Frequency-Dependent Weak Localization and Antilocalization in Graphene Measured at Sub-THz Frequencies

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Weak localization arises at low temperatures due to coherent electron scattering with impurities and the constructive interference of self-crossing electron trajectories, which leads to measurable increase in the material's resistivity. In graphene at temperatures around 1 K, the characteristic time of dephasing scattering events that lead to decoherence is of the order of τ_φ ~ 10 ps, or equivalently, a dephasing scattering rate of τ_φ ~ 100 GHz. By performing AC magnetotransport measurements on graphene using microwaves in the frequency range 90-350 GHz, we demonstrate numerous and continuous transitions between localization to antilocalization behavior induced exclusively by the microwaves. We argue that as the microwave frequency is comparable to the dephasing scattering rate, it plays a role in the decoherence dynamics that is not explained by extending the current theory of weak localization in graphene to the AC limit. The presented data uses an advanced frequency and field dependence mapping of graphene samples, showing how advancing in spectroscopic methods can unveil yet new phenomena in this intriguing and extensively studied material.

Figures

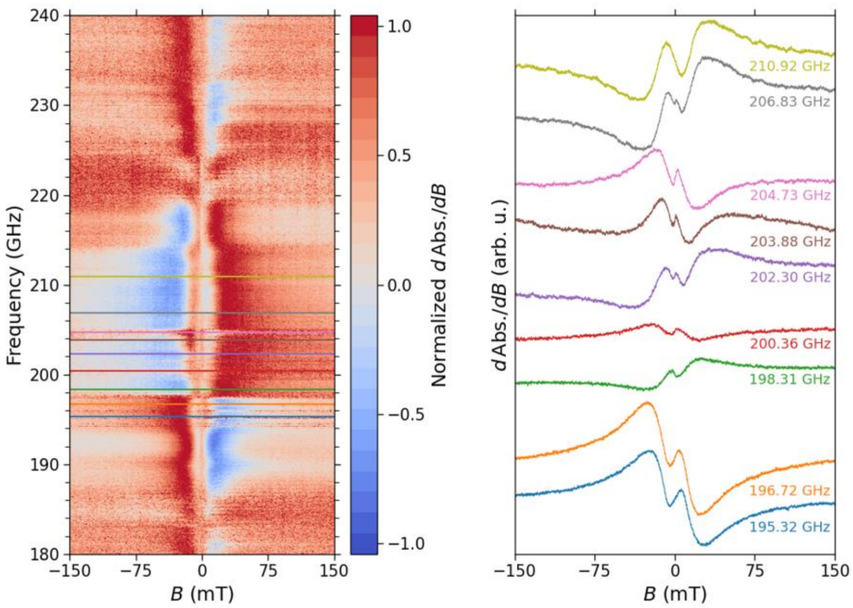

Figure 1: Microwave absorption experiments on CVD graphene exhibiting a frequency dependence of the weak localization. The plots display the derivative of the microwave absorption with respect to the magnetic field (*d* Abs./*dB*), which is proportional to $d\sigma_{xx}(\omega)/dB$, with $\sigma_{xx}(\omega)$ the longitudinal optical conductivity at frequency ω. (left) Continuous measurement of *d* Abs./*dB* as a function of microwave frequency and mangetic field. The horizontal coloured lines are the frequencies plotted on the right figure. (right) Derivative of microwave absorption as a function of the magnetic field at selected frequencies.