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Microscopic approach to high-temperature superconductors

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Starting from the t-J model, microscopic properties of high-temperature superconductors will be discussed in the superconducting and in the pseudogap phase at moderate hole doping. Our theoretical approach (PRM) is based on a stepwise elimination of high-energy transitions using unitary transformations. For both phases, one arrives at renormalized 'free' Hamiltonians for correlated electrons. For the superconducting phase, the order parameter turns out to have d-wave symmetry with a correlation length of a few lattice constants. Also, the spectral function from angle-resolved photoemission spectroscopy (ARPES) along the Fermi surface is in good agreement with experiment. For the pseudogap phase, our analytical results show well-defined excitation peaks around $\omega = 0$ near the nodal direction which become strongly suppressed around the antinodal point. The origin of the pseudogap can be traced back to a suppression of spectral weight from incoherent excitations in a small ω-range around the Fermi energy.