Pseudo-Spin Winding Number in Hydrogenated Graphene

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Introduction

The quantum Hall effect (QHE) has been previously observed in highly resistive hydrogenated graphene, with an estimated hydrogen coverage of up to ~0.1% sufficient to impart strongly insulating behavior in zero magnetic field [1]. The opening of an impurity induced gap in graphene upon hydrogenation is anticipated to break local sub-lattice symmetry, and thus may alter the Berry phase of Shubnikov-de Haas (SdH) oscillations as well as the Landau level (LL) sequence. We report here the observation of SdH oscillations in a strong magnetic field in graphene samples hydrogenated to different degree, and study the topological part of the Berry phase.

Experimental

As expected, the disorder introduced by hydrogenation leads to a broadening in the LLs. Consequently, high magnetic fields are required to observe the QHE. Strong magnetic fields from the DC facility at the NHMFL and the pulsed facility in Toulouse were used to study a variety of hydrogenated graphene samples by way of transverse (Hall) and longitudinal resistance.

Results and Discussion

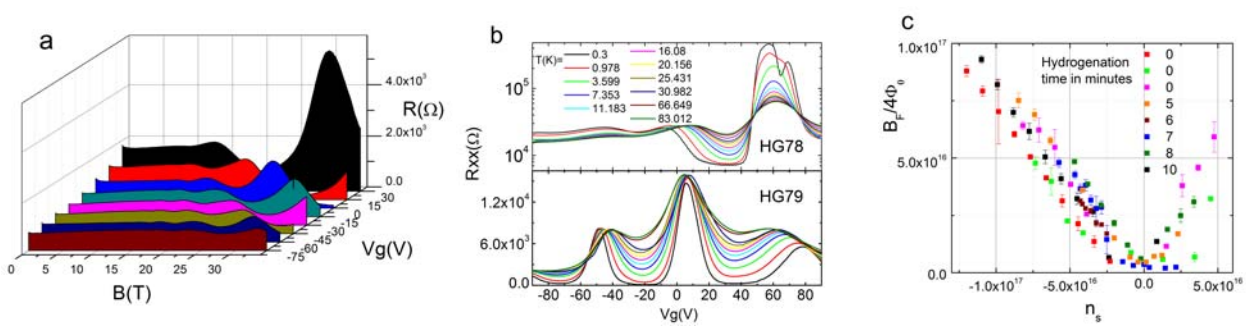

Figure 1 (a) shows an example of SdH oscillations versus magnetic field and gate voltage (hole density) for a representative sample. Figure 1 (b) shows the temperature dependence of the longitudinal resistance versus gate voltage (carrier density) for both a pristine (HG79) and a hydrogenated sample (HG78). At the Dirac point, a clear difference between both graphene samples is observed. Figure 1 (c) shows the SdH oscillation frequency B_F normalized to the flux quantum Φ_0=h/e versus the carrier density, n_s, for a variety of samples with different hydrogenation level. The collapse of the data over a universal curve with a near identical slope indicates that within ±15% the LL sequence remains four-fold degenerate in hydrogenated graphene.

Conclusions

Our observations of SdH oscillations in a variety of hydrogenated graphene samples indicate that the topological part of the Berry phase, meaning the pseudo-spin winding number that determines the LL sequence [2], is robust against the strong disorder introduced by the hydrogenation of graphene.

Acknowledgements

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References

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[2] J.N Fuchs et al, Eur. Phys. J. B 77, 351-362 (2010)