Observation of 3D massless fermions in a zinc-blende semiconductor at the point of a topological transition

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A spectacular analogy between ultra-relativistic particles in quantum electrodynamic and electrons in some solid-state systems has been demonstrated both in one dimension (carbon nanotubes [1]) and in two dimensions (graphene [2, 3]). However, a three-dimensional (3D) solid-state system whose electrons would mimic massless particles (in which such an analogy would be even closer) appeared to be missing up to now. In the present work, we fabricate and characterize a zinc-blend semiconductor, HgCdTe, at the point of a topological transition. The presence of 3D massless electrons with the velocity about 10^6 m.s^{-1} in this material is clearly manifested (i) by infrared absorption which increases strictly linearly with the photon frequency, and (ii) in a magnetic field B, by a $\sqrt{B}$ dependence of inter-Landau-level resonances, see Fig. 1.

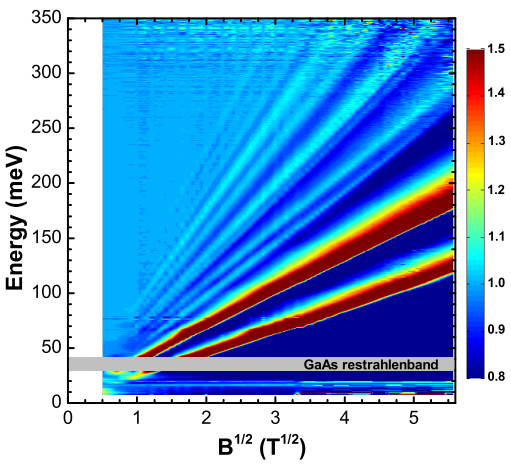

Figure 1: Relative change of absorbance of a thin layer of $Hg_{0.83}Cd_{0.17}Te$, grown by MBE method on a GaAs semi-insulation substrate, plotted as a false color-map. All the observed inter-Landau level resonances clearly follow the characteristic follow the $\sqrt{B}$-dependence, which is typical of massless particles.

[1] J.-C. Charlier, X. Blase, and S. Roche, Rev. Mod. Phys. **79**, 677 (2007).
[2] K. S. Novoselov *et al.*, Nature **438**, 197 (2005).
[3] Y. B. Zhang *et al.*, Nature **438**, 201 (2005).