Tunable Dichroism in One-dimensional Graphene Superlattices

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Abstract

One-dimensional graphene superlattices are periodic potentials on graphene spatially modulated along one direction and constant in the perpendicular direction. These systems can be constructed by the positioning of adatoms on graphene [1], applying local top-gate voltages [2-3], or by placing graphene on a substrate with nanometer scale periodicity [4-6]. The Dirac fermion nature of low energy quasiparticles in graphene is expected to give rise to unusual transport phenomena, such as the proposed supercollimation effect [7-9], in which electron wavepackets are predicted to exhibit dissipationless transport along the modulated direction of the graphene superlattice.

In this contribution, we demonstrate theoretically that the optical absorption spectrum provides an alternative route for observing the unusual physics of electrons in graphene superlattices. We show that graphene superlattices exhibit a tunable dichroism effect – different absorbance for different linear polarizations of light (Figure 1). This result is reminiscent of the highly anisotropic transport properties of graphene superlattices at low energies. In addition, we show that the absorption spectrum at optical energy scales contains certain easily identifiable characteristic features. These results enable the observation of graphene superlattice physics via optical means, as well as increasing the range of technological applications of graphene superlattices to the optical domain.

We analyze separately periodic graphene superlattices and disordered graphene superlattices. In the former, absorption is increased in the modulated direction and decreased in the constant direction at low frequencies. At higher frequencies, van Hove singularities affect the absorption of light polarized along the constant direction but not the modulated direction, in sharp contrast to the case of the two dimensional electron gas in a periodic potential. For disordered graphene superlattices, we show that the low frequency absorption spectrum behaves in the same way as the periodic case, regardless of the form of the disorder.

References

Figure 1: Absorbance, relative to pristine graphene, of graphene superlattices for light linearly polarized in the modulated (red) and constant (blue) directions.