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Chiral Enhanced Phonon Excitations in Inelastic Electron Tunneling Spectroscopy of Graphene[1]

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In graphene, phonons are important agents for a wide range of phenomena; they mediate relaxation rates for hot carriers, they lead to van-Hove singularities, and they induce a renormalization of the Fermi velocity due to electron-phonon coupling and many-body interactions [1]. The previous observations of phonons [2-4] by inelastic electron tunneling spectroscopy (IETS) have been expandable in terms of detail and resolution, due to weak signals and other spectral features which inhibit a clear distinction between phonons and miscellaneous excitations. We find that utilizing a back gated graphene device, where the graphene charge carrier density can be varied in magnitude and sign, allows all the critical point graphene phonons with large density of states to be sampled by IETS with the scanning tunneling microscope, and in good agreement with density functional calculations. In addition, a strong overtone excitation at 360 meV is observed. Quite surprisingly, we observe all the graphene excitations are resonantly enhanced when the charge carrier type is switched, indicating that this amplification occurs whenever the inelastic transition allows a change in the graphene chirality. The chiral enhancement is observed to follow a linear trend with energy and reaches almost an order of magnitude for the highest transition. Our averaging technique suppresses charge carrier dependent excitations, while it improves the signal for inelastic transitions. This approach can be employed as a guide in advanced studies that are relying on gate tunable graphene devices, such as for the detection of spin, vibrational, or rotational excitations in adsorbates.

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