Topological origin of subgap conductance in insulating bilayer graphene

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The edges of graphene-based systems possess unusual electronic properties, originating from the non-trivial topological structure associated to the pseudo-spinorial character of the electron wave-functions. These properties, which have no analogue for electrons described by the Schrodinger equation in conventional systems, have led to the prediction of many striking phenomena, such as gate-tunable ferromagnetism and valley-selective transport [1-3]. In most cases, however, the predicted phenomena are not expected to survive the influence of the strong structural and chemical disorder that unavoidably affects the edges of real graphene devices. Here, we present a theoretical investigation of the intrinsic low-energy states at the edges of electrostatically gapped bilayer graphene (BLG), and find that the contribution of edge modes to the linear conductance of realistic devices remains sizable even for highly imperfect edges (see Figure 1 below). This contribution can dominate over that of the bulk for sufficiently clean devices, such as those based on suspended BLG samples. Our results illustrate the robustness of phenomena whose origin is rooted in the topology of the electronic band-structure, even in the absence of specific protection mechanisms.

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References

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Figures

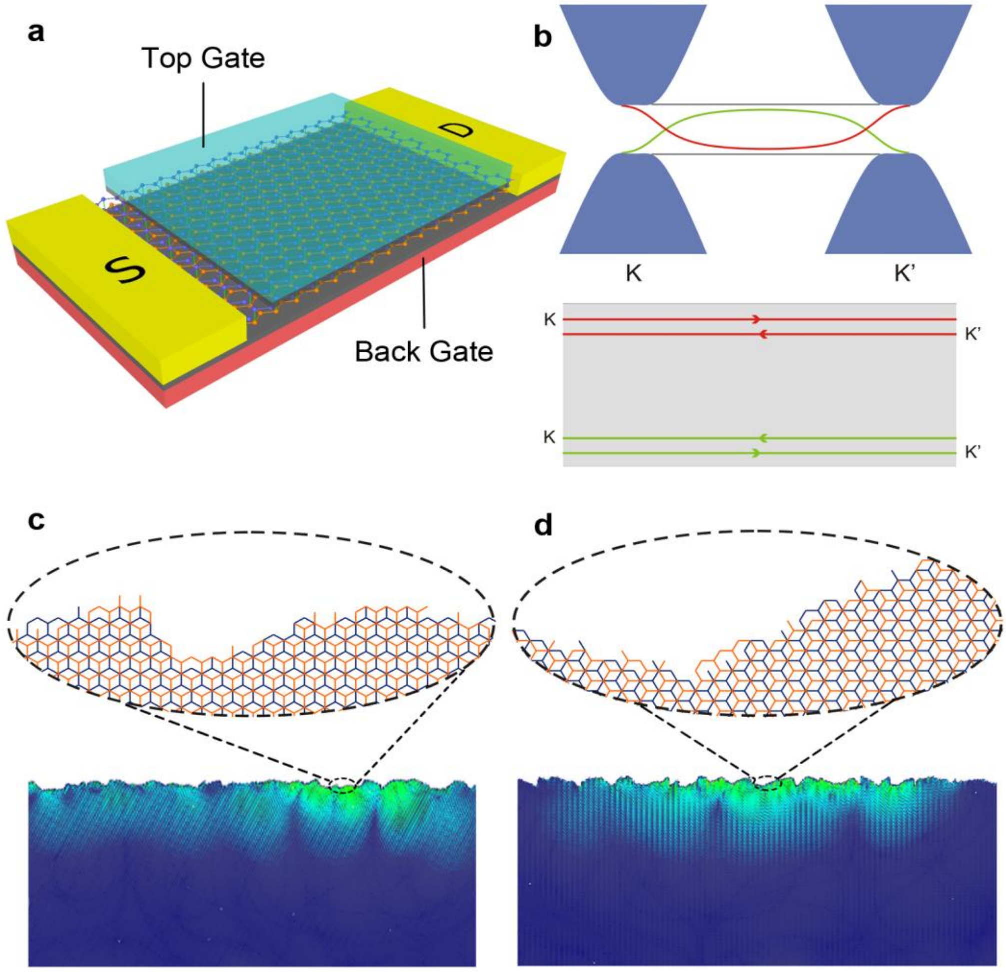

Figure 1: ***Edge states in gapped BLG.*** *Panel* ***a*** *shows a schematic view of the device. By controlling the gate voltages applied to the top and back gates separately, an energy gap in the bulk of BLG can be opened and tuned, while maintaining the Fermi energy in its center. Panel* ***b*** *shows the dispersion of the sub-gap edge states in gapped BLG at a zig-zag edge. At both edges, the states are helical with respect to the valley degree of freedom, with states in opposite valleys propagating in opposite directions. This conclusion holds for periodic edges of rather general shape (i.e. not only for zig-zag), but it does not hold for the ideal armchair edge, where two valleys (K and K') are fully coupled and no sub-gap edge states are present. Panels* ***c*** *and* ***d*** *show the typical probability density near zero energy for strongly disordered BLG zig-zag (****c****) or armchair (****d****) edges. In the presence of realistically strong disorder, the existence of such edge states -- and their long localization length -- is a universal property of gapped BLG (the panels correspond to a BLG that is approximately 100 nm long).*