Giant Linear Magnetoresistance in Two-Dimensional non-Galilean invariant conductor

G. M. Gusev,[1] A. D. Levin,[1] Z. D. Kvon,[2,3] V. M. Kovalev,[2,4,5] M. V. Entin[2,3], and N. N. Mikhailov[2,3]

[1] *Instituto de Física da Universidade de São Paulo, 135960-170, São Paulo, SP, Brazil*
[2] *Institute of Semiconductor Physics, Novosibirsk 630090, Russia*
[3] *Novosibirsk State University, Novosibirsk 630090, Russia*
[4] *Novosibirsk State Technical University, Novosibirsk 630073, Russia*
[5] *Abrikosov Center for Theoretical Physics, Moscow Institute of Physics and Technology, Dolgoprudny, 141701, Russia*

In this study, we conducted experimental investigations on the magnetoresistance of a two-dimensional system within a HgTe quantum well. This system exhibits a unique coexistence of energy bands, featuring both linear and parabolic-like spectra at low energies. As a result, it lacks Galilean invariance. The interactions between the two-dimensional Dirac holes and the heavy holes are responsible for breaking the Galilean invariance, leading to interaction-limited resistivity and magnetoresistivity. At elevated temperatures, we observed linear magnetoresistance, which can be attributed to the Dirac plasma magnetohydrodynamic behavior.

The recent discovery of the large magnetoresistance (MR) exceeding 100% in conductors and semimetals under only a few tesla has garnered considerable attention. This finding necessitates a reevaluation of the semiclassical theory, particularly in the context of the Boltzmann transport equation. In this work, we investigate magnetoresistance of HgTe gapples quantum well at elevated temperatures, where resistance is primarily determined by particle-particle scattering (figure 1a) [1]. We observe significant positive magnetoresistance, compare it with theoretical predictions, and find reasonable agreement. At some fixed densities, magnetoresistance demonstrates a linear dependence on the magnetic field (figure 1b). Therefore, we illustrate that irrespective of the carriers' sign, spectrum type, and other characteristics, hole-hole collisions are responsible for magnetoresistance at high temperature. These findings imply that the investigated system serves as a valuable experimental platform for exploring different magnetohydrodynamic regimes in a two-component plasma with distinct charge signs and distinct effective mass.

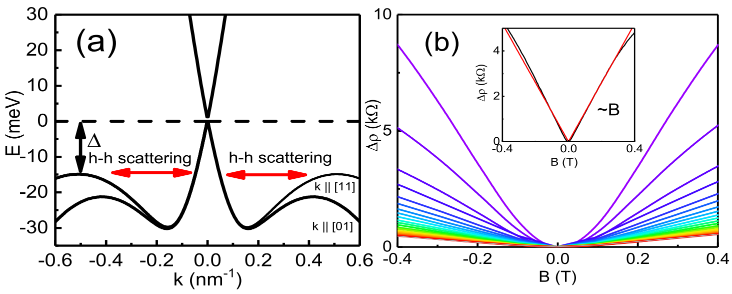

Figure 1: (a) Schematic representation of the energy spectrum of a 6.4 nm mercury telluride quantum well. (b) Magnetoresistivity as a function of the magnetic field for different gate voltages: $-6V < V_g < -2V$, T=48 K. The insert-example of the linear margnetoresistivity at density $N_h = 3.9 \times 10^{11} cm^{-2}$.

[1] G. M. Gusev, A. D. Levin, E. B. Olshanetsky, Z. D. Kvon, V. M. Kovalev, M. V. Entin, and N. N. Mikhailov, *Phys.Rev.B.* **108**, 035302 (2024).