Cyclotron Resonance in Graphene/Boron Nitride Heterostructures

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Introduction -

Measurements of the high magnetic field cyclotron resonance of graphene provided one of the clearest demonstrations of the Dirac nature of the charge carriers in graphene, clearly observing the predicted √B and √N dependence of the Landau level energies [1], where B is the magnetic field and N is the Landau level index. Unexpectedly, the CR also showed great promise for performing spectroscopy on many-body correlated states in graphene [2]. Since then, a vast improvement in sample quality has led to a need to re-visit these experiments with an eye toward spectroscopy of the newly-discovered Hofstadter butterfly [3], as well as the many-particle states that are stronger in the new samples.

Experimental -

Graphene-on-boron nitride devices were fabricated and brought to NHMFL for investigation in the transmission IR probe in SCM3. At liquid helium temperatures, FTIR spectroscopy was performed on these devices. The magnetotransport—in particular, the quantum Hall effect—was also measured in order to calibrate the back gate voltage vs. quantum Hall state sequence.

Results and Discussion

Fortuitously, a bilayer graphene-on-boron nitride sample happened to have a crystallographic alignment suited to the observation of Hofstadter's butterfly, as shown in Figure 1 through a plot of the diagonal magnetoresistance R_{xx} vs gate voltage and magnetic field. Besides the standard quantum Hall effect arising from the central Dirac peak near V_g = 0 V, a satellite peak near V_g = -45 V develops a copy of the QHE, and the horizontal lines visible at increasing field are manifestations of integer numbers of flux lines threading the Moiré unit cells created by the slight misalignment of the graphene and boron nitride.

We were unable to observe the cyclotron resonance in transmission IR data for this sample. Based on these results, we are focusing new effort in two directions: fabrication of larger samples since the transmission signal scales with sample area; and design and construction of a new transmission IR probe.

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References

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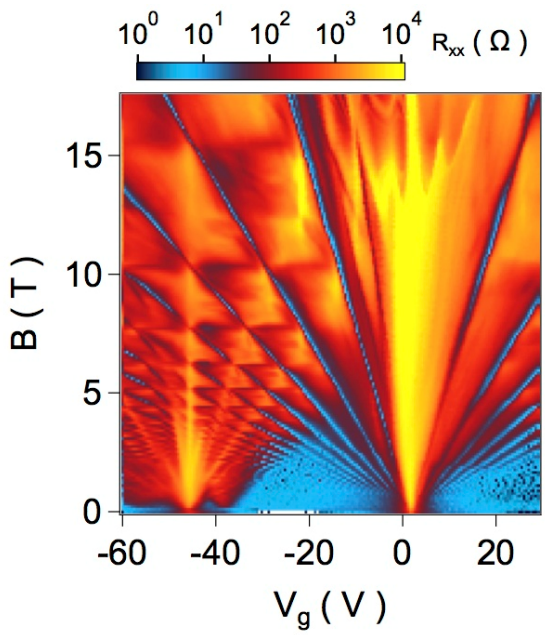

Fig.1 Magnetoresistance vs gate voltage and magnetic field for high mobility bilayer graphene on boron nitride.