Gate Dependent Magnetophonon Resonance in Graphene

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The magneto-phonon resonance (MPR) effect is observed in semiconductors when the optical phonon energy coincides with the separation of two Landau levels (LLs). In graphene, the MPR can be described as a resonant mixing of inter-LL excitations and zone-center E_{2g} phonons into a combined mode, leading to a splitting proportional to the electron-phonon coupling [2],[3]. As a result, the Raman G-peak is expected to exhibit a series of filling-factor-dependent, multi-component anti-crossing structures as a function of applied magnetic field. Recently, we performed a polarization-resolved high-field magneto-Raman spectroscopy study of ungated, chemically doped graphene and identified three distinct types of G peak magnetic-field dependencies, providing a comprehensive experimental evidence of the MPR effect in graphene [1].

Here, we report a Raman spectroscopy study of MPR in gated single layer graphene in magnetic field up to 18T, demonstrating continuous tuning of the MPR lineshape by varying the carrier density. Tuning the gate voltage from -70V to 70V at constant magnetic field, we observe the progressive development of the low-field anticrossing branch corresponding to the fundamental MPR with $-1 \rightarrow 0$ and $0 \rightarrow 1$ inter-LL transitions, expected at approximately 25-30T. As the Fermi energy crosses the n=0 LL, a complex structure E_F dependent appear in the Raman spectra. This is because a higher (lower) occupancy of the n=0 LL reduces (enhances) the oscillator strength of the $0 \rightarrow 1$ transition due to the availability of filled and empty states in the involved LLs, whereas the same change in the electron density has the opposite effect on $-1 \rightarrow 0$ transition.

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