The electronic properties of graphene

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In this talk we shall review the electronic properties of graphene [1] and some of the recent developed applications. Graphene was discovered in the late 2004 at the Centre for Mesoscopic and Nanotechnology of the University of Manchester, directed by Prof. A. K. Geim. This two-dimensional material is made entirely out of carbon atoms which arrange themselves in a honeycomb (hexagonal) lattice.

The electronic density of this material corresponds to having one electron per each carbon atom. The lattice geometry and its corresponding symmetry group determines the form of the electronic energy dispersion associated with the electron Bloch waves. The interplay between the lattice geometry and the electronic content of the material put the Fermi energy in such a position that the Fermi surface is reduced to six points in the Brillouin zone. The electronic dispersion around these six points is observed to be isotropic and linear in momentum. A consequence is that the effective model that describes the electronic excitations around the Fermi points is given not by the Schrödinger equation but by the Dirac equation in two spatial dimensions. The two spinor elements describing the electron wave function around the Fermi points represents the fact that the honeycomb lattice has two atoms per unit cell.

The fact that the elementary excitations are effectively described by the Dirac equation has wide range and some times even unpredictable consequences on the electronic properties of this system. In particular, most of the results one reads in the condensed matter literature about the two-dimensional electron gas formed in the inversion layers does not apply to electrons in graphene. This means that thermodynamic, transport, and spectral properties of electrons in graphene need to be revisited. The prospects of finding new exciting physics in graphene, which in turn may lead to unexpected applications in nanotechnology has been fueling both the experimental and theoretical research in this rapidly accelerating field.

We shall review the transport properties of graphene and its bilayer and how these properties are a consequence of the Dirac-like nature of the spectrum of graphene.

Keywords: graphene, Dirac, nanotechnology

References

[1] A. H. Castro Neto, F. Guinea, N. M. R. Peres, K. S. Novoselov, A. K. Geim, "The electronic properties of graphene", to appear in Review of Modern Physics (2008); (http://arxiv.org/abs/0709.1163)