IR Study of Magneto-Plasmons in Grapheme in the Ultra-Quantum Regime

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Introduction

Plasmons -- collective oscillations of charge carriers -- in graphene have attracted a lot of interest due to their rich physics and great potential for applications. Magneto-plasmons are elementary electron-hole excitations in magnetic fields, which are important for understanding the many-body physics in the quantum regime. Here, we explore magneto-plasmons in graphene from optical measurements in high magnetic fields.

Experimental

Graphene samples were grown by chemical vapor deposition (CVD) and then transferred to proper substrates. We used electron beam lithography and oxygen plasma etching to define graphene disks. The pattered areas were always 3.6 mm wide by 3.6 mm long. IR transmission spectra were measured at cell 8 and SCM3 of NHMFL.

Results and Discussion

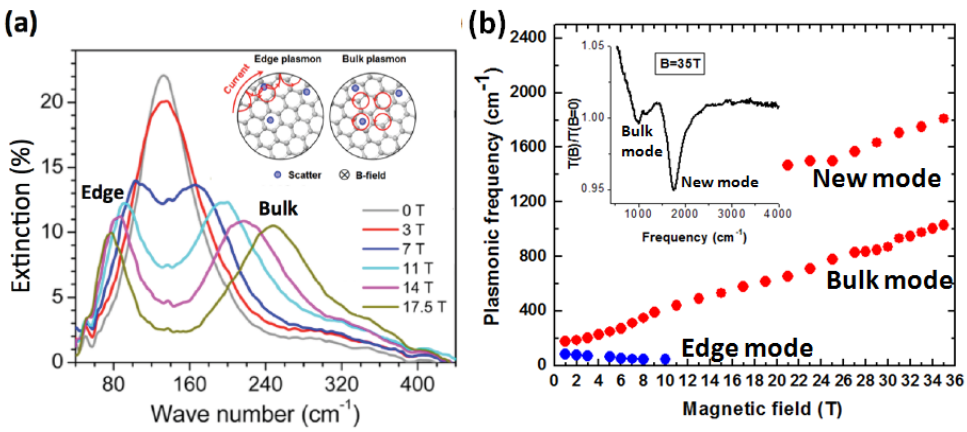

Figure 1: (a): Extinction in transmission in graphene disks in zero and low magnetic fields. Inset: Illustration of the charged carrier motion for edge and bulk modes. (b) The energy of absorption peaks of graphene disks in field up to 35T. Inset: transmission ratio T(B)/T(B=0) data of a graphene disk sample at 35T.

We measured the IR transmission spectra of plasmons in graphene disk arrays in high magnetic field [1, 2]. The plasmon resonance peak in zero field splits into two modes in magnetic field: edge and bulk magneto-plasmon modes, as shown in figure 1a. At very high field above 18T, a new magneto-plasmon mode besides the edge and bulk plasmon modes was observed (figure 1b). The energy of the new mode in graphene disks is close to but nevertheless shows pronounced blue shift with respect to inter- Landau level (LL) transition LL0→LL1 of graphene due to coupling to excitations with finite wave-vector q~1/d, where d is the diameter of the disks. This new observation clearly shows that we observed the magneto-plasmon mode in the quantum regime associated with LL0→LL1. More measurements are in progress and a manuscript is in preparation on these results.

Conclusions

We observed magneto-plasmon modes associated with Landau levels in the quantum regime, which will allow us to explore the electron-hole excitations in magnetic fields in graphene, which are of fundamental importance.

Acknowledgements

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References

[1] Yan, H., et al, Nano Lett. 12, 3766 (2012).
[2] Yan, H., et al, New Journal of Physics, 14, 125001 (2012).