Resonance Raman studies in monolayer and bilayer graphene

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Resonance Raman spectroscopy is a very useful tool to investigate electrons and phonons near the Dirac point of graphene, due to the specific double resonance (DR) Raman process that occur in these materials. By changing the energy of the incident excitation laser, it is possible to probe different points within the interior of its Brillouin zone. We have performed investigations of monolayer and bilayer graphene using this methodology and we were able to determine the tight-binding parameters that describe the electronic dispersions of these materials. Our results reveal a significant asymmetry between the electronic dispersion in the valence and conduction bands of bilayer graphene. The special process of electron-phonon interaction, that renormalizes the phonon energy giving rise to the Kohn anomaly, was investigated by gated experiments where the position of the Fermi level can be changed. In the case of a back gated bilayer graphene the changes in the Fermi level induced by charge transfer splits the Raman G band, hardening its higher component and softening the lower one. These two components are associated with the symmetric (S) and antisymmetric vibration (AS) of the atoms in the two layers, the later one becoming Raman active due to inversion symmetry breaking. The phonon hardening and softening are explained by considering the selective coupling of the S and AS phonons with interband and intraband electron-hole pairs.