Re-Entrant Sign-Alternating Quantum Hall Effect in the Hgte/Cdhgte Double-Quantum-Well

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Introduction

The energy spectrum of the HgTe quantum well wider than 6.3 nm is fundamentally different from that of a traditional one: it is inverted and both the conduction and the valence subbands are of the Γ_8 nature. This is manifested in a large nonparabolicity, strong spin splittings [1] and well pronounced effects of spin polarization [2]. It is known, on the other hand, that peculiar physical phenomena, like formation of new correlation states of the electronic system, are realized in double-quantum-wells (DQW) due to interlayer interactions. A question arises: how the unusual properties of the HgTe layers would manifest in a DQW built of them? Will an additional degree of freedom due to well pronounced spin splittings cause some consequences or will an unusual inverted energy band structure do it? We are making the first efforts to find it out.

Experimental

Quantum magnetotransport in a set of HgTe/$Cd_{0.65}Hg_{0.35}Te$ single and double quantum wells, some of them with a upper gate, has been measured up to 18T and 31 T at 0.32 K in NHMFL SCM-2 and cell-9 respectively. The DQWs consist of two HgTe 20 nm wide layers separated by a $Cd_{0.65}Hg_{0.35}Te$ barrier with the width of 6-10 nm. The DQWs are symmetrically δ-doped with In.

Results and Discussion

Strong conduction and valence band overlaps are revealed in the HgTe DQWs expressed in pronounced *N*-shaped Hall magnetoresistivity $\rho_{xy}(B)$ concomitant with the parabolic $\rho_{xx}(B)$. In addition to the found unusually large strength of the effect, a novel feature is a robust *re-entrant sign-alternating* behavior of $\rho_{xy}(B)$ found at large positive gate voltages V_g (see an example in Fig.1). After its first inversion from negative to positive values due to superposition of classical electron and hole conductivities at weak fields, followed by the quantum Hall behavior of the hole conductivity component up to the plateau for filling factor ν=1, the re-entrant inversion to negative $\rho_{xy}(B)$ values is observed. The experimental traces show inversion symmetry in field, thus the found peculiarities are not due to an admixture of $\rho_{xx}(B)$ to $\rho_{xy}(B)$. We interpret this unusual behavior on the basis of a calculated picture of the magnetic levels as being due to a superposition of electron- and hole-type localized states in the gap between the lowest electron and the highest hole magnetic levels and the oscillating behavior of the hole levels within an energy range around the lateral maximum of the valence subband.

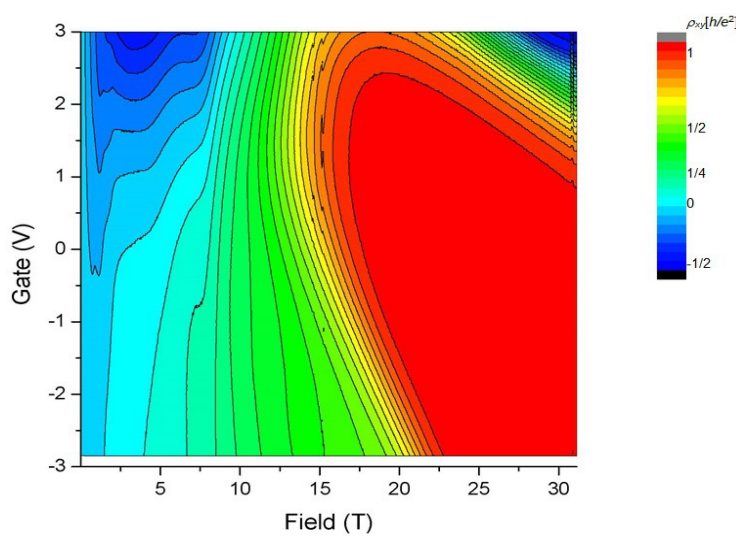

Fig. 1. A re-entrant sign-alternating quantum Hall effect in the HgTe/CdHgTe DQW at T = 0.32 K presented as $\rho_{xy}(B,V_g)$.

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References

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