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Low energy electronic excitations and magneto-phonon resonance in graphite and graphene

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Recently, much attention has been paid to electron-phonon coupling in graphene. The zone-centre, doubly degenerate E2g phonon, strongly interacts with electrons, resulting in renormalization of phonon frequencies and line broadening. These phenomena are predicted to be tunable by electric and magnetic fields, through Fermi-energy shifts and Landau quantization, respectively. In particular, the Raman G peak is predicted to exhibit magneto-phonon resonance manifested as strong anti-crossings when the E2g phonon energy matches the separation of two Landau levels (LLs) [1,2].

Here, we report high-field magneto-Raman measurements of graphene and graphite in magnetic fields up to 45 T. In single-layer graphene, the Raman G peak exhibits clear splitting at approximately 27 T, which we attribute to the fundamental magneto-phonon resonance (MPR) associated with (0,1) inter-LL transitions. The coupled electron-phonon modes demonstrate characteristic anti-crossing behavior allowing for an accurate determination of the electron-phonon coupling strength in graphene [3]. Circularly polarized Raman scattering measurements allows revealing unique polarization- and filling-factor dependence of MPR in graphene, predicted in Ref.[2].

Graphene's parent compound, graphite is expected to exhibit even richer carrier-phonon coupling phenomena. Graphite, a bulk semimetal containing both electrons and holes even at zero temperature, has a linear ("massless") dispersion for the hole pocket around the H-point of the Brillouin Zone and a parabolic ("massive") dispersion for the electron pocket around the K-point. We demonstrate a complex picture of MPR effects caused by coupling of the E2g phonon to both H-point (SLG-like) and K-point (BLG-like) inter-LL excitations and extract the strengths of electron-phonon coupling [4].

References:

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