An extended abstract

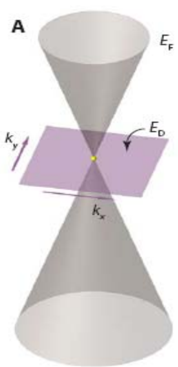
Observation of Plasmarons in Quasi-Free-Standing Doped Graphene

1) A. Bostwick, F. Speck, T. Seyller, K. Horn, M. Polini, Reza Asgari, A. H. MacDonald and Eli Rotenberg, Science (2010).

Graphene is a newly realized two-dimensional (2D) electron system which has engendered a great deal of interest because of the new physics which it exhibits and because of its potential as a new material for electronic technology. The possibility to isolate and investigate graphene has been recently demonstrated by experimental groups. They were reported showing states near the Fermi energy of a graphene sheet are described by a massless Dirac equation which has chiral band states in which the honeycomb-sublattice pseudo-spin is aligned either parallel to or opposite to the envelope function momentum. In graphene, the physics of relativistic electrons is now experimentally accessible in solid-state devices, whose behavior differs drastically from that of similar devices fabricated with common semiconductors. Consequently, new unexpected phenomena have been observed, and phenomena that are well understood in common semiconductors –such as the quantum Hall effect or weak-localization- exhibit surprising differences in graphene. Graphene device allows simulating in solid-state experiments some subtle and previously unreachable effects from high-energy physics, such as Klein tunnelling and vacuum breakdown. At the same time, graphene is considered as a perspective material for *'post-silicon electronics'*, and the first graphene transistors were already created and studied. Being both transparent and highly conducting, graphene has a very high potential for use in optical devices. Chemical, mechanical and other properties of graphene also open new ways for numerous important applications. It is not surprising therefore than graphene became one of the hottest subjects in contemporary physics and materials science and the number of publications in the field, including top-level scientific journals, as well as the number of researchers involved, grew exponentially.

In our recent work [1], by measuring the spectral function of charge carriers in quasi-free-standing graphene using angle-resolved photoemission spectroscopy and by calculating the many-body electron-electron and electron-phonon interactions based on the microscopic calculation of the quasiparticle self-energies, we show that at finite doping, the well-known linear Dirac spectrum does not provide a full description of the charge-carrying excitations. We report that there also exist composite "***plasmaron***" particles, consisting of particles dressed by density oscillations of the graphene electron gas. Plasmaron particles can be described by the short-range interactions between quasiparticles through creation of a polarization cloud around each charge carrier, screening each from its neighbors. The Dirac crossing point is resolved into three crossings: the first between pure charge bands, the second between pure plasmaron bands, and the third a ring-shaped crossing between charge and plasmaron bands. These findings pave the way for new plasmonic devices based on graphene.

A: Non-interacting, single-particle picture



H: Interacting, many-body picture