Quasiparticles in $d-$wave superconductors

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Abstract

We present a semiphenomenological approach to calculating the quasiparticle spectra of high temperature superconductors. It is based on a particularly efficient parametrization of the effective electron-electron interaction afforded by the density functional theory for superconductors and a tight-binding-linearized-muffin-tin-orbital scheme for solving the corresponding Kohn-Sham-Bogoliubov-de Gennes equations. We apply this methodology to $YBa_2Cu_3O_{7-\delta}$ (YBCO) and illustrate its potential by investigating a number of site and orbital specific, but otherwise phenomenological, models of pairing in quantitative detail. We compare our results for the anisotropy of the gap function on the Fermi surface with those deduced from photoemission experiments on single crystals of YBCO. Also, the low temperature specific heat and penetration depth are calculated and compared with measurements. We investigate the doping dependence of the superconducting gap, transition temperature, T_c, and penetration depth. We present new evidence that the Van Hove-like scenario is an essential feature of superconductivity in the

cuprate superconductors. Since our description of pairing is phenomenological, we shed new light on the physical mechanism of pairing only indirectly and conclude, provisionally, that the dominant pairing interaction operates between electrons of opposite spins, on nearest neighbour Cu sites in $d_{x^2-y^2}$ orbitals.