Valley filtering and electronic optics in polycrystalline graphene systems

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Abstract

Due to its peculiar electronic structure, graphene has been shown to be an ideal platform for exploring novel transport phenomena [1,2], e.g., Klein tunneling, anomalous quantum Hall effect, valley-dependent transport, optical-like behaviors of charge carriers, etc. Among them, two phenomena, valley-dependent transport and optical like behaviors, have attracted a great amount of attention from the scientific community because they are essential ingredients for applications in valleytronics and electronic optics devices [2], respectively. Valleytronics lies in exploiting the manipulation of charge carriers in two valleys of graphene to encode data, i.e., to represent the zeroes and ones in digital computing. Electronic optics exploits the optical-like behaviors of charge carriers in graphene to design novel quantum devices with a variety of interference and diffraction effects. In this work [3], we theoretically proposed a new and practical scheme to manipulate simultaneously highly valley-polarized currents and optical-like behaviors of charge carriers in graphene (see Fig.1). The approach lies in the use of polycrystalline graphene systems containing two misoriented domains separated by a grain boundary that is composed of a periodic array of dislocations. In principle, these two domains exhibit different electronic structures, especially when the system is strained. We show that such a discrepancy can manifest itself in a strong breaking of the inversion symmetry of the system, and hence a high valley polarization can be achieved. Additionally, in analogy to optical systems, these domains act as different media for electron waves, leading to optical-like behaviors of charge transport through the system.

References

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Figures

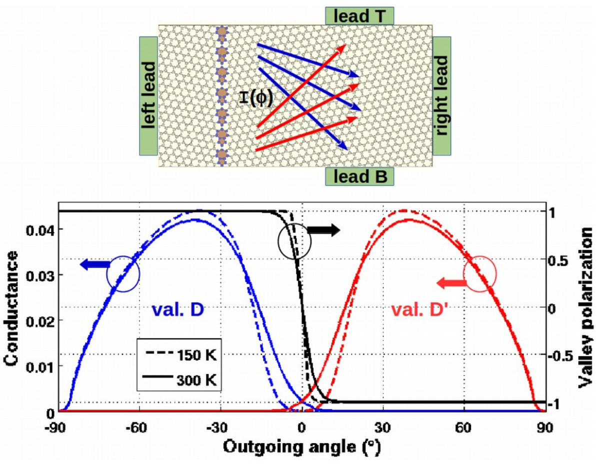

Fig. 1: (a) Schematic of considered graphene systems where the charge transport across the grain boundary is calculated. (b) Obtained directional currents and valley polarization when a uniaxial strain of 3% is applied.