Quantum transport in nanostructured graphene

Ballistic and quantum effects are often suppressed in nanostructured graphene due to disorder effects. With careful sample preparation, however, spectacular effects can be observed and modelled with quantitative agreement. In this talk, I describe three such cases. The first one is a theoretical prediction – yet to be realized, but the next two are jointly carried out by experimentalists and theorists, and a very satisfactory agreement is achieved between theory and experiment. (1) A nonplanar sheet of graphene may exhibit “pseudomagnetic” fields. The two inequivalent valleys in the band structure of graphene couple differently to a pseudomagnetic field suggesting the possibility of manipulating the valley index (valleytronics) with the pseudomagnetic fields. I describe a recent suggestion utilizing these ideas based on bubbles in a graphene sheet [1]. (2) Graphene nanowires, formed at the step edges of a SiC crystal, can display exceptional ballistic transport [2]. In recent experiments, in a multiprobe STM setup, spatially resolved measurements can probe the details of the conductance channels, thus putting these useful theoretical concepts on a firm experimental basis. I describe these measurements, and their detailed modelling, which agree in quantitative detail [3]. (3) Commensurality oscillations may occur in magnetotransport in periodically modulated two-dimensional systems. The challenge for graphene based systems has been the fabrication of sufficiently tight and regular superlattices. Recently it has been realized that encapsulating the graphene layer between hBN layers first, and only subsequently applying the ebeam-assisted etching to fabricate the periodic lattice, leads to sufficiently regular structures where these quantum effects can be observed [4].

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