends on the valley degree of freedom, the steered current is partially valley polarized. Our findings show how to control and manipulate the current flow in TBLG. Technologically, they are of relevance for applications in twistronics and valleytronics.

Figures

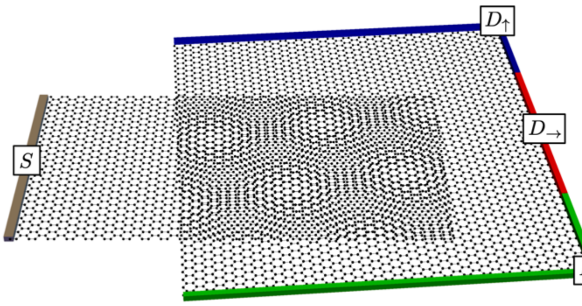

Figure 1: Schematic representation of the studied TBLG device. It consists of two stacked graphene nanoribbons, where the upper layer is twisted by the angle θ with respect to the lower one that remains fixed. Electrons are injected through the source contact at the left edge of the bottom layer. They pass through the twisted bilayer region and are detected by three drain contacts at the edges of the top layer (blue, red, and green bars).

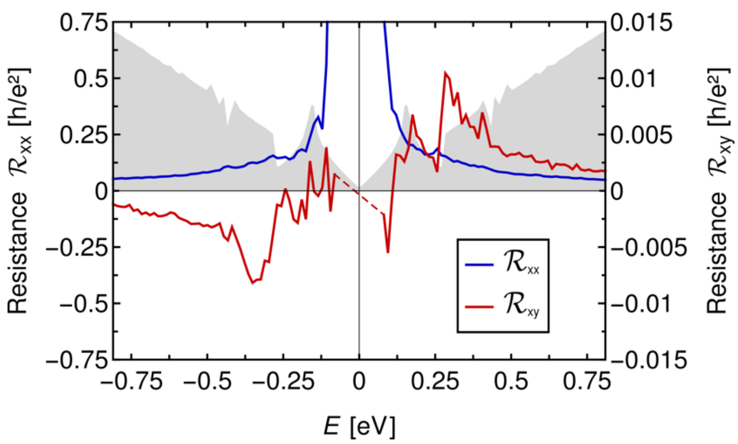

Figure 2: Longitudinal resistance R_{xx} (blue curve) and Hall resistance R_{xy} (red curve) as a function of energy for the TBLG device at a twist angle of θ=2.9 degree. The steering of the current flow to one of the lateral edges generates a non-local Hall resistance. The DOS (in arbitrary units) is indicated by the gray color shading.

References

[1] J. A. Sánchez-Sánchez, M. Navarro-Espino, Y. Betancur-Ocampo, J. E. Barrios-Vargas, T. Stegmann, J. Phys. Mater. 5: 024003 (2022).