Suspended bilayer graphene in high magnetic fields

H.J. van Elferen[1], A. Veligura[2], N. Tombros[2], B.J. van Wees[2], J.C. Maan[1], U. Zeitler[1]

[1]High Field Magnet Laboratory, Radboud University Nijmegen, Toernooiveld 7, Nijmegen, The Netherlands
[2]Physics of nanodevices, Rijksuniversiteit Groningen, Nijenborgh 3, Groningen, The Netherlands

helferen@science.ru.nl

We have measured the two-terminal magnetoresistance in high-mobility suspended bilayer graphene at low temperatures down to 0.3 K and in high magnetic fields up to 30 T. We observe the field-induced appearance of an insulating phase at the charge neutrality point (CNP), a splitting of the lowest Landau level into eight distinct sub-levels, and, for the highest magnetic fields (B > 20 T), we demonstrate evidence for the development of a fractional quantum Hall effect (FQHE) in bilayer graphene

The mobility of standard graphene transistors is limited by the interaction with the SiO_2 substrate and chemisorbed impurities. Making suspended graphene eliminates the interaction with the substrate and allows removing impurities by local current annealing [1]. The most common technique for underetching the graphene is directly etching the SiO_2 with buffered HF. For our samples, the graphene is placed on an organic polymer on top of the SiO_2 [2]. This technique allows an underetching with inert solvents which make the devices much mechanically more stable. After processing the samples, we clean up the suspended graphene by using in-situ current annealing at cryogenic temperatures and obtain high mobilities up to 200.000 $cm^2\ V^{-1}s^{-1}$.

In fig. 1a we show how the integer quantum Hall effect in one of our suspended bilayer samples becomes fully pronounce at 1 T. Additionally, we find a gap-opening at the CNP, visible as a strongly diverging resistance, $R \propto \exp(-\Delta/2\ k_B T)$. Plotting the gap as function of the magnetic field we obtain a square-root dependence (see fig. 1b) and thus tentatively attribute this behavior to a ferromagnetic origin which is in contrast to previous reported data in suspended bilayers with a linear field dependence of the gap proposing due to many body effects [3]. Owing the existence of inhomogeneities leading to electron and hole puddles, the Coulomb potential is disordered, which might be the reason for the observation of quantum Hall ferromagnetism in our device [4].

High magnetic fields break the complete eight-fold degenerated lowest Landau level in bilayer graphene, illustrated in fig. 1c. In addition the possible appearance of a FQHE in the lowest Landau level is illustrated in Fig. 1d where we plotted the conductance as function of filling factor v. When approaching the CNP, we can identify a FQHE at filling factors $v = 1/3$ and $v = 2/3$. Additional plateaus with an N-shaped features also appear for $v < 1/3$ as well as a relatively wide plateau between $v = 1/3$ and $v = 2/3$.

In conclusion we show the latest results on two-terminal measurements on bilayer graphene suspended on an organic polymer in high magnetic fields. Our experiments demonstrate experimental evidence for a FQHE in suspended bilayer graphene. So far, we can tentatively identify fractional filling factors with denominator three.

References

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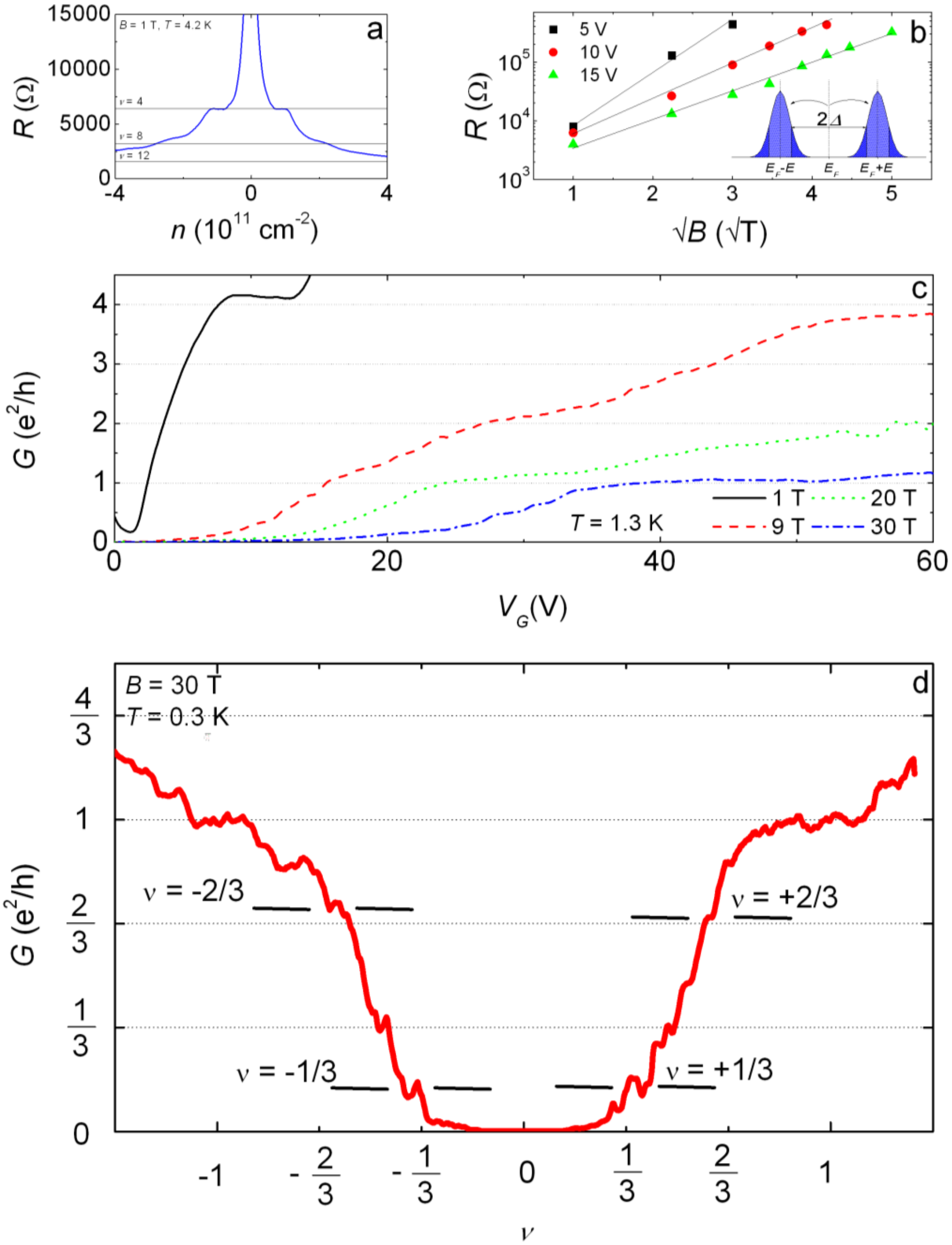
Figures



a) *Two-terminal resistance of suspended bilayer graphene around the CNP. The integer quantum Hall effect with quantized plateaus at filling factors $\nu = 4$ and 8 is already visible and the divergence of the resistance at the CNP indicates the opening of a gap.*

b) *Gaps extracted from the temperature dependent resistance around the CNP. The scaling $\sqrt{B}$ points towards a quantum Hall ferromagnetic behaviour.*

c) *Splitting of the eight-fold degenerated lowest Landau level in bilayer graphene.*

d) *High-field two-terminal conductance in the lowest Landau level at B = 30 T and T = 0.3K. Features appearing around $\nu = 1/3$ and $\nu = 2/3$ propose the appearance of a FQHE.*