Abstract

CONTINUOUS UNITARY TRANSFORMATION APPROACH
TO THE STRONGLY CORRELATED SYSTEMS

Magdalena Barańska

In the doctoral thesis we discuss an alternative theoretical tool based on the selfadapted continuous unitary transformation. Its algorithm belongs to the renormalization group techniques allowing to investigate the correlation effects beyond a perturbative framework. On a technical level the method develops unconventional scaling in the entire Hilbert space, gradually disentangling the low from high energy modes. Continuous diagonalization of the relevant Hamiltonian is achieved via the set of scaling (flow) equations. We shall give a few examples how this continuous unitary transformation technique can be applied to strongly correlated systems, for instance: superconductors and the Kondo impurities hybridized with external charge reservoirs.

Superconducting order and magnetic impurities are usually detrimental to each other. We show, however, that in nanoscopic objects the induced electron pairing can have constructive influence on the Kondo effect originating from the effective screening interactions. Such situation is possible at low temperatures in the quantum dots placed between the conducting and superconducting reservoirs, where the proximity induced electron pairing cooperates with the correlations amplifying the spin exchange potential. The emerging Abrikosov - Suhl resonance, which is observable in the Andreev conductance, can be significantly enhanced by increasing the coupling to superconducting lead. We explain this intriguing and unintuitive tendency within the Anderson impurity model using: the generalized Schrieffer - Wolff and the continuous unitary transformation.

All conventional superconductors at critical temperature Tc loose any resistance to the electric current and simultaneously become ideal diamagnets, perfectly screening dc magnetic fields. We have theoretically shown that remnants of such ideal diamagnetism can be preserved throughout a wide temperature regime above Tc if the conduction band electrons bind into the pairs without yet forming the Bose - Einstein condensate necessary for establishing global macroscopic coherence of the superconducting state. We adopt the continuous unitary transformation to the boson - fermion model describing melange of preformed pairs mixed with unpaired single electrons

Warszawa, 27.06.2016 M. Barańska

we have investigated the linear response to an external electromagnetic field. Our study provides the evidence for the fragile diamagnetism surviving to as high temperatures as twice Tc. This theoretical result could explain the puzzling experimental data obtained by the torque magnetometry for the high Tc cuprate compounds and might be relevant to similar behavior in other low-dimensional correlated systems.

Hannover, 27.06.2016 M. Bandres