Kinematical spin-fluctuation mechanism of high-temperature superconductivity in cuprates

Nikolay M. Plakida
Joint Institute for Nuclear Research, 141980 Dubna, Russia

Abstract

We review a microscopic theory of superconductivity based on the spin-fluctuation mechanism of pairing. We argue that the cuprate superconductors are strongly correlated electronic systems where electronic excitations have to be described by the projected (Hubbard) electron operators in the singly- and doubly occupied Hubbard subbands. Due to the unconventional commutation relations for the Hubbard operators, a specific kinematical interaction of electrons with spin and charge fluctuations emerges. A new energy scale of the order of kinetic energy of electrons $W \sim 2$ eV appears in the itraband hopping which is much larger than the antiferromagnetic exchange interaction J induced by the interband hopping. Taking into account this interaction, a microscopic theory of superconductivity in cuprates is presented within the extended Hubbard model where the intersite Coulomb repulsion V and electron-phonon interaction are taken into account [1]. The Dyson equation for the normal and pair Green functions for two Hubbard subbands is derived using Mori-projection technique. The self-energy is calculated in the self-consistent Born approximation. We found the d-wave pairing with high-T_c mediated by the kinematical spin-fluctuation interaction. Contributions coming from the realistic in cuprates intersite Coulomb repulsion and electron-phonon interaction turned out to be small since only $L = 2$ harmonic of interactions gives contributions to the d-wave pairing. Isotope effect on T_c induced by electron-phonon interaction is weak at optimal doping and increased at low doping. Superconductivity can be suppressed only for the large intersite Coulomb repulsion $V > W$ [2]. The kinematical interaction is absent in the spin-fermion models and is lost in the slave-boson (-fermion) models treated in the mean-field approximation.

[1] N.M. Plakida, V.S. Oudovenko, EPJ **86**, 115 (2013), arXiv:1301.4347.
[2] N.M. Plakida, V.S. Oudovenko, JETP **146**, 631 (2014), arXiv:1402.4934.