Cyclotron Resonance of Single Valley Dirac Fermions in Gapless HgTe Quantum Well

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Introduction

Since the Dirac-like character of the low-energy band structure in graphene was first demonstrated in 2005, there has been a continuous search for other Dirac-fermion materials. 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].

Results and Discussion

We performed low-temperature IR magneto-transmission measurements on two HgTe QWs at and near the critical thickness corresponding to either a gapless or small-gap state. The two QW samples studied in this work were grown by molecular beam epitaxy on [013]-oriented GaAs substrates, with nominal well widths of 6.6 nm (sample A) and 6.5 nm (sample B). We observe that the dominant cyclotron resonance (CR) lines follow a $\sqrt{B}$ dependence over the whole range of studied magnetic fields, up to 16 T. For both samples, the same slope is extracted from the CR energy versus $\sqrt{B}$ curve, while a single- or double-Lorentzian CR absorptions are observed for the gapless or gapped HgTe QW, respectively. The results are described as CR transitions between the n=0 and n=1 Landau leves of 2D Dirac fermions with the same band velocity v_F=6.4 x 10^5 m/s and either zero or small, finite relativistic masses [4].

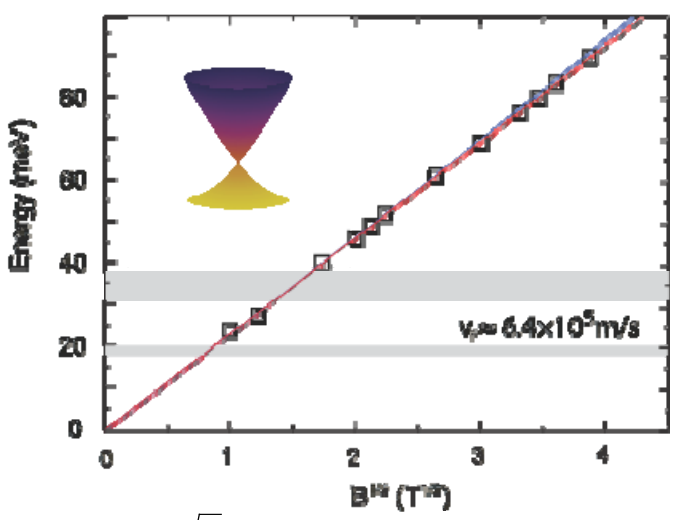

Fig. 1. The CR energies plotted as a function of $\sqrt{B}$ for gapless HgTe QW (sample A). Inset: Low-energy band structure of HgTe QW at the critical well thickness.

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