The Case for Quasiparticles in the Superconducting
State of the High $T_c$ Cuprates

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To what extent can we understand the superconducting phase of the cuprates in terms of a $d_x^2-y^2$-BCS framework?

Is the superconducting state of the cuprates adiabatically connected to the $d_x^2-y^2$-BCS state?

So what is the problem?

The BCS theory is based on the pairing instability of a hypothetical “normal state fermi-liquid” while the normal state of the undoped cuprates is a Mott AF insulator and the doped state is a “strange metal”.

Here we will remind ourselves what enters a $d_x^2-y^2$-BCS quasiparticle description (e.g. a renormalized band energy $\epsilon_k$, a renormalized gap $\Delta_k = \frac{\Delta_0}{2} (\cos k_x - \cos k_y)$, lifetimes, and a finite renormalized quasiparticle weight $Z(k_f)$. Then remembering that there can be vertex corrections, we will discuss how well a quasiparticle description works in describing the thermal and microwave conductivities and see what it tells us about the low temperature electronic specific heat and NMR relaxation rates. Then we’ll turn to the STM and ARPES results.

We’ll argue that one can understand the collapse of both the inelastic and forward elastic scattering rates leading to well-defined BCS quasiparticles. Then, provided one avoids the underdoped regime of multiple-order parameters, the BCS framework can provide a useful description of the cuprate superconducting phase.

Finally, we’ll look at what one can learn about the pairing mechanism by looking at the low-temperature superconducting state within the BCS framework.