Application Note
Plasmaronic particles in graphene

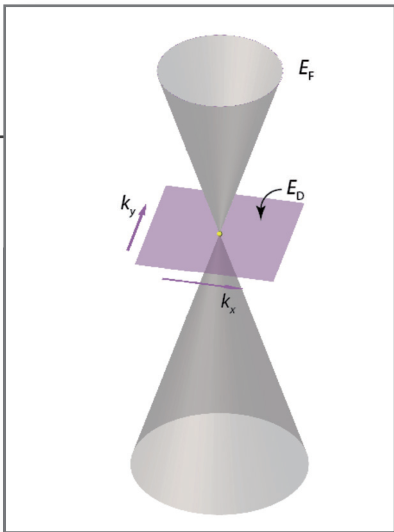

Figure 1: Schematic illustration of the band dispersion of graphene. The Dirac point energy is marked with E_D.

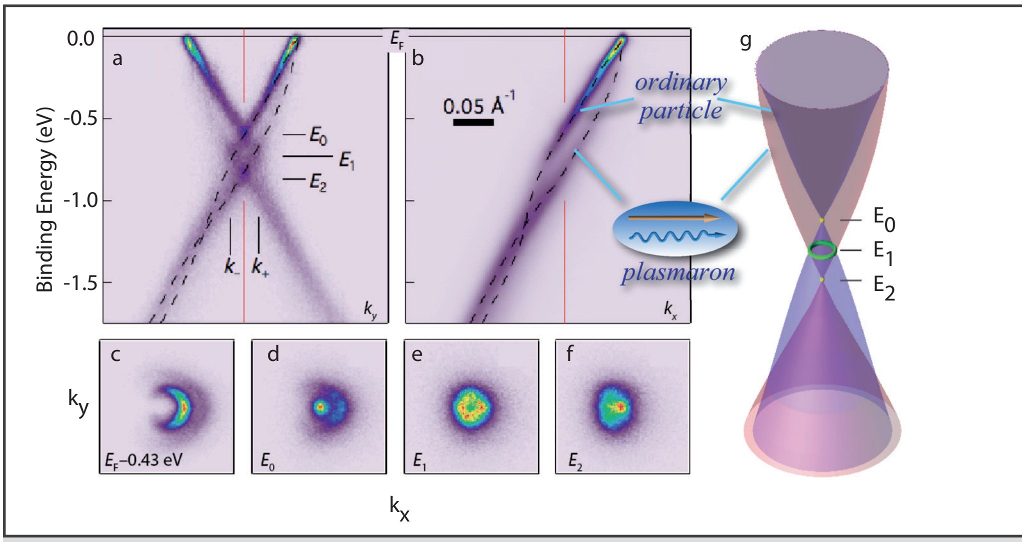

Figure 2: a-f) ARPES spectra of doped graphene. a and b) k vs binding energy spectra perpendicular and parallel to ΓK direction of the graphene Brillouin zone. Dashed lines are guidelines to the observed hole and plasmaron bands. Red lines indicate k = 0. a-f) Constant energy cuts (at E_F = -0.43 eV and as indicated in g). k-scale according to scale bar in b. g) Schematic illustration of the band dispersion of doped graphene.

Graphene has rendered a huge interest over the last years due to its promising future in a variety of fields, such as in electronic applications where it is a candidate for 'post-silicon' transistors. But it also offers new insights in physics.

A. Bostwick et al. report in Science 328(2010)999 on the first observation of plasmaron bands in any material as detected in graphene using angular resolved photoemission (ARPES).

The experiments reported on here were carried out at the 7.0.1 beamline at the Advanced Light Source using a Scienta Omicron R4000 analyser on a quasi-freestanding doped graphene sample.

ARPES spectra of a finite doped system show a picture where the presumed linear Dirac spectrum is not seen (see Figure 1). Instead, the Dirac crossing region is completely reconstructed (see Figure 2 g), now showing new bands associated with plasmaronic particles. Plasmarons are bound states of charge carriers with plasmons which are density oscillations of the remaining charges. Thus, the plasmarons are a manifestation of strong electron-electron interactions in graphene. The band structure near the Dirac crossing point is here divided into pure charge bands, pure plasmaron bands and a ring-shaped crossing between these two bands. The observed plasmarons are formed by the coupling of the elementary charges with plasmons. Understanding how charge carriers interact is necessary to exploit graphene as a material to build the next generation electronics.

This application note is made in collaboration with Eli Rotenberg at the Advanced Light Source, a division of the Berkeley Lab, California, USA.

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