Pinning Modes of 2D Electron Systems with Controlled Alloy Disorder Near Landau Filling ν=1

B. H. Moon, A. Hatke, S. Chakraborty, L. W. Engel (NHMFL), D. C. Tsui, L. N. Pfeiffer and K. W. West (Princeton University, Electrical Engineering)

Introduction

A resonance in the microwave conductivity spectrum of a high magnetic field insulating phase of a two dimensional electron system (2DES) is understood as evidence for Wigner solidification of the carriers [1]. Interaction between the carriers causes their motions to be correlated, so that the disorder potential is averaged, and the resonance, known as a pinning mode, is sharper than it would be if the carriers could oscillate independently. Here we study samples in which the 2DES resides in $Al_xGa_{1-x}As$, with controlled, small x. The Al are randomly distributed, and the essentially point like potential produced by an Al atom is known [2], so we have an excellent understanding of the disorder potential.

For low-disorder 2DES within the Landau-filling (ν) region of the integer quantum Hall effect, just above and below integer ν, pinning modes have been studied earlier [3], and were ascribed to Wigner solidification of quasiparticles and quasiholes. The present work focuses pinning modes of the controlled-disorder samples near ν=1.

Experimental

We calculated real diagonal conductivity Re σ_{xx} from transmission-line spectroscopy [1] data taken in SCM 1.

Results and Discussion

Figure 1 shows the spectra on either side of ν=1. Resonances are present but evolve differently with ν, for the quasiparticle and quasihole insulators with ν respectively above and below 1. The resonance extends down to the high ν edge of the 2/3 fractional quantum Hall effect (FQHE) and reemerges shifted downward in frequency for ν just below 2/3. The ν-range of the downward-shifted resonance, between 2/3 and 3/5, matches that of a reentrant quantum Hall effect observed earlier in dc transport [2].

An explanation of the resonance in these materials will likely require significant modification of existing pinning theory [4], likely including both correlation and localization effects.

Acknowledgements

This work was supported by DOE BES award DE-FG02-05ER46212.

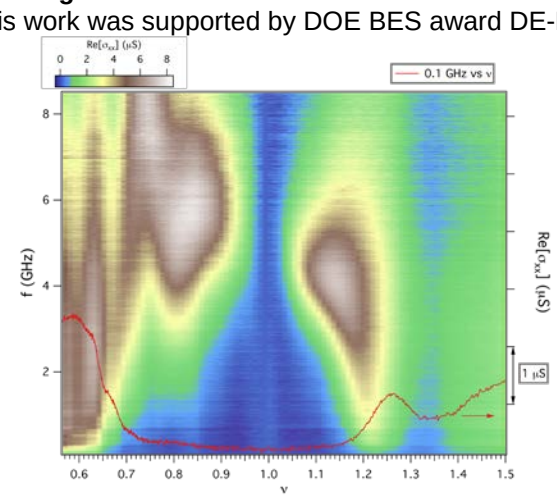

Figure 1. Image plot of diagonal conductivity (Re σ_{xx}) spectra of 2DES in a sample with x=0.85 %, on frequency- n plane. Sample density is 2.4x $10^{11}/cm^{-2}$. Red line shows Re σ_{xx} vs ν, and refers to right vertical axis.

References

[1] See Sambandamurthy, G. *et al*., Solid State Comm. **140**, 100 (2006) for a brief review.
[2] Li ,Wanli *et al.,* Phys. Rev. Lett. **105**, 076803 (2010).
[3] Chen, Yong *et al.,* Phys. Rev. Lett. **91,** 016801 (2003).
[4] Fertig, H. A., Phys. Rev. B **59** 2120 (2000); Fogler, M. M. and Huse D. *ibid*. **62** 7553 (2000); R. Chitra, R.; Giamarchi, T and Le Doussal,P. *ibid*. **65** 035312 (2001).