Spectroscopy for the Masses (of Carbon Atoms)

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When valence and conduction band energies are linear in momentum or nearly so, as in graphene near the K point, qualitatively new things happen to absorption, pulse-probe emission, and Raman spectroscopy. A transition for a photon of fixed frequency “slides” and has amplitude for producing correlated holes and electrons up and down the valence and conduction bands, along with a phonon, all resonant with the photon. Normally the phonon processes are minor compared to elastic absorption and emission, but the inelastic sliding process can overwhelm by sheer numbers of possible transitions. The bright Raman features and other aspects of Raman spectroscopy are thus explained, the excess absorption in the UV is quantitatively explained, and the hot thermal emission after pulsed absorption is shown to be a result of the instantaneous production of phonons and many electron-hole pairs up and down the Dirac cones (forming an exciton), not e-e scattering and relaxation.