Workshop “Localization in Quantum Systems”
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Localization in Dynamical Mean Field Theory, V. Dobrosavljevic

Lecture 1: Effective Medium Approaches (EMA) for Disorder within DMFT

Dynamical Mean-Field Theory is currently regarded as the most successful non-perturbative method for strongly interacting electronic systems. Here, the electron-electron scattering processes are described within a local approximation, reducing the lattice problem to the solution of a quantum impurity embedded in a self-consistently defined Effective Medium (the “Cavity”), representing its environment. Its simplest implementation in presence of disorder leads to the Coherent Potential Approximation (CPA), which despite capturing some nontrivial disorder effects for correlated strongly electrons, is not able to describe disorder-induced bound state formation (“Anderson localization”). A more sophisticated DMFT-based effective medium approach to disorder, the so-called Typical Medium Theory (TMT), is able to capture both Anderson localization and strong interaction effects at the same footing, thus representing a new order parameter theory of the metal-insulator transition. We briefly review several recent applications of these methods, providing insight on how Anderson localization is affected by various interaction effects, including the electronic correlations of Mott-Hubbard type, the role of the lattice deformations and polaronic effects, as well as the effects of electron (Coulomb) glass formation.

Lecture 2: Beyond EMA - Friedel Oscillations and Electronic Griffiths Phases

DMFT-based Effective Medium Approaches to interaction-localization replace the environment (the “Cavity”) of each site with an appropriately chosen (algebraic or geometric) average. To properly capture situations with significant spatial fluctuations of the electronic wave function amplitude, one must go beyond EMA, allowing the electronic self-energy to assume site-to-site fluctuations. This strategy, which is formally similar to the Thouless-Anderson-Palmer (TAP) approach to spin glasses, provided significant new insight in how strong correlations renormalize the random potential seen by itinerant electrons. The resulting “healing” effect of strong correlations is found to dramatically suppress the long-distance component of the Friedel oscillations, suggesting strong suppression of weak-localization effects. The same mechanism is also found to play a significant role in correlated superconductors, strongly limiting the pair-braking effects in d-wave systems, reconciling the Abrikosov-Gor’kov mechanism with experimental observations in cuprates. Furthermore, a novel Electronic Griffiths Phase is identified in moderately disordered Mott systems, where rare disorder configurations (“Mott droplets”) dominate the thermodynamic response of a strongly correlated metal, producing disorder-driven non-Fermi liquid behavior.