Infrared Measurements of Landau Level Transitions in Single and Bilayer Graphene

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Introduction

The recent successful fabrication of graphene, sheets of carbon with atomic thicknesses, has presented the opportunity to explore the physics of electrons in a new two-dimensional material. While echoing the properties of two-dimensional electronic wells in semiconductors, the band structure of graphene leads to a number of novel effects, including a dispersion relation that mimics relativistic physics, an ambipolar system with a charge neutral point as the Fermi level moves from hole to electron carriers, and a valley degeneracy of the electronic states due to the honeycomb lattice symmetry. Our work focuses on the unusual properties of the quantized Landau Levels (LL) that form in graphene in a high magnetic field.

Experimental Results

By examining the infrared absorption of graphene in high fields we can identify transition energies between LLs, analogous to classical cyclotron resonances. Unlike traditional 2D systems, for a fixed field the LL spacing varies in energy. By adjusting the Fermi level of graphene the evolution of the LL absorptions at different filling factors, \( \nu \), can be observed (Fig. 1). While confirming the predicted field dependence of LL spacing, the derived band velocities of these absorptions suggest robust many-body effects occur near the charge neutral point, in contrast to conventional 2D systems.[1]

![Fig. 1](image1)

![Fig. 2](image2)

With knowledge of the LL degeneracy, the absorption energies can also be used to reconstruct the zero-field density of states in graphene (Fig. 2) and reveal its unique linear character. Further studies have begun to reveal the lifting of LL degeneracy at high fields.[2]

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References