Experimental Studies of the Fractional Quantum Hall Effect in the First Excited Landau Level

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Introduction

The first even-denominator FQHE state at ν=5/2 remains enigmatic. Not following the initial "odd-denominator" rule of the lowest Landau level, its underlying physics has been hotly debated. At present, theory favors a condensed state of CF pairs with quasi-particle excitations of non-abelian statistics. Experiments at ultra-low temperatures can provide critical information to determine the ground state of the ν=5/2 state.

Experimental

The specimen was a quantum well, symmetrically doped on both sides at a setback distance of 100nm. The electron density $n=3.1\times10^{11}$ cm^{-2} and mobility, $\mu=31\times10^{6}$ cm^2/Vs. Ultra-low temperature measurements were carried out using the nuclear demagnetization system of the NHMFL High B/T facility. Specially designed sintered silver heat exchangers were used to cool the 2DES. The temperature was monitored using CMN, ^{3}He melting curve, and Pt-NMR thermometers.

Results and Discussion

Figure 2(a) shows the variation with temperature of the value of R_{xx} at the minimum of the ν=19/8 state. The scatter of the data reflects the fragility of the state. The derivative of Rxy for the ν=19/8 and ν= 12/5 states is shown in Fig. 2(b). The ν=12/5 state shows the quantum hall plateau while the ν=19/8 state falls short.

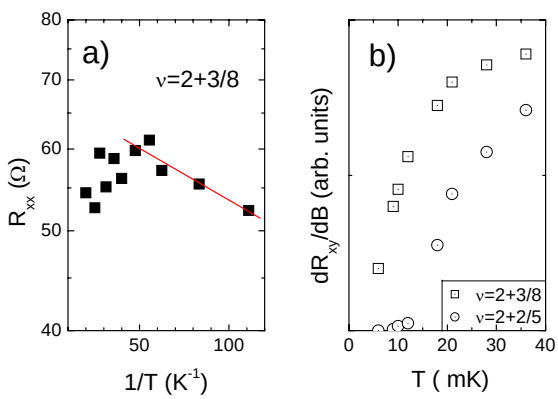

Figure 1 (a): Temperature dependence of the R_{xx} minimum at ν=19/8. The line is a linear fit.
(b): Temperature dependence of the derivative of the Hall resistance R_{xy} at ν=19/8 and 12/5. (See Ref. [1] with an extra data point at T = 6 mK.)

Conclusions

For the ultra-high mobility 2DES studied, the ν=5/2 state has an energy gap of 0.45K that depends on the residual disorder. For the ν=19/8 state an energy scale of ~5mK is deduced for the gap, attesting to the need of still lower electron temperatures and/or higher sample quality for this state to be fully developed. The state at ν=12/5 is developed into a full FQHE state, but its particle-hole conjugate state, the ν=13/5 state, is entirely missing.

Acknowledgements

HLS was supported by DOE under contract DE-AC04-94AL85000 and W.M. Keck Foundation, and DCT by the AFOSR and the DOE. The experiment was performed at the NHMFL high B/T facilities supported by NSF Cooperative Agreement No. DMR-9527035.

References

[1] Xia, J.S., *et al*., Phys. Rev. Lett., **93**, 17809-17813 (2004).