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2D quantum wells: band structures and quantum effects from terahertz spectroscopy

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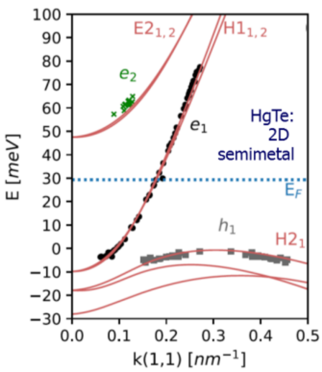
Abstract

Terahertz magneto-spectroscopy of 2D quantum wells allows to observe several classical and quantum phenomena. For example, HgTe-based heterostructures reveal fascinating thickness-dependent properties that arise due to inverted bands of the bulk material. Besides two-dimensional semimetals with coexisting electrons and holes, HgTe systems have been shown to take form of 3D topological insulators, Dirac semimetals, etc. Surprisingly, the band structure of these materials can be accessed experimentally via the analysis of the quasi-classical cyclotron resonance. Standard techniques like angle-resolved photoemission spectroscopy cannot be applied here due to multiple layers in the growth process.

In quantum regime, several physical effects can be observed in the terahertz range:

- Quantized Faraday rotation equal to the fine-structure constant in quantum anomalous Hall regime.
- Universal value of absorption equal to half of that in graphene.
- Unusual sensitivity/immunity of the photoresistance to the helicity of the terahertz radiation.



Band structure of 2D semimetal based on HgTe quantum well. Experimental points are obtained from the analysis of the cyclotron resonance in the quasi-classical approximation. Solid lines are predictions of the $\mathbf{k}\cdot\mathbf{p}$ *theory with no free parameters. Splitting of the conduction* ($e_{1,2}$) *and valence* (h_1) *band is due to the quantum confinement.*

[J. Gospodaric, AP, et al., PRB 104, 115307].