Electronic Band Structure in n-type GaAs/AlGaAs Wide Quantum Well in Tilted Magnetic Field

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Introduction

The carrier density distribution in a wide quantum well (WQW) can be substantially bilayer-like. If the layers interact, the energy spectrum in such a system consists of the symmetric (S) and anti-symmetric (AS) subbands divided by an energy gap Δ_{SAS}. It is well known that in high mobility structures with moderate QW width the conductivity could show magnetooscillations corresponding to filling factors ν with even denominators ν=x/2: 7/2, 9/2, 11/2 at temperatures T < 150 mK which are usually attributed to the formation of the stripe phases (see, i.e., [1] and refs. therein). We for the first time have observed deep regular conductivity oscillations corresponding to half-integer filling factors in WQW which in contrast to stripes exist up to 400 mK, and whose nature is explored in the present work.

Experimental and Discussion

AC conductivity $\sigma^{ac}(\omega)=\sigma_1-i\sigma_2$ was studied in the high quality samples of multilayer n-GaAlAs/GaAs/GaAlAs structures with a wide balanced quantum well (75 nm) with the electron density n=1.4×10^{11} cm^{-2} and the mobility 2.4×10^7 cm^2/Vs (at T = 0.3 K) using the contactless Surface Acoustic Wave (SAW) technique. The measurements in magnetic field up to 18 T perpendicular to the sample plane were carried out in SCM1 in the temperature interval 20-500 mK at the SAW frequencies *f*=28-307 MHz. The measurements in tilted magnetic fields were done in SCM2.

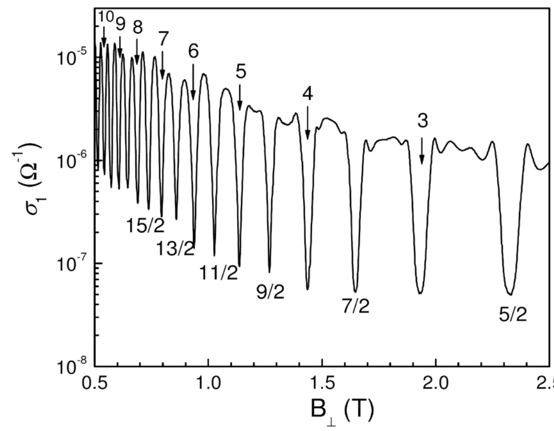

Fig.1 σ_1 on $B_\perp$ at T=20 mK, *f*=30 MHz.

Dependence of the real component of AC conductivity σ_1 on the magnetic field is drawn in Fig. 1. Conductivity σ_1 undergoes the oscillations corresponding not only to the integer filling factors but to factors with even denominators manifested up to ν=43/2 at 20 mK and ν=21/2 at T=310 mK. The oscillations at half-integer $\nu \geq 5/2$ have the same form as at integer ν. These oscillations exist up to *T*=400 mK and the conductivity in their minima has the activation character. Note that the filling factors were determined by the formula $\nu=nc\hbar/|eB_\perp|$. Analysis of the oscillation minima positions has been shown that the integer and half-integer fillings oscillations bid fair to go respectfully from the Landau levels (LL) in the lower symmetric subband and the upper antisymmetric subband, divided by Δ_{SAS}=0.42 meV [2]. To clarify the nature of this oscillation pattern we measured AC conductivity in tilted magnetic field at T=310. The results of corresponding measurements are presented in Fig. 2. This figure shows that at some tilt angles of the magnetic field the minima of the conductivity oscillations are changed to maxima. Usually this effect is associated with the LLs crossing. We have shown that the crossings of the LLs from the S and AS subbands take place here. The developed theory demonstrates that the crossings occur due to different dependencies of cyclotron energies in the subbands on the tilt induced parallel field. Namely, the cyclotron energy in the S (AS) subband decreases (increases) with $B_{||}$, while Δ_{SAS} changes weakly. We estimated the value of the electron g-factor *g*=9±2 by fitting the theoretical dependences to our experimental data.

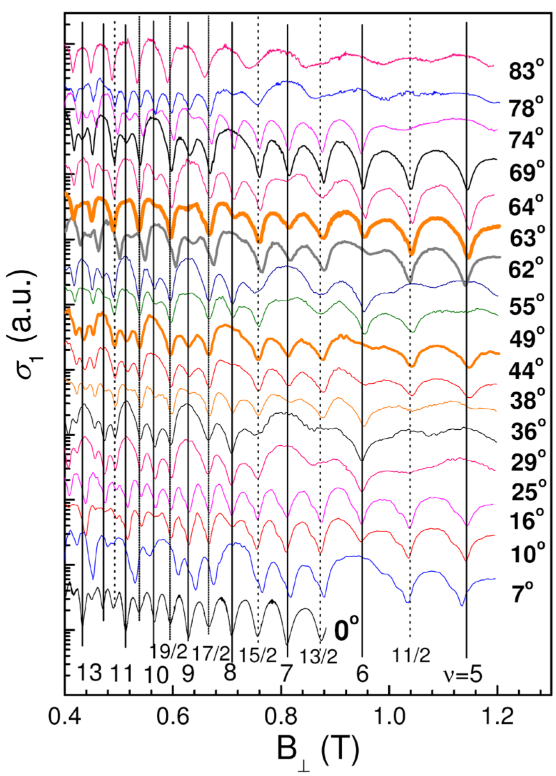

Fig.2 Dependence of the conductivity σ_1 on $B_\perp$ at different angles of the magnetic field tilt at *T*=310 mK, *f*=30 MHz. The numbers below the minima denote the filling factors.

Acknowledgements

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References

[1] Shi, Q., *et al*., Phys. Rev. B, **95,** 161303 (2017).
[2] Drichko, I. L., *et al*., Phys. Rev. B, **97**, 075427 (2018).