Transition Between Electron Solids in Wide Quantum Wells Near Landau Filling $\nu = 1$

A.T. Hatke, B.A. Magill, B.H. Moon (NHMFL); Y. Liu, M. Shayegan (Princeton University); L.W. Engel (NHMFL), L.N. Pfeiffer, K.W. West (Princeton University)

Introduction

In the Landau filling factor (ν) region of an integer quantum Hall effect (IQHE) plateau the microwave spectra of a two-dimensional electron gas has a pronounced resonance [1]. This resonance is understood as the pinning mode of an insulating Wigner solid (WS) of quasiparticles, which oscillates about a pinning potential. Recent transport measurements in wide quantum wells (WQWs) have revealed a reentrant integer quantum Hall effect (RIQHE) that occurs for $4/5 < \nu < 6/5$ [2]. Such a quantum Hall state is characterized by a ν range which is discontinuous with the IQHE minimum centered at $\nu = 1$ but still has a quantized Hall resistance of h/e^2 and vanishing longitudinal resistance. The observed RIQHE was attributed to a WS. Here we test this hypothesis by performing microwave spectroscopy measurements on WQWs near $\nu = 1$ which have shown the RIQHE.

Experimental

Meandering coplanar waveguides were lithographically patterned on wide quantum wells of width w = 54 nm and 65 nm, which were used to obtain microwave conductivity spectra using the SCM1 magnet system.

Results and Discussion

In Fig. 1(a) we present measurements of the microwave conductivity in the (f, ν)-plane obtained from a w = 65 nm sample with symmetric charge distribution of carriers at $n = 1.72 \times 10^{11}$ cm^{-2}. For $\nu > 1$, we observe monotonic movement of the frequency peak (f_{pk}) of the resonance with increasing ν. However, for $\nu < 1$ f_{pk} first decreases and then increases for a small region of ν before decreasing again. This result is better exemplified in Fig. 1(b) were we extract f_{pk} and plot versus ν for several different densities (n) as marked, in units of 10^{11} cm^{-2}. At the lowest n we observe monotonic decay of f_{pk}. Once n is increased we observe f_{pk} abruptly jump to a region of enhanced-f_{pk} and develop a local maximum (up arrow) which evolves closer to $\nu = 1$ with increasing n. The position of this local maximum corresponds well to the edge of the RIQHE observed in transport measurements.

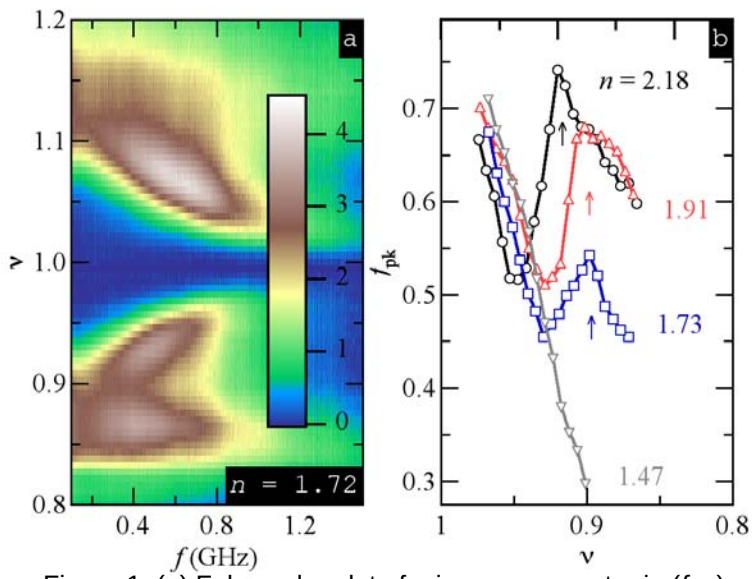

Figure 1: (a) False color plot of microwave spectra in (f, ν) plane. (b) Peak frequency, f_{pk}, versus ν at different n.

Conclusions

Our measurements show an abrupt change in the pinning mode frequency that is naturally interpreted as due to a transition between two distinct solids. While the nature of the enhanced-f_{pk} solid is undetermined we have observed that it exists at larger n and w relative to the other solid, which is associated with the previously observed IQHE [1] solid. Comparison with transport measurements reveals that the solid in the region of enhanced-f_{pk} is related to the RIQHE of Ref. 2.

Acknowledgements

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References

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[2] Liu, Y., *et al.*, Phys. Rev. Lett. **109**, 036801 (2012).