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Anomalous superconductivity near the Mott transition

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High-temperature superconductivity appears near an antiferromagnetic Mott insulating phase and a normal phase with a pseudogap. It was suggested early on by Anderson that the strong-coupling limit of the Hubbard model should contain the main physics. It is only recently that we have begun to have access to sufficiently accurate algorithms and powerful enough computers to begin to extract the main features of the phase diagram of high-temperature superconductors from the Hubbard model in a nearly quantitative manner. In this talk, the zero temperature phase diagram of the two-dimensional Hubbard model is discussed based on several "quantum cluster" approaches, mainly Variational Cluster Perturbation Theory [1] and Cellular Dynamical Mean Field Theory [2], that shall be introduced. The overall ground state phase diagram of the high-temperature superconductors as well as the asymmetric one-particle excitation spectra for both hole- and electron-doping are reproduced. The d-wave order parameter is found to assume a dome shape as a function of doping and to scale like the magnetic exchange coupling J for U comparable to the bandwidth. We stress the features of superconductivity that are non-BCS like due to the proximity to the Mott insulator. In stark contrast with BCS theory, the superconducting gap can decrease monotonically at the same time as the d-wave order parameter increases away from half-filling. Also, d-wave superconductivity is driven by a lowering of kinetic energy instead of potential energy, in conformity with experiments on cuprates. The pseudogap [3-5] and results of other approaches will also be briefly touched upon.

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