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Spectroscopic Signatures of Strong Correlations and Unconventional Superconductivity in Twisted Trilayer Graphene

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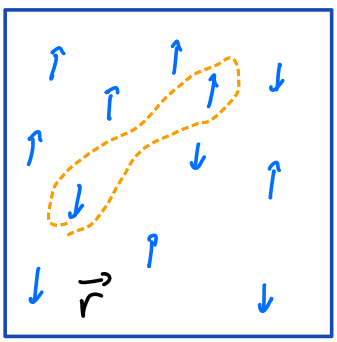
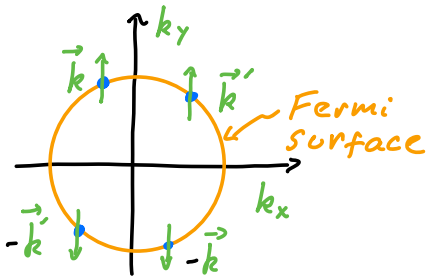
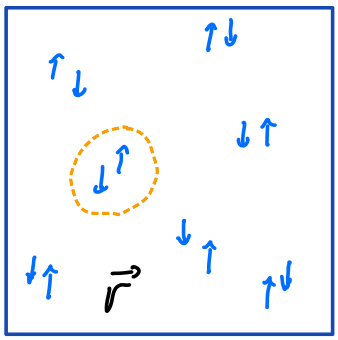
temperatures and magnetic fields. The observed evolution of the conductance with doping is consistent with a gate-tunable transition from a gapped to a nodal superconductor, which we show theoretically is compatible with a sharp transition from a Bardeen-Cooper-Schrieffer (BCS) to a Bose-Einstein-condensation (BEC) superconductor with a nodal order parameter.

$$H = \sum_{\vec{k}} E(\vec{k}) \left\{ c^{\dagger}_{k\uparrow} c_{k\uparrow} + c^{\dagger}_{-k\downarrow} c_{-k\downarrow} \right\} - \sum_{\vec{k}\vec{k}'} c^{\dagger}_{k\uparrow} c^{\dagger}_{-k\downarrow} V(\vec{k},\vec{k}') c_{-k'\downarrow} c_{k'\uparrow}$$

$N_{k\uparrow}$







BCS

BEC

$$\psi_{\text{Pair}}(\vec{k}) = \langle c_{\vec{k}\uparrow} c_{-\vec{k}\downarrow} \rangle = \Delta(\vec{k})/\mathcal{E}(\vec{k})$$

$$\langle \psi_{\uparrow}(\vec{r}) \psi_{\downarrow}(\vec{r}) \rangle$$

Quasiparticle dispersion: $\mathcal{E}(\vec{k}) = 2\sqrt{E^2(\vec{k}) + \Delta^2(\vec{k})}$

Self-consistent gap: $\Delta(\vec{k}) = -\sum_{\vec{k}'} V(\vec{k},\vec{k}') \frac{\Delta(\vec{k}')}{\mathcal{E}(\vec{k}')}$

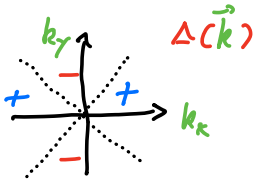
Gap symmetries:

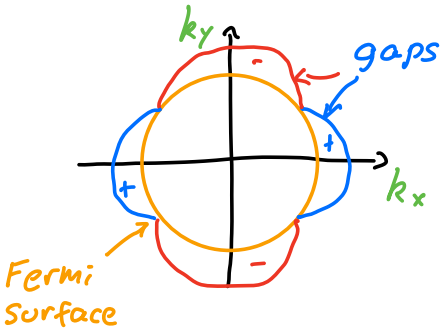
s-wave $\Delta_s(\vec{k}) = \Delta_0$ nodeless

d-wave $\Delta_d(\vec{k}) = \Delta_0 (\cos k_x - \cos k_y)$ nodal lines

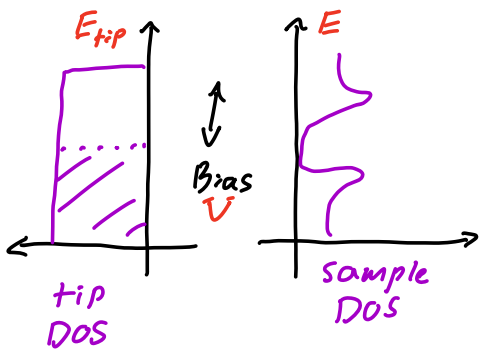
also: p-wave $\vec{\Delta}_p(\vec{k})$, s+id, etc.

$d_{x^2-y^2}$:

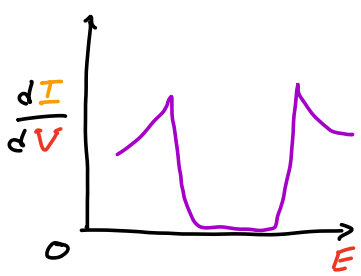




Tunneling spectroscopy

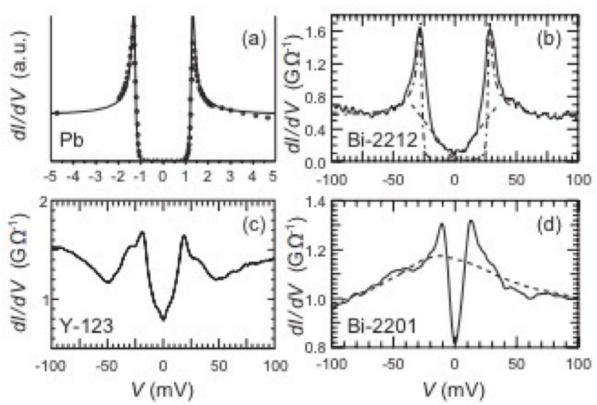


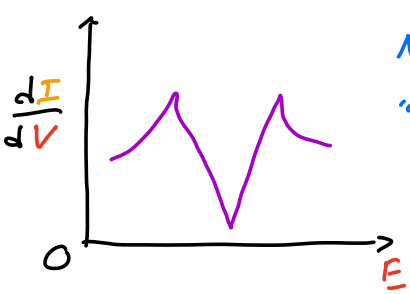
$\Rightarrow$



Isotropic gap

"U-shaped"





Nodal gap

"V-shaped"