Cyclotron Resonance in Narrow Gap HgTe Quantum Wells

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Introduction

It has been shown that two-dimensional (2D) Dirac fermions can be realized in HgTe-based semiconductor quantum wells (QWs) with an inverted band structure and vanishing band gap [1,2]. Recent magneto-transport measurements performed on HgTe QWs with a critical well thickness (d_c) where the band gap vanishes have provided experimental evidence of a single Dirac valley in the system, and Hall measurements show the anomalous sequence of quantum Hall plateaus specific to 2D Dirac fermions [3].

Experimental

A HgTe QW with a thickness of 6nm in between layers of HgCdTe was grown by MBE on a GaAs[013] substrate. We measured cyclotron resonance (CR) in a 17.5T superconducting magnet coupled to a Bruker 70 vertex FTIR spectrometer at the NHMFL in Tallahassee. The transmission through the samples was measured by a composite Si bolometer mounted directly below the sample.

Results and Discussion

This work is a continuation of our previous study on HgTe QWs grown at the critical thickness [4]. In Fig1(a) we show the CR transition energies from the sample with a nominal thickness of 6.5nm. The fundamental transition, between the 0 and first Landau levels, follows a √B dependence over the entire range of fields studied. The data is described well by a 4-band Dirac model with a Fermi velocity of 6.4×10^5m/s, and the splitting of the fundamental transition results from an addition of a small relativistic mass. We now add a third sample to the series, sample C, with a nominal thickness of 6.0nm. We plot the CR transition energies from sample C in Fig1(b). The fundamental transition still shows a √B dependence and can be fit by the 4-band model with the same Fermi velocity of 6.4×10^5m/s. We estimate the gap in this sample to be ~16meV. However, even though sample C is still a narrow-gap QW with only a 0.6nm thinner QW, we cannot describe any of the other transitions with the simple 4-band model.

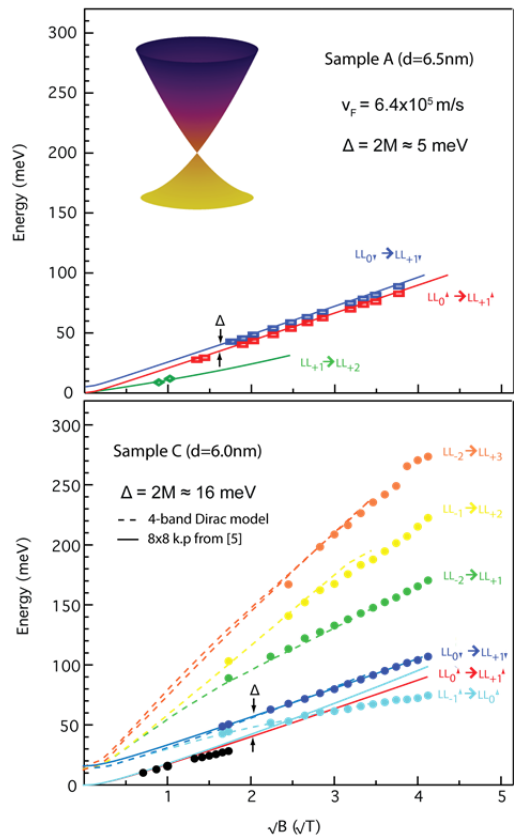

Fig 1: CR energies as a function of √B for (a) sample A with d=6.5nm and (b) sample C with d=6.0nm. Experimental points are shown by symbols. Calculated transition energies using a 4-band Dirac model are shown by solid lines. The dashed lines are from the k.p model on a similar HgTe QW from ref. 5.This inset shows the low energy band structure of a HgTe QW at the critical thickness.

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