THE DIAGRAMMATIC THEORY FOR STRONGLY CORRELATED ELECTRON SYSTEMS

L. A. Dohotaru
Technical Universityof Moldova, Chisinau 2004, Moldova.
E-mail: l_dohotaru@mail.utm.md

Solution of high-temperature superconductivity problem is closely connected with the construction of the theory of strongly correlated electron systems, which is now the central problem of condensed matter physics.

The strong coupling diagram technique [1-4] is an approach for investigating systems with moderate to strong electron correlations. V.A. Moskalenko and co-workers [1]-[5-8] have developed a new approach in the theory of strongly correlated electrons, using the original diagram technique for the Hubbard model [9], the basic model of strongly correlated electron systems. They formulated a new version of the thermo-dynamic perturbation theory for these systems. The new diagram method is based on Wick's theorem for conduction electrons and a generalized Wick's theorem for strongly correlated impurity electrons, which coincides with the definition of the Kubo cumulants. We prove a linked-cluster theorem for the mean of the evolution operator and obtain Dyson-Larkin type equations for the one particle propagators. The main element in these equations is the impurity electron correlation func-tion, which contains the spin, charge, and pairing fluctuations of the system caused by the strong Coulomb repulsion of electrons.

New research method permit to establish a number of significant properties relating to such phase changes as the metal-insulator transition, spin-density wave and superconductivity and other. In particularity, we have calculated the thermodynamic potential of a strongly correlated system described by the models [9-10] and then proved the stationary property of the thermodyna-mic potential under changes of the mass operator [11-12]. This result generalizes the Luttinger–Ward theorem [13] established for non-strongly correlated systems. The generalized theorem could be useful for studying thermodynamic quantities, for example, the specific heat of these systems.

We have developed a strong-coupling diagram perturbation theory approach for investigating the twofold degenerate AIM [14] and proved that orbital degeneracy gives an additional contribution to the "metallization" of the impurity states, i.e., enhances the transfer of spectral weight to the Fermi level.

We investigate the Anderson–Holstein model [15] with strong repulsion of impurity electrons. The strong electron–phonon interaction determines the formation of polarons with heavy clouds of phonons surrounding the impurity electrons. We describe the collective mode of phonon clouds and the relation between electron propagators and correlation functions. We obtain the dependence of the collective mode energy on the hybridization parameter and proved that the collective mode in the case $T = 0$ is suppressed as the hybridization strengthens.

[1] M. I. Vladimir, V. A. Moskalenko, *Theor. Math. Phys.* **82** (1990) 301.
[2] W. Metzner, *Phys. Rev.* **B 43** (1991) 8549.
[3] L. Craco, M.A. Gusmao, *Phys. Rev.* **B 52** (1995) 17135.
[4] A. Sherman, *Phys. Rev.* **B 73** (2006) 155105; **B 74** (2006) 035104.
[5] S. I. Vakaru, M. I. Vladimir and V. A. Moskalenko, *Theor. Math. Phys.* **85** (1990) 1185.
[6] N. N. Bogoliubov and V. A. Moskalenko, *Theor. Math. Phys.* **86** (1991) 10.
[7] N. N. Bogoliubov and V. A. Moskalenko, *Theor. Math. Phys.* **92** (1992) 820.
[8] V. A. Moskalenko, P. Entel, and D. F. Digor, *Phys. Rev.* **B59** (1999) 619.
[9] J. H. Hubbard, *Proc. Roy. Soc*. **276A** (1963) 238; **281A**, (1964) 8401; **285A** (1965) 542.
[10] P. W. Anderson, *Phys. Rev.* **124(1)** (1961) 41.
[11] V. A. Moskalenko, P. Entel, L.A. Dohotaru, P. Citro, *Theor. Math. Phys.* **159** (2009) 454.
[12] V. A. Moskalenko, L. A. Dohotaru, I. D. Cebotari, *Sov. Phys. JETP.* **138** (2010) 107.
[13] J. M. Luttinger and J. C. Ward, *Phys. Rev.* **118** (1960) 1417.
[14] V. A. Moskalenko, L.A. Dohotaru, I. D. Cebotari, D. F. Digor, *Theor. Math. Phys.* **178** (2014) 131.
[15] V. A. Moskalenko, L.A. Dohotaru, I. D. Cebotari, D. F. Digor, *Theor. Math. Phys.* **179** (2014) 242.