

## High Pressure Studies of Composite Fermions

The magnetoresistance of high mobility GaAs-GaAlAs heterojunctions has been measured under high pressure, using a 15 kbar pressure cell, 30mK dilution fridge and 17 T superconducting magnet. Under these conditions the electron g-factor may be dramatically reduced and even approach zero, at which point the spin degeneracy will be removed. By varying the g-factor with pressure we may study the spin dependence of Fractional Quantum Hall Effect (FQHE) states. The FQHE energy gaps are measured from the temperature dependence of  $\rho_{xx}$  [1].

Spinless composite Fermions (CFs) provide a neat description of the principle FQHE features around  $\nu=1/2$  [2]. In the region around  $\nu=3/2$  electrons of both spin states are present, so how is the CF picture affected? If the spin splitting were large compared to FQHE correlation energies the lowest electron spin level would be completely filled and CFs could be formed by attaching 2 flux quanta to each *electron* in the upper spin level. However this is almost never the case, so the CFs must be formed by considering the number of *holes* in the complete, spin degenerate Landau levels (LLs) and attaching 2 flux quanta to each of these [3]. Note that, unlike the region around  $\nu=1/2$ , the number of CFs changes with magnetic field.

Figure 1 is a fan diagram of the CF LL energies for the two spin states showing how the Fermi energy  $E_F$  moves. The slope of the levels is determined by the measured CF effective mass [4]. Whenever a CF LL is completely full there is a gap in the density of states at  $E_F$  and a FQHE state results. The size of the jump in  $E_F$  gives an indication of the strength of each fraction. In fig 1(a)  $g=0.44$  corresponding to zero pressure. In (b) it is reduced by an order of magnitude. This reduction in spin splitting causes the gaps at even numerator fractions,  $4/3$  and  $8/5$  to increase relative to those at odd numerator fractions like  $5/3$  and  $7/5$ .

Figure 2 shows the measured energy gaps for the  $4/3$ ,  $5/3$ ,  $7/5$  and  $8/5$  fractions as a function of pressure at fixed electron density. The energy is divided by  $\mu_B B$ , which for a pure spin gap would give the g-factor. The slopes for  $4/3$  and  $5/3$  are equal and opposite, consistent with the model of  $5/3$  having a Zeeman splitting and  $4/3$  the difference between cyclotron and Zeeman

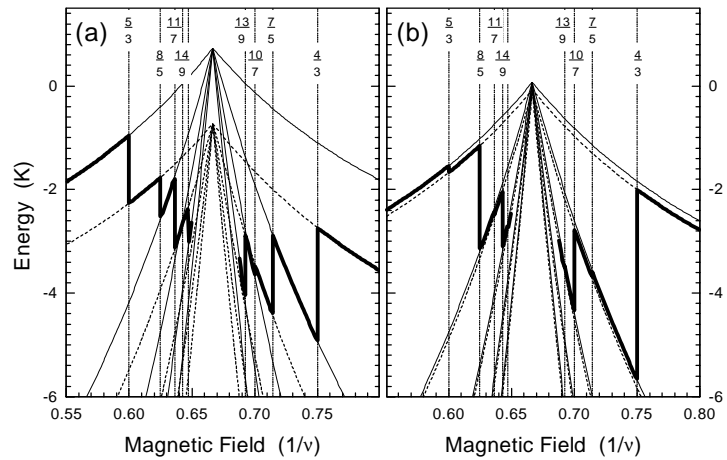


Figure 1: Calculated CF Landau levels for both spin states (solid and dotted lines) Thick line shows the Fermi energy, with jumps giving rise to the FQHE. (a)  $g=-0.44$  and (b)  $g=-0.044$ . Notice the even numerator fractions dominate in (b) i.e. at higher pressures.

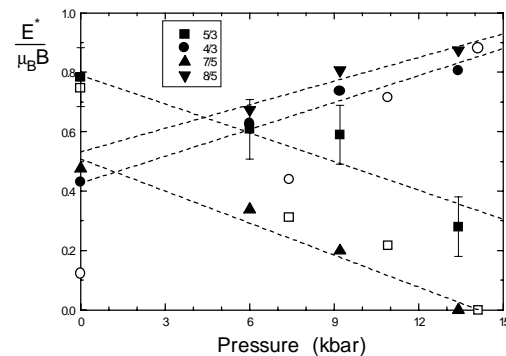


Figure 2: Pressure variation of the FQHE energy gap.

splitting. (Trying to form CFs from electron rather than hole states would give the opposite character, which is inconsistent with the data.) The size of the  $5/3$  gap at ambient pressure is  $0.8\mu_B B$ , almost twice the bare Zeeman energy. This may be due to spin correlations between CFs enhancing the gap. For  $7/5$  the enhancement is less since the spin population difference is smaller.

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