Gapped ground state in suspended bilayer graphene

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Bilayer graphene is an exciting material, widely extending the range of phenomena as compared to monolayer graphene. In bilayer graphene a gap can be opened by applying a potential difference between the two layers, for example. Furthermore, the eight-fold ground-state degeneracy of the zero-energy Landau level provides a large Hilbert space with novel composite particles, and due to the added mass, Coulomb interaction is expected to be much larger than in monolayer graphene when the carrier density is reduced. It has already been shown that the eight-fold ground state degeneracy can be lifted in a magnetic field. Here we show that high-mobility suspended bilayer graphene devices allow for a spontaneous gap formation at zero magnetic field [1] (similar work is reported in [2]) The properties of this gap are investigated by means of electronic transport measurements in magnetic field as a function of gate-voltage, source-drain bias voltage, and temperature. We find a very pronounced dip in the conductance at the charge neutrality point in a rather narrow gate-voltage window. The differential finite-bias conductance (dI/dV) reveals two kinds of gaps: a wide one of size ~2meV with a shape that mimics the BCS density-of-states and a smaller one of size ~0.5meV. When repeating current annealing we find samples where the conductance is vanishing fully over the whole width of the large gap and samples for which the conductance does not vanish at the charge-neutrality point. For the latter the conductance rather appears to saturate at low temperatures at a value that is independent of the applied magnetic field. The minimum conductance of 0.2 e^2/h at 230mK is however much lower than the typical minimum conductance values in monolayer graphene. We will also discuss recent four terminal measurements on suspended bilayer graphene.

We discuss the origin of the gaps in terms of the various many-electron broken symmetry states that have been put forward by theory in recent years.

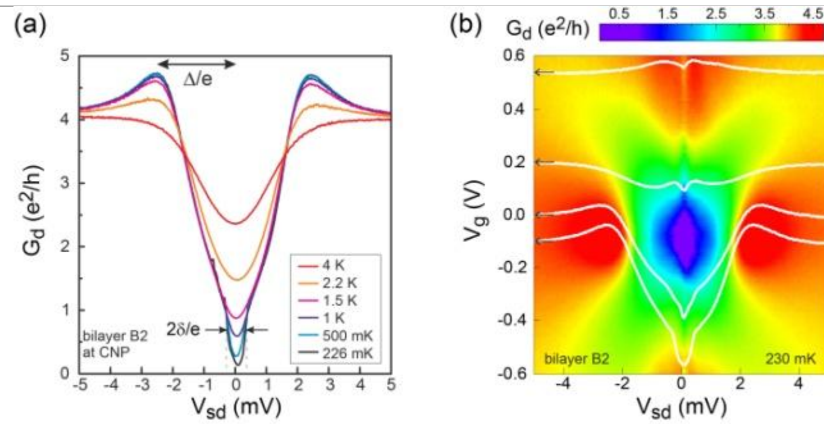

Figure: Differential conductance G_d=dI/dV measured as a function of source-drain bias voltage V_{sd} and back-gate voltage V_g. A pronounced gap forms around the charge neutrality point.

[1] F. Freitag, J. Trbovic, M. Weiss, and C. Schönenberger, arXiv:1104.3816, Phys. Rev. Lett. In press

[2] J. Velasco Jr., L. Jing, W. Bao, Y. Lee, P. Kratz, V. Aji, M. Bockrath, C.N. Lau, C. Varma, R. Stillwell, D. Smirnov, Fan Zhang, J. Jung, A.H. MacDonald arXiv:1108.1609