Surface Acoustic Waves Probe of the Anomalies in AC Conductivity near Filling Factor 1/5 in GaAs/AlGaAs Structure

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Introduction

High frequency (AC) conductivity in a single 65 nm quantum well AlGaAs/GaAs/AlGaAs structure with the carriers concentration of n=5×10^{10} cm^{-2} and with high mobility μ=8.5×10^{6} cm^{2}/Vs was studied by acoustic methods in the fractional quantum Hall effect regime in magnetic fields of up to B=18 T and temperatures down to 30 mK. We studied the dependence of ac conductivity on temperature and frequency focused in the region in the vicinity of the filling factor 1/5.

Experimental Results and Discussion

In our experiments we used the contactless acoustic method when a Surface Acoustic Wave (SAW), excited by an interdigital transducers, propagates along the surface of the piezodielectric lithium niobate, and the studied structure is pressed onto the same surface of the $LiNbO_3$.An electric field produced by the SAW interacts with the carriers in 2D channel. Via this interaction the attenuation Γ and velocity $\Delta v/v$ of the acoustic wave are governed by the conductivity of the 2DEG. In such "sandwich" setup no deformation is transmitted into the sample. The measurements have been carried out in the frequency domain of 28-300 MHz at temperatures 30-380 mK. In our system magnetic field induces oscillations of the absorption coefficient and the velocity change with a rich IQHE and FQHE states pattern. Figure 1 illustrates experimental dependence of Γ and velocity $\Delta v/v$ on magnetic field for the frequency f=196 MHz. However here we studied the effects in the vicinity of the filling factor ν=1/5 only.

It turned out that for frequencies f≥140 MHz in magnetic fields B>10 T (i.e. in the vicinity of ν=1/5) $\Delta v/v$ changes its sign and becomes negative.

From simultaneously measured attenuation and velocity of SAW real σ_1 and imaginary σ_2 components of the complex ac conductivity $\sigma^{ac}=\sigma_1+i\sigma_2$ were calculated. Frequency dependences of σ_1 and σ_2 for filling factor ν=0.19 at T=35 mK are illustrated in Fig.2. Similar frequency behavior of these components is observed for ν=0.21 also.

However in magnetic field 11 T, exactly corresponding to ν=1/5, there is a weak dependence of σ_1 on frequency and weak metallic-like dependence on temperature (the conductivity decreases with temperature increase). More to say, for all frequencies the ratio between the real and imaginary components was $\sigma_1 < \sigma_2$, which is a character of the hopping conductivity.

Frequency dependences shown in Fig.2 are usually observed in the vicinity of resonance frequencies. Such a behavior of ac conductivity could be possibly interpreted as manifestation of a pinning mode of the Wigner crystal/glass.

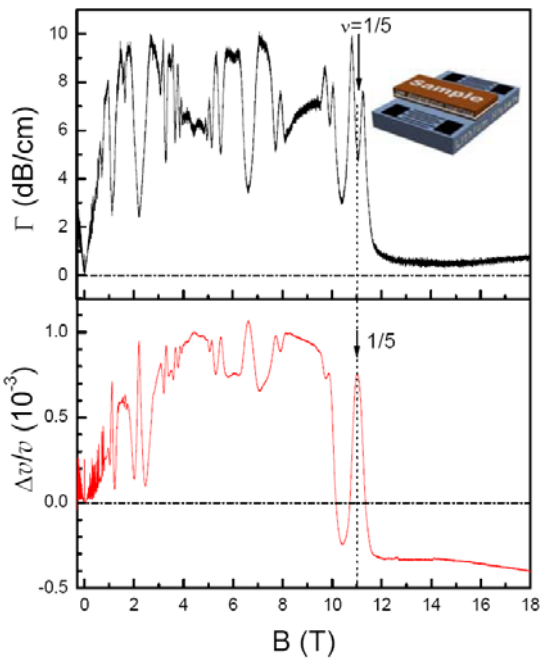

Fig. 1 SAW attenuation and velocity shift at frequency f=196 MHz and temperature 37 mK.

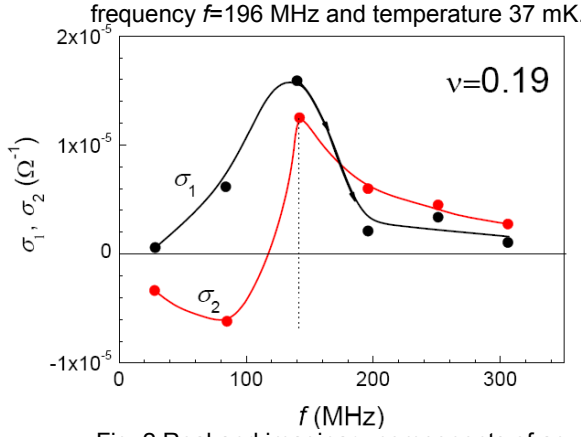

Fig. 2 Real and imaginary components of ac conductivity vs frequency at ν=0.19; 28.5 MHz.

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