CONDENSED MATTER SCIENCES SEMINAR

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Host

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Title

Fermi-volume-changing quantum phase transitions and the cuprate phase diagram

Friday, January 31st, 2025

1st Floor – B101

15:00-16:00

Abstract

A Fermi liquid with a 'large' Fermi surface (FL) can have a quantum phase transition to a spin density wave state (SDW) with reconstructed 'small' Fermi pockets. Both FL and SDW phases obey the Luttinger constraints on the volume enclosed by the Fermi surfaces. The critical spin fluctuations lead to spin-singlet d-wave pairing, as observed in the cuprates. Studies of the influence of spatial disorder on the SDW-FL quantum phase transition predict an extended quantum-critical Griffiths-type phase at low temperatures on the large Fermi surface side. These computations agree with recent low temperature neutron scattering observations on LSCO.

However, this theory cannot explain the higher temperature pseudogap and strange metal phases of the hole-doped cuprates. Here we need to consider underlying Fermi-volume-changing quantum phase transitions without symmetry breaking. Then the small Fermi surface phase does not obey the Luttinger constraint, and is instead a `fractionalized Fermi liquid' (FL*). A theory of FL* in single band models describes photoemission observations in the pseudogap phase. The FL*-FL quantum phase transition, and the influence of spatial disorder, is described by an analysis inspired by the Sachdev-Ye-Kitaev model. This theory successfully describes linear-in-temperature resistivity, optical conductivity and thermopower observations.

The crossovers connecting these lower and higher temperature descriptions are also discussed.