A Study of Phase Transitions in Wide High-Quality GaAs Quantum Wells at Higher Landau Levels

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

Studies involving bilayer quantum Hall systems, both double quantum wells and wide single quantum wells, have yielded a number of interesting discoveries over the last several decades. Among them are the observations of a two-component quantum Hall effect at Landau level filling fraction $\nu = 1/2$ and the formation of an excitonic condensate at $\nu = 1$.

Experimentally less attention has been given to higher Landau levels with $N > 1$. From a theoretical perspective, the phase diagram for a bilayer system with $N > 1$ is thought to be very rich as the parallel component of the magnetic field ($B_\parallel$) is increased and a number novel phases have been predicted [1,2].

Experimental

We have utilize a series of wide GaAs quantum wells, with differing well widths, to explore the effect of parallel magnetic field on the quantum Hall states in the $N=1$ and $N=2$ Landau levels. Using SCM1 we have measured the magnetotransport over a wide range of tilt angles, (i.e. $B_\parallel$) at a temperature of $T \sim 20$ mK.

Results and Discussion

Figure 1 displays the transport data at various tilt angles ($\theta$) for the quantum well with a width of 70 nm. As $\theta$ is increased, we have observed reentrant quantum Hall states for odd values of $\nu$ with $\nu \geq 5$. The reentrance occurs in the range $20^\circ < \theta < 35^\circ$. This does not coincide with predictions using a single-particle, Landau level crossing description, which predicts a crossing at $\theta = 89^\circ$.

The origin of the reentrant behavior is not fully understood, although it may be an experimental indication of oscillations in the amplitude of electron tunneling between the layers of the system.

Conclusions

We have observed reentrant behavior in the $N=1$ and $N=2$ Landau levels for odd values of $\nu$ with increasing tilt angle. The origin of these observations is currently being studied.

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References