Experimental detection of graphene's singular orbital diamagnetism at the Dirac point.

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Abstract
The electronic properties of Graphene have been intensively investigated in the last decade, and signatures of the remarkable features of its Dirac spectrum have been displayed using transport and spectroscopy experiments. In contrast, the orbital magnetism of graphene, which arguably is the most fundamental signature of graphene's characteristic Berry phase, has not yet been measured at the level of a single flake. In particular, the striking prediction of a divergent diamagnetic response at zero doping calls for an experimental test.
Using a highly sensitive Giant Magnetoresistance Detector (GMR) we have measured the gate voltage-dependent magnetisation of a single graphene flake encapsulated between boron nitride (BN) crystals. The signal exhibits a diamagnetic peak at the Dirac point whose magnetic field and temperature dependence agree with theoretical predictions starting from the work of McClure in 1956 [1]. Our measurements open a new field of investigation of orbital currents in graphene and 2D topological materials, offering a new mean to monitor Berry phase singularities and explore correlated states generated by combined effects of Coulomb interactions strain or Moiré potentials.

References

[1] McClure, J. W., Physical Review, 104(3), 666, 1956.

Figures

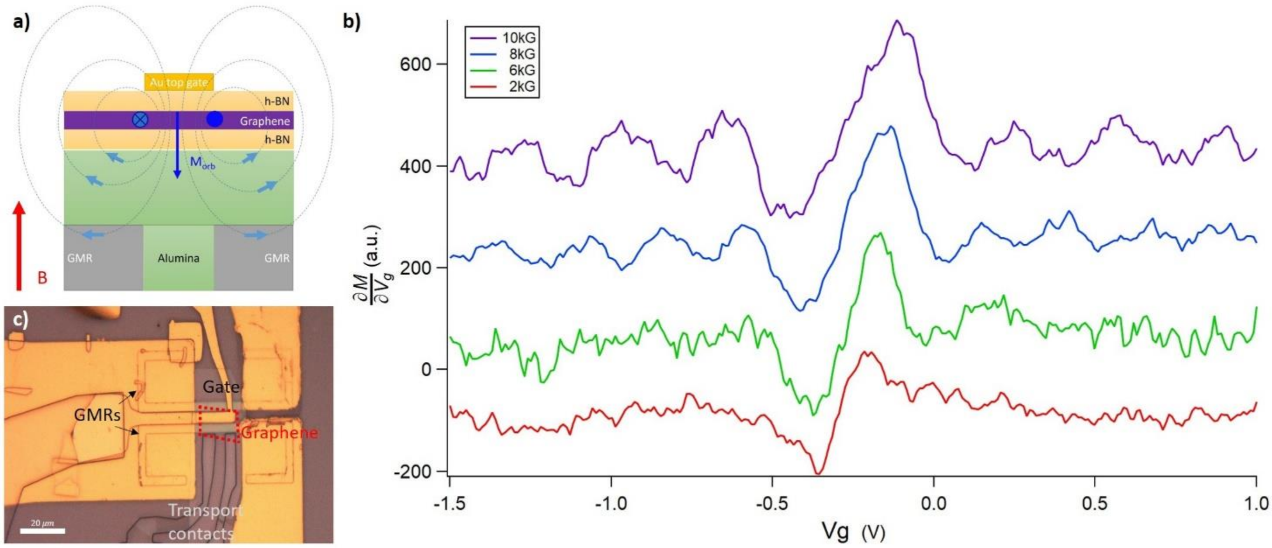

Figure 1: a) Schematics of the sample: encapsulated graphene (in BN) with a top gate was placed over two GMR probes to measure the leak field produced by its diamagnetic response to an external perpendicular magnetic field B. b) $\frac{\partial M}{\partial V_g}$ as a function of V_g for different external magnetic fields. Around $-0.3\ V$ one can distinguish the McClure peak. For $8\ kG$ and $10\ kG$, the de Haas - van Alphen oscillations are visible. c) Top image of the actual sample.