Gap opening at the charge neutrality point of a graphene transistor on hBN

Francesca Chiappini[1], Steffen Wiedmann[1], Uli Zeitler[1], Konstantin S. Novoselov[2], Andre K. Geim[2], Roman V. Gorbachev[2], and Jan C. Maan[1]

[1] *Radboud University Nijmegen, Institute for Molecules and Materials and High Field Magnet Laboratory, Toernooiveld 7, 6525 ED Nijmegen, The Netherlands*
[2] *School of Physics and Astronomy, University of Manchester, UK;*

We have performed magneto-transport experiments in a high-mobility graphene transistor sandwiched between h-BN in magnetic fields up to 30 T. We find an exponentially increasing resistance at the charge neutrality point (CNP) when increasing the magnetic field and/or decreasing the temperature. This behaviour suggests a field-induced gap opening at zero energy. Additionally, resistance minima at filling factors $\nu=\pm1$ develop for B >8 T which indicates a full lifting of the four fold degeneracy of the zero-energy Landau level [1].

In order to probe the nature of the $\nu=0$ state in more detail, we have carried out experiments in tilted magnetic fields. Extracting the gap Δ_0 from the field and temperature dependence of the resistance at the CNP, $R_{CNP} \propto \exp(\Delta/2K_BT)$, yields $\Delta \approx 3$ meV at 8 T perpendicular field which is considerably larger than the bare Zeeman splitting. Together with the fact that Δ mainly scales with the perpendicular field component, this suggest a gap opening driven by exchange interaction, and thus, v=0 is not spin polarized.

Adding an additional in-plane field and leaving the perpendicular field component constant leads to a slight decrease of the resistance at the CNP which can be explained by an increased spin-splitting within the two level pairs above and below zero energy [2].

[1] Y. Zhang *et al.*, Phys. Rev. Lett. **96**, 136806 (2006).
[2] A. Veligura *et al.*, Phys. Rev. B **85**, 115412 (2012).

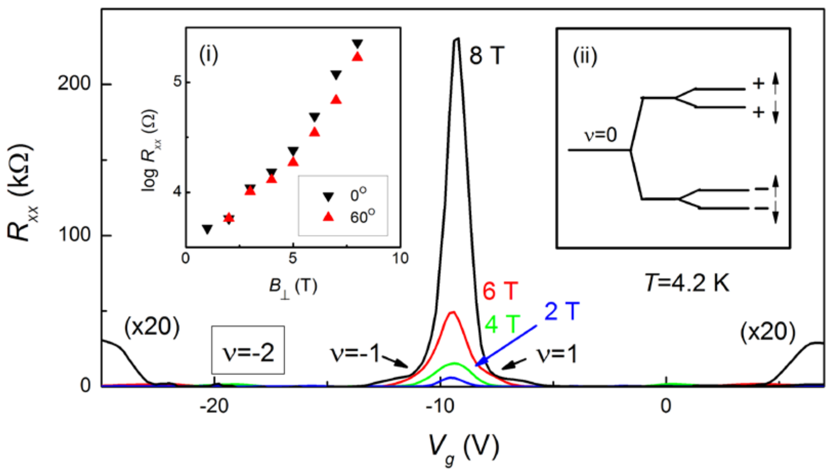

Fig. 1: Resistance as a function of gate voltage around the CNP. The inset (i) shows R_{CNP} as a function of the perpendicular field component for two tilt angles. Inset (ii) sketches the splitting scenario around v=0.