Magneto-Optical Study of Graphene and Bilayer Graphene

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Introduction

The massless Dirac quasiparticles in graphene give rise to a broad range of new physics. In particular, many novel phenomena are predicted due to many body interactions in strong magnetic fields. Here, we propose to carry out magneto-optical measurements on high mobility single and bilayer graphene to explore the Landau level (LL) physics and electron-electron interactions in these materials.

Experimental

In our experiments, graphene samples were grown by chemical vapor deposition (CVD) and then transferred to silicon substrates. IR transmission spectra were measured using an IR spectrometer at SCM3 and cell 8 of NHMFL in fields up to 35T.

Results and Discussion

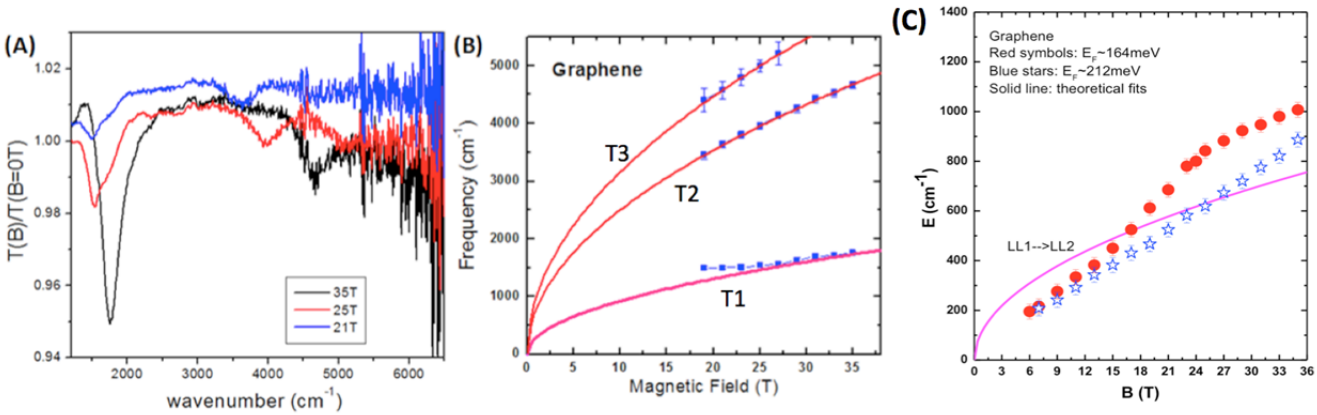

Figure 1: (A), The mid-IR transmission ratio spectra T(B)/T(B=0) of graphene in three magnetic fields. (B), Observed absorption peaks (dips in transmission) and fits (solid lines). (C), Observed transition peaks at low energy and the theoretical LL1→LL2 transition (solid line).

Representative data in magnetic fields are shown in figure 1A. Three absorption peaks (dips in transmission spectra) were observed. The observed peaks can be assigned to the inter-LL transitions of T1: n=0 (n=-1)→ n=1 (n=0), T2: n=-1 (n=-2)→ n=2 (n=1), and T3: n=-2 (n=-3)→ n=3 (n=2). Interestingly, fitting the observed transition energies with theoretical LL formula (figure 1B) yields Fermi velocity $v_F \approx 1 * 10^6 \mathrm{m/s}$ for transition T1 and $v_F \approx 1.1 * 10^6 \mathrm{m/s}$ for transitions T2 and T3, resulting in higher $v_F$values for T2 and T3 than that for T1. This result is consistent with previous observation of strong Fermi velocity renormalization for high-energy LL transitions in exfoliated graphene, which can be attributed to many-body effects in high field [Phys. Rev. Lett. 98, 197403 (2007)]. Moreover, we also observed a transition peak at energy lower than T1 and in the vicinity of LL1→ LL2 transition (figure 1C). This transition shows significantly higher energy (30%) than the values expected within the single particle picture for the LL1→ LL2 transition. The data shown in figure 1C is **the first observation** of substantial deviation of the LL1→ LL2 transition from single particle picture with a “kink” in the magnetic field dependence, which suggests strong many body interactions in magnetic fields.

Our measurements on bilayer graphene are in progress.

Conclusions

Our magneto-optical experiments on graphene revealed strong renormalization of Landau levels in high magnetic fields, which will provide new insights into many body interactions in graphene.

Acknowledgements

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References

A paper is being written on these results.