Infrared Study of Magneto-Plasmons in Graphene

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Introduction

Recently, plasmons -- collective oscillations of charge carriers -- in graphene have attracted a lot of interest due to their rich physics and great potential for applications. In particular, magneto-plasmons are elementary electron-hole excitations between Landau levels (LLs) in magnetic fields, which are important for understanding the many-body physics in graphene in the quantum regime.

Experimental

In our experiments, graphene samples were grown by chemical vapor deposition (CVD) and then transferred to proper substrates. Electron beam lithography and oxygen plasma etching were used to define graphene disks [1,2]. IR transmission spectra were measured using a Fourier transform spectrometer at cell 8 and SCM3.

Results and Discussion

Infrared spectra showed that the plasmon resonance peak in zero field splits into two modes in magnetic field below 18T: edge and bulk magneto-plasmon modes (figure 1a). The collective charged carrier motion for the edge and bulk modes are shown in the inset of figure 1a. At very high field above 20T, a new magneto-plasmon mode besides the edge and bulk plasmon modes was observed, as depicted in figure 1b, c. The energy of the new mode in graphene disks shows pronounced blue shift with respect to inter- Landau level (LL) transition LL0→ LL1 of pristine graphene due to coupling to electron-hole excitations (magneto-plasmons) with finite wave-vector q~1/d, where d is the diameter of the disks.

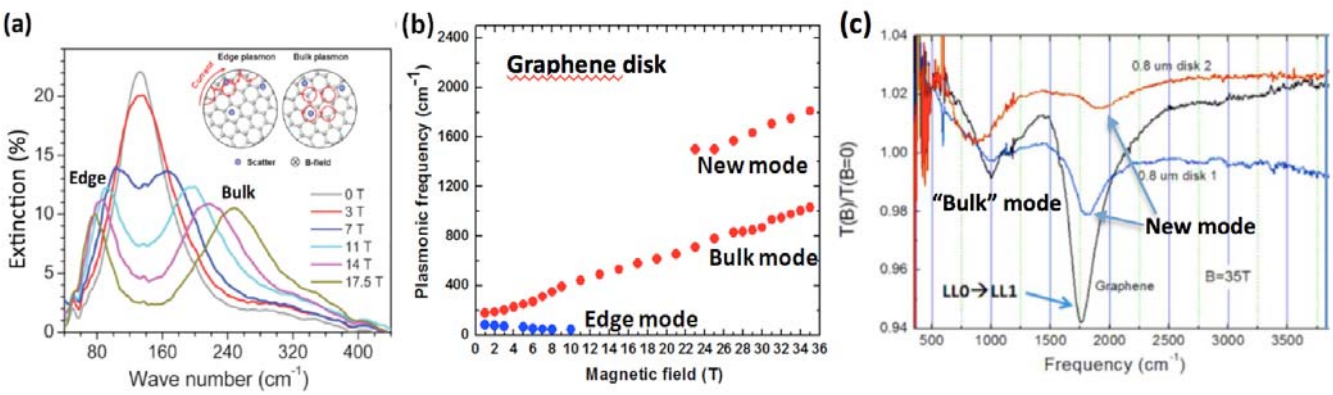

Figure 1: (a): Extinction in transmission of graphene disks in zero and low magnetic fields. Only two modes, edge and bulk magneto-plasmons, were observed below 18T. Inset: Illustration of the charged carrier motion for edge and bulk modes. (b): The energy of absorption peaks of graphene disks in field up to 35T. Besides the bulk and edge modes, a new magneto-plasmon mode was observed above 20T. (c): Transmission ratio T(B)/T(B=0) data of two 0.8 micron graphene disk samples and a pristine graphene sample at 35T.

Conclusions

Our study revealed a new mode related to electron-hole excitations between LLs that remains unexplored experimentally so far. These results may lead to significant contributions to the basic understanding of graphene.

Acknowledgements

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References

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