KOÇ UNIVERSITY

Science – Math Seminar

Speaker: Nihat Berker
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Date: Thursday, April 21, 2005
Time: 16:45 (Tea and cookies will be served at 16:30)
Place: Science Building, Room Z42

Title: Phase Diagrams with Two Superconducting Phases, Superfluid Weights and Free Carrier Densities: Microscopic Renormalization-Group Theory

Abstract:

The theoretical solution of quantum mechanical electronic conduction systems is essential for the understanding of high-T_c superconductivity. We have made progress along this line, by solving the Hubbard and tJ models in d=3 with renormalization-group theory and obtaining their phase diagrams and thermodynamic properties for all temperatures, densities, and coupling strengths. In the Hubbard model, at low temperatures and around half filling, an antiferromagnetic phase, of purely quantum mechanical origin, is obtained. Furthermore: (1) At strong coupling and 30-35% electron or hole doping from half filling; (2) At weak and intermediate coupling and 10-18% electron or hole doping; two distinct novel phases, which we call τ phases, were found. The distinguishing characteristic of these phases is that the electron or hole hopping expectation value is non-zero at all length scales. The weak-intermediate coupling τ phase exhibits, as in BCS superconductivity, an excitation spectrum gap and, in the specific heat, a low-temperature exponential decay and a cusp phase transition singularity. The strong coupling τ phase exhibits, as in BEC

superconductivity, in the specific heat, an α~-1 phase transition singularity and a pair-formation peak above the phase transition temperature. In the limit of large Coulomb repulsion, the tJ model is obtained. In our calculations for this model, we find that the superfluid weight increases with doping, passes through a maximum within the τ phase at 32-37% doping, and decreases, and that the free carrier density also increases to a maximum value at 32-37% doping but remains at this value for further doping. These characteristics, seen experimentally in high-T_c superconductors, have not been obtained in previous theoretical studies.

This research has been performed with my doctorate student Michael Hinczewski.

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