Quantum Hall effect in $In_{0.75}Ga_{0.25}As/In_{0.75}Al_{0.25}As$ two-dimensional electron gas bilayer samples

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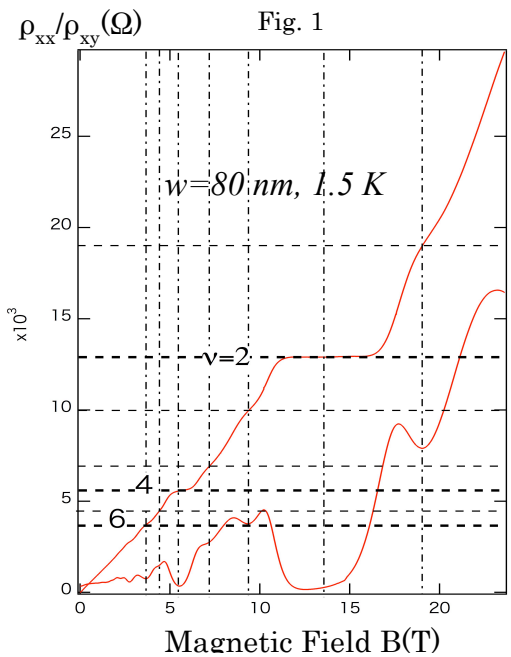
We have recently fabricated $In_{0.75}Ga_{0.25}As/In_{0.75}Al_{0.25}As$ two-dimensional electron gas (2DEG) bilayer samples and found that the bilayer system could be a base material for new type spintronics devices [1] by using spin-orbit interaction still surviving. We have this time measured quantum Hall effects (QHEs) in those samples up to 23 Tesla and observed some curious plateau features similar to those in the fractional QHE.

The bilayer samples were made in the form of wide quantum wells (thickness w) modulation-doped from both the upper and lower sides. In the five samples with different ws (40, 60, 80, 100, 120 nm), sheet electron densities (n_ss) in the upper and lower 2DEGs are almost equal and they are typically 1 (2×10^{11}/cm^2) : 3 (6×10^{11}). So that, in this sense, the bilayer system is very asymmetric and especially under high magnetic field, the lower 2DEG could play a dominant role.

Figure 1 shows ρ_{xx} and ρ_{xy} in the w = 80 nm sample. As seen in the figure, not ν =3 plateau (ν, filling factor) but close fractional (ν = 4/3, 8/3, 10/3) plateaus seem to be observed. Similar curious behavior is confirmed also in the wide well sample (w = 120 nm) but not in the narrow well one (40 nm). The reason is not clear at present, since the interaction between the upper and lower 2DEGs is weak due to the relatively low n_s of the upper 2DEG. The behavior of ρ_{xy} in the latter sample is very normal and there is almost no fractional plateaus up to ν =2. This might suggests that the bilayer 2DEG in the w = 40 nm sample should be regarded as a monolayer 2DEG.

Fig. 1



Reports on the fractional QHEs have seemed to be very rare [2] in the 2DEGs in InGaAs/InAlAs material system. We are thus planning to make even low temperature magneto-resistance measurements to resolve the fractional properties more precisely.

[1] M. Akabori, et al., J. Appl. Phys. **112**, 113711 (2012).
[2] P. Wei et al., Phys. Rev. B**32**, 7016 (1985).