Search for Pfaffian Quantum Hall States in High Quality Wide GaAs Quantum Wells

D.R. Luhman (Princeton University), W. Pan (Sandia National Laboratories), D.C. Tsui (Princeton University), L.N. Pfeiffer (Bell Labs), and K.W. West (Bell Labs)

Introduction

The observation of a fractional quantum hall state at Landau level filling $\nu = 5/2$ is drastically different than the metallic behavior exhibited at $\nu = 1/2$. The $\nu = 5/2$ state is generally believed to be due to *p*-wave pairing of composite fermions (CFs) and described by the Pfaffian or Moore-Read wave function. Numerical calculations have indicated that the pairing of CFs may be possible in a wide, single-layer quantum well (QW) at $\nu = 1/2$ [1]. To search for possible Pfaffian states in wide QWs, we conducted low temperature transport studies in a series of five high quality GaAs QWs with well widths ranging from L=50 nm to L=80 nm using both the 35 T and Hybrid magnets.

Experimental

The total electron density of the quantum wells in this series of samples is $n_e \sim 2.6 \times 10^{11}$ cm^{-2}, requiring a magnetic field of B~21.5 T to reach $\nu = 1/2$. Using the facilities at NHMFL we have measured the transport coefficients of these samples in high magnetic field. We have also explored the effect of tilt angle near $\nu = 1/2$.

Results and Discussion

In our series of samples, the $\nu = 1/2$ fractional quantum Hall state was only observed in the narrowest quantum well with L=50 nm. The state is confirmed by a minimum in the longitudinal resistance and a plateau near $2h/e^2$ in the Hall resistance. The observation of the $\nu = 1/2$ state is unusual in several ways. The reduced well width of L=50 nm leads to a calculated value of the tunneling parameter which is quite large, and the state appears to strengthen as θ is increased. In addition, a self-consistent calculation indicates that the electron system is very close to the single-layer regime in this sample. Whether the origin of this state is the two-component 331 wavefunction similar to earlier observations of the ν=1/2 state[2], or can be described by something more exotic such as the Pfaffian wave function is still not known.

Conclusions

In summary, we have observed a fractional quantum Hall state at $\nu = 1/2$ in a high quality GaAs quantum well with a width of 50 nm. The origin of this state has not yet been determined.

Acknowledgements

Work at Sandia was supported by DOE/BES. Sandia is operated by Sandia Corporation, a Lockheed Martin company, for the US DOE's NNSA under contract DE-AC04-94AL85000. The work at Princeton University was supported by the DOE and NSF. We thank E. Palm, T. Murphy, and G. Jones for experimental assistance.

References

[1] K. Park *et al*., Phys. Rev. B, **58**, 10167 (1998).
[2] Y.W. Suen, *et al.*, Phys. Rev. Lett. **72**, 3405 (1994).