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FRACTIONAL QUANTUM HALL STATES AT $\nu=7/11$ AND 9/13

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Low temperature magnetotransport coefficients of high-quality two-dimensional electron systems display anomalous features near filling factors $\nu=7/11$ and 9/13. These features show a non-activated temperature dependence and vanish upon tilting of the sample with respect to the magnetic field.

In the "standard" Haldane–Halperin hierarchical scheme [1] of the fractional quantum Hall effect (FQHE) [2] the non-Laughlin (non $\nu=1/m$) [3] states occur at rational filling factors $\nu=p/q$ when the fractionally charged quasiparticles of the "parent" state form a FQHE "daughter" state themselves. In this picture the FQHE states may occur at all rational ν in a sequence of hierarchies given by

$$\nu=\cfrac{1}{q+\cfrac{\alpha_1}{s_1+\cfrac{\alpha_2}{s_2+\ldots}}}, \qquad (1)$$

where q is odd, s_i are even and $\alpha_i=0,\pm1$.

Recently, however, different hierarchical pictures have been proposed [4,5]. The Yoshioka–MacDonald–Girvin scheme involves total spin $S=0$ ground states and is currently developed for states $\nu=q/p$ when $q=1$ or 2, $p=2,3,4,5\ldots$. Jain has argued that the FQHE is a manifestation of the integer QHE ($i=q$) of electrons bound to an even number ($2m$) of flux quanta and, therefore, the hierarchies follow

$$\nu=\frac{q}{q(2mq\pm1)}, \qquad (2)$$

a more restrictive set than that given by (1). It should be emphasized that both (1) and (2) describe *only* spin-polarized states.

Here we report evidence for and a preliminary study of the FQHE states $\nu=7/11$ and 9/13 [6] which may help to differentiate between various hierarchical schemes.

Very low disorder samples employed in this study were cut from GaAs–AlGaAs heterostructures described previously [7]. Typically, after a brief low-temperature illumination, the samples have electron concentration $n=5\times10^{10}$ cm^{-2} and mobility $\mu=1.3\times10^6$ cm^2/V·s. Measurements were carried out in the van der Pauw configuration using the AC lock-in-phase technique (typically 4 Hz, 2 nA RMS excitation).

Fig. 1 shows an overall low-field view of both ρ_{xx} and ρ_{xy} at 19 mK of a sample from the M69 wafer. The ρ_{xx} data displays two sharp dips on either side of the prominent $\nu=2/3$ FQHE dip, in addition to previously observed hierarchy states $\nu=5/7$, 3/5, 4/7 and 5/9. The ρ_{xy} trace shows two corresponding anomalies, in addition the the QHE plateaus. The features near $\nu=9/13$ and 7/11 have been observed

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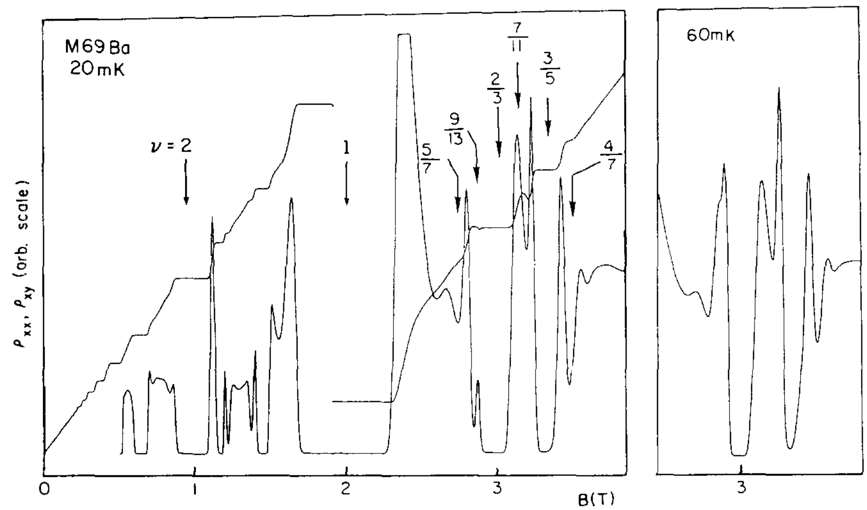

Fig. 1. The magnetotransport coefficients versus magnetic field. Arrows give the expected positions for the filling factor ν.

in many samples cut from several wafers, under different conditions of illumination. They appear to be intrinsic and do not result from a spatial inhomogeneity or other artifacts in the samples.

The behavior of the features in ρ_{xx} and ρ_{xy} near $\nu=9/13$ and $7/11$ as a function of temperature is somewhat peculiar and puzzling.

Fig. 2 gives the ρ_{xx} versus B data at three higher temperatures. It is apparent that the strength of the dips near $\nu=9/13$ and $7/11$ does not show simple activated behavior. Moreover, the $\nu=7/11$ dip *broadens* and shifts to slightly *lower* magnetic field as T is raised, in contrast to the usual narrowing of the QHE ρ_{xx} dips. Also, an additional shoulder near $\nu=10/17$ (on high-B side of FQHE at $\nu=3/5$) is quite apparent in these data.

The behavior of the Hall resistance near $\nu=9/13$ and $7/11$ is even less systematic. At about 300 mK deviations form the straight-line behavior become apparent. Upon the lowering of the temperature instead of developing QHE plateaus ρ_{xy} grossly overshoots the expected plateau positions, develops a minimum (which is *not* due to an ρ_{xx} admixture) and then tends to form a plateau next to the neighboring lower ν FQHE state (cf. fig. 1). Preliminary high-excitation-current measurements, however, show a weakening of the features near $\nu=9/13$ and

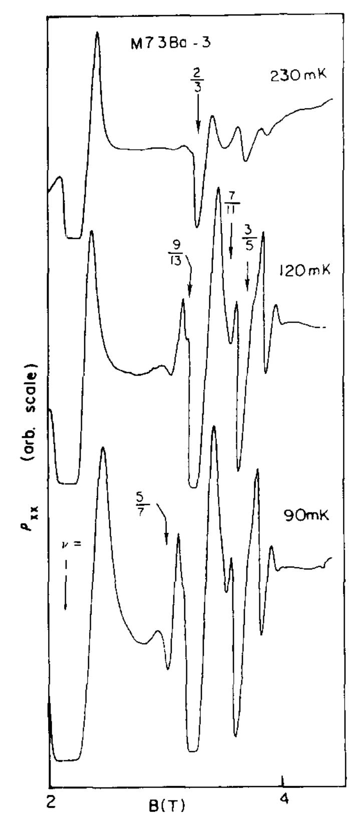

Fig. 2. Diagonal magnetoresistance at higher temperatures.

7/11 analogous to that seen in the FQHE states of similar strength (e.g. $\nu = 5/7$ and $4/7$).

Fig. 3 shows ρ_{xx} data for tilted magnetic field. The features near $\nu = 9/13$ and 7/11 completely disappear (as well as the FQHE at $\nu = 8/5$ [8], 7/5 and 4/3). The shoulder near $\nu = 10/17$, however, becomes more prominent. This indicates that the states near $\nu = 9/13$ and 7/11 are either total spin zero (spin-unpolarized) or mixed-spin states.

In conclusion we should like to stress that at this time we cannot identify with *certainty* the features near $\nu = 9/13$ and 7/11 as manifestations of developing FQHE states at these filling factors. These features seem to differ in their behavior from other developing FQHE states. On the other hand, it is possible that since the states at $\nu = 9/13$ and 7/11 are, for the first time "falling" in between the states of a lower hierarchy, there is a considerable competition between the neighboring states.

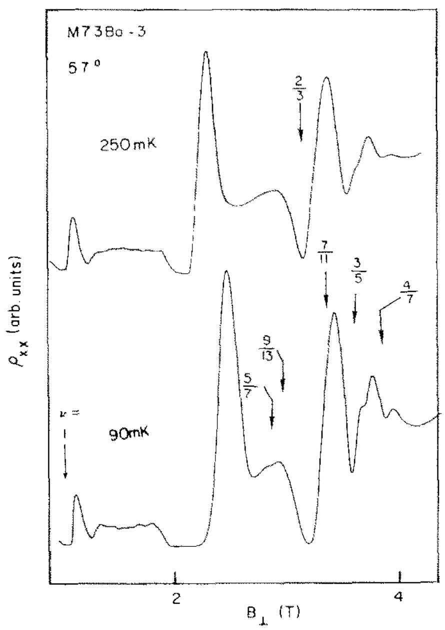

Fig. 3. Diagonal resistance of a tilted sample ($\theta = 57°$) versus normal component of magnetic field $[\cos(57°)]^{-1} \cong 1.84$.

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