Charge-Carrier Screening in Single-Layer Graphene

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WIDTHS OF MDCS

Extracting the widths of MDCs (momentum distribution curves, or intensity profiles at constant energy) follows a standard procedure. [1] MDCs are typically Lorentzian functions with widths proportional to the inverse lifetime and positions given by the real part of the self energy. Figure S1a shows the MDCs (black) used in figure 2b, as well as the Lorentzian fits (red) used to extract the widths of the peaks. The statistical error in these fits gives us the error bars in figure 2b.

The units of figure 2b are given in terms of $\mathring{A}^{-1}$, whereas equation (1) is written in terms of the self-energy (ImΣ). Extracting the imaginary self-energy from the peak widths requires the well-known relation [2]

$$2\mathrm{Im}\Sigma = \hbar v_k \delta k, \tag{1}$$

where $v_k = v_F$ is the Fermi velocity, δk is the MDC width, and $\hbar = 1$ in the units of equation (1). Since both the left and right sides of equation (1) has a factor of v_k in the numerator, the extraction of the impurity density from figure 2b is roughly independent of the Fermi velocity:

$$\delta k_{\mathrm{k_F}} = \alpha^2 n_{\mathrm{imp}} \pi I(2\alpha)/k_{\mathrm{F}} + Const. \tag{2}$$

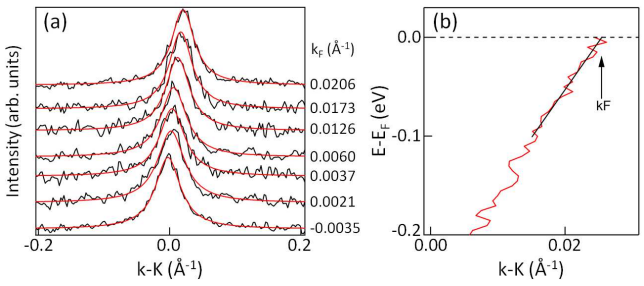

FIG. 1: (a) Extraction of MDC widths. Fermi MDCs (black) and Lorentzian fits (red) contributing to figure 2b in the primary manuscript. MDCs from progressively higher dopings are offset for clarity. Panel (b) demonstrates the extraction of the Fermi momentum ($\mathrm{k_F}$).

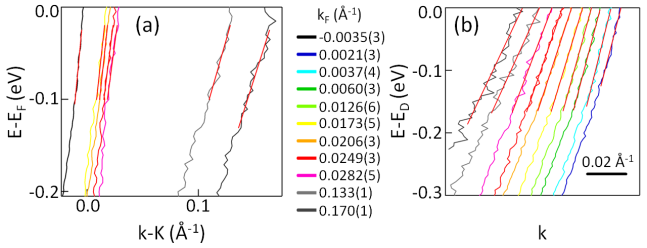

FIG. 2: Extraction of band velocities and Fermi momenta. Panel (a) shows linear fits (red) to the dispersions near $\mathrm{E_F}$. Panel (b) shows linear fits (red) to the dispersions near $\mathrm{E_D}$. The dispersions in panel (b) have been given arbitrary momentum offsets for better visibility. The errors in the last significant figure of $\mathrm{k_F}$ are given in parentheses.

EXTRACTION OF BAND VELOCITIES AND FERMI MOMENTA

The extraction of band dispersions also follows a standard procedure. Peak positions are extracted from MDCs, then plotted as a function of energy and momentum. These are shown in figures S2a-b.

Band velocities are proportional to the slopes of the dispersions. Looking at figures 3b and 3c in the main text, it is clear that the slopes of the dispersions change as a function of doping: near the top of both panels the dispersions coincide, but as doping increases the dispersions shift progressively further to the left with increasing binding energy; the differing slopes of the dispersions cause them to separate as they approach the bottom of the panels. Panel 3d was then obtained by fitting straight lines to these dispersions over a small energy range. These straight lines are shown in red in figures S2a-b, and the error bars in figure 3d are the statistical errors in these fits.

Extraction of the Fermi momentum is demonstrated in figure S1b. The Fermi momentum is taken to be the point where the dispersions cross the Fermi level, marked by the arrow in the figure. Error bars for the Fermi momenta are smaller than the size of the markers in figures 2b and 3d in the main text but are listed in figure S2.

[1] A. Damascelli, Z. Hussain, and Z.-X. Shen, Rev. Mod. Phys. **75**, 473 (2003).

[2] T. Valla, A. V. Fedorov, P. D. Johnson, and S. L. Hulbert,
Phys. Rev. Lett. **83**, 2085 (1999).