Magneto-Photoconductivity of Graphene Boron Nitride Heterostructures

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Introduction

When graphene is placed on atomically flat top of boron nitride (BN) sheets with a small twisting angle, the periodic electro static potential of the BN leads to replicas of the Dirac points (DP) at integer values of $n/n_0=g_sg_v=4$ [1], where n is the carrier density and n_0 is the inverse of the moiré pattern area. When a perpendicular magnetic field is applied, the interplay of the quantizing magnetic field and the periodic electrostatic potential leads to a self-recursive structure known as the Hofstadter spectrum. 'Butterfly samples' exhibiting the Hofstadter spectrum have been extensively studied already by traditional transport methods [2,3]. Here we exploit graphene's strong photocurrent (PC) response to probe fine details in the recursive spectrum.

Experimental

We measure PC on an encapsulated BN/bilayer grahpene structure. Light is delivered to the sample through either a single mode fiber or through a 200µm fiber for global illumination. Light from a 532nm diode is modulated by an AC voltage and the PC generated is measured by a lock-in amplifier triggering off the modulation frequency. Typically, a small DC bias is applied across the source/drain. The measurements were performed with the magnets in DC-field (18T SCM2) and EMR (14.5T) programs.

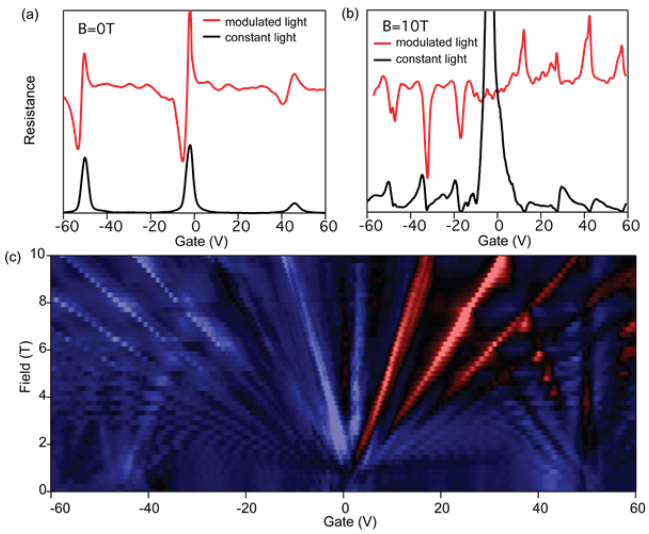

Fig 1: R_{xx} as a function of applied gate for B=0 (a) and 10T (b). The black curve is measured with an AC current and constant illumination and the red curve with modulated light and the PC measured at the modulated frequency. (c) LL fan diagram showing R_{xx}.

Results and Discussion

Fig1(a) shows the measured longitudinal resistance, R_{xx} as a function of applied gate voltage at zero magnetic field for both constant and modulated light, with the main and secondary Dirac peaks visible in both curves. When constant light is applied the gate response is the same as what would be expected with out light. When the light is modulated, the measured R_{xx} appears as a derivative of the constant light gate response. We believe that the derivative like nature of R_{xx} with modulated light is due to the modulation of the carrier density. In Fig1(b) we plot the measured R_{xx} as a function gate voltage at 10T for both constant and modulated light. Now the resistance measured with modulated light shows peaks at each landau level. However, the main Dirac peak is missing. Fig1(c) shows the evolution of R_{xx} in magnetic field. From this plot we can clearly see the Landau level spectrum from the main Dirac peak as well as from the secondary peaks. We also see very clearly down to 2T the horizontal lines referred to as 'pure cases' [1,4] where the normalized magnetic flux, $\Phi/\Phi_o = 1/m$, where m is integer valued. Careful inspection of Fig1(c) and other data (not shown) show possible recursive structure of levels that do not originate from either the main or secondary DPs. We therefore believe that PC on graphene heterostrucutres may provide an additional route to viewing the recursive structure of the Hofstadter spectrum in more detail than traditional transport. However, more experiments at higher magnetic fields are needed.

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References

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