Aharonov-Bohm effect in graphene having Aluminum mirrors

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We observe the Aharonov-Bohm (A-B) effect in graphene rings with aluminum (Al) mirrors. The Al pads acting as mirrors are deposited in two different configurations, either on the bias lines (L-mirrors) or in the perpendicular direction (T-mirrors). This is shown in Figure 1a and 1b. Graphene is fabricated using mechanical exfoliation of Kish graphite and patterned using e-beam lithography (ebl) and oxygen plasma. Electrodes and Al pads are also defined using ebl.

At temperatures down to 17 mK, we could observe up to the third harmonic of A-B oscillations in the case of L-mirrors and up to the second harmonic in the case of T-mirrors. This represents an enhancement of the visible phase coherence as compared to earlier A-B experiments on graphene[1]. A typical measurement of resistance with varying magnetic field at our base temperature is shown in Figure 1c. Small periodic oscillations are seen on top of the stronger aperiodic universal conductance fluctuations. In Figure 1d, the FFT spectrum for such measurements is shown for temperatures ranging from 17 mK to 1590 mK.

We observe the higher order harmonics at magnetic fields up to ~1 T which is lower than in previously reported experiments but still exceeds the superconducting critical field of Al. This indicates that it is not superconductivity which is responsible for the observed improved coherence. We believe instead that a large Fermi-energy mismatch between graphene and aluminum explains this. The Al pads act as mirrors, confining the electrons within the A-B ring making the higher number of revolutions more probable. From weak localization measurements we estimate the phase coherence length to be 1.1 µm and 1.4 µm for L- and T-mirrors, respectively.

Our measurements were performed at temperatures down to 17 mK which is lower than for previously reported A-B experiments on graphene. At such low temperature we also observe a small transport gap of less than 1 mV. Assuming Coulomb-blockade effects, the size of the gap can be reasonably explained.

References

[1] S. Russo, J. B. Oostinga, D. Wehenkel, H. B. Heersche, S. S. Sobhani, L. M. K. Vandersypen, and A. F. Morpurgo, Phys. Rev. B, **77** (2008) 085413.

Figures

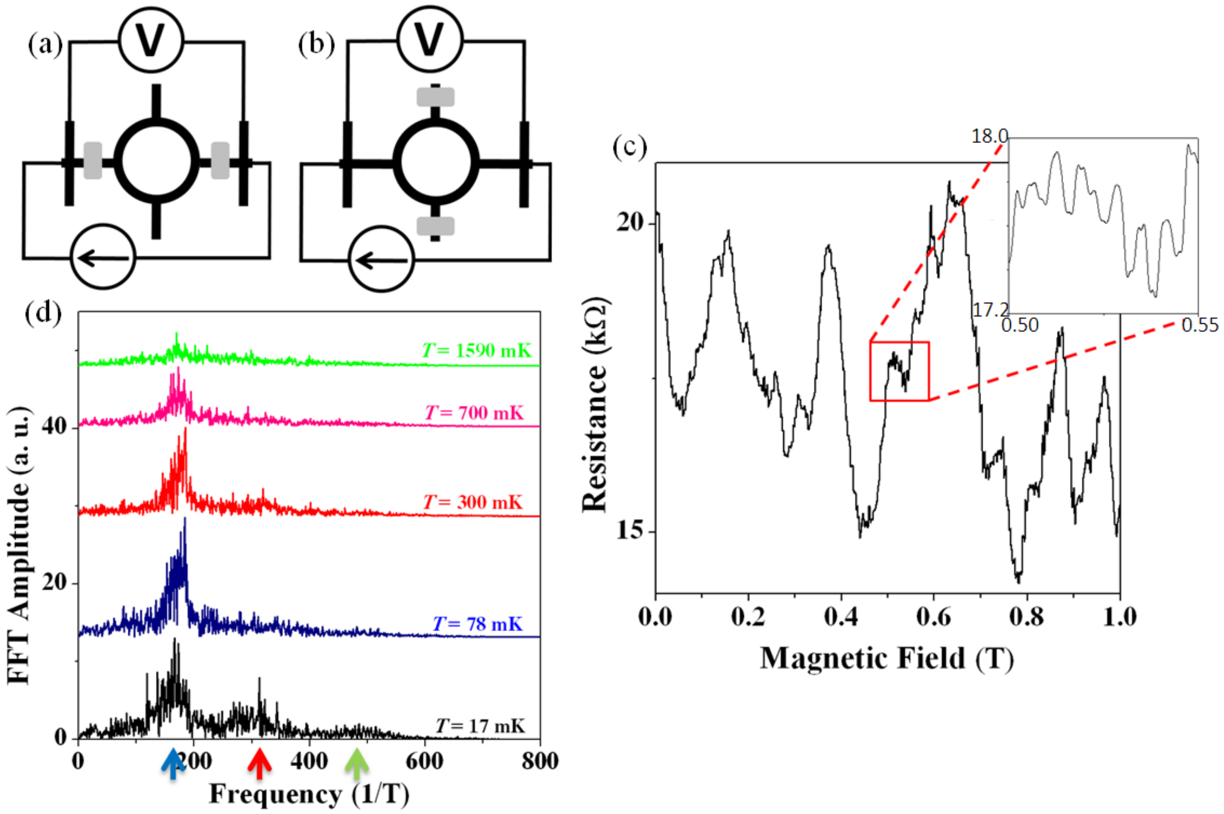

Figure 1*: a), b) The graphene is shaped into a A-B ring with several electrodes connecting to it. The grey rectangles correspond to Al pads deposited on the bias lines (L-mirrors) or in the perpendicular direction (T-mirrors) as shown in a) and b), respectively. c) Resistance of a graphene structure with L-mirrors as a function of magnetic field at 17 mK. There are small periodic oscillations on top of the large aperiodic universal conductance fluctuations. d) FFT spectrum of traces such as that in c) for temperatures ranging from 17 mK to 1590 mK. At our base temperature of 17 mK, we can see up to the third harmonic and at 1590 mK the first harmonic is still visible. The blue, red and green arrows correspond to the first, second and third harmonic peak as estimated from the device geometry.*