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Optical properties of single- and few-layer graphene: the role of interlayer and many-body interactions

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Graphene, a single layer of carbon atoms, has attracted much attention in the past few years because of its unique 2D structure and linear dispersion relation near the K-point of the Brillouin zone. Optical spectroscopy provides a powerful tool for probing the electronic structure and interactions in graphene. In this talk we will discuss two types of interactions that affect the optical response – those arising from interlayer coupling of electrons and those arising from many-body effects. The possibility of altering the low-energy band structure of graphene through the interlayer interactions in few-layer graphene (FLG) was recognized theoretically several years ago and was demonstrated experimentally recently by infrared absorption spectroscopy. Two distinct classes of IR absorption spectra for crystalline samples of the same number of layers, but different stacking order, were also observed. These findings demonstrate the pronounced effect of interlayer interaction and stacking order on the electronic structure of FLG. Furthermore, significant many-body effects are revealed in the optical conductivity spectra. These were manifested as excitonic modifications to optical absorption near the saddle- point singularities. The strong electron-hole interactions produce an asymmetric resonance, significantly red-shifted from the value predicted by ab-initio GW calculations for the band- to-band transitions. Our experiment also showed a weak dependence of the excitonic resonance in FLG on layer thickness. This result reflects the effective cancellation of the increasingly screened repulsive electron-electron and attractive electron-hole interactions.