HTSC in Modern Anisotropic Compounds

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The contribution of Moldavian theoretical physicists to the development of the theory of superconductivity in systems with many energy bands and the application of this theory to the description of experimental results on thermodynamic, magnetic and kinetic properties of newly discovered high-Tc anisotropic compounds such as Fe-pnictides and Fe-chalcogenides, intermetallic compound MgB_2, oxide ceramics is presented in this communication. In order to describe the properties of real superconductors, which are anisotropic systems, a many-band model which would be able for taking into account the anisotropic character of superconducting systems is needed. Assuming that the Cooper pairs of electrons are formed within energy band and their transition as a whole from one band to another, the group headed by Prof. Maria E. Palistrant has developed researches on the thermodynamic and electromagnetic properties of many-band superconductors [1-4].

The state of superconductivity is favored by the overlapping of energy bands on Fermi surface because the overlapping of bands increases the total density of electron states and leads to the appearance of additional inter-band electron-electron interaction which strongly influences the thermodynamic characteristics of anisotropic superconducting systems. As a result, besides quantitative difference, the overlapping of energy bands gives qualitatively new results in comparison with the case of one-band systems. For example: a) possibility of high values of T_c in the case of repulsive interaction when inter-band interaction prevails over intra-band one; b) violation of Anderson theorem in two-band doped superconductors due to inter-band scattering of electrons on impurity; c) dependence of thermodynamic properties on the concentration of non-magnetic impurity; d) phase fluctuations of order parameters lead to collective oscillations of exciton-type Leggett modes; e) changing by doping the location of the Fermi level the thermodynamic and magnetic properties of two-band superconductors may be influenced.

The modern high-T_c superconductors are complex systems and, along with their many-band character and anisotropy, other important features have to be taken into account. Such as: lowered dimensionality of the system; presence of symmetry points; nesting on Fermi surface; phase transitions into the state of charge density wave (CDW) and spin density wave (SDW); mixed states at variable charge carrier density; coexistence of superconductivity and magnetism etc. Based on these features the thermodynamic, magnetic and kinetic properties are described theoretically for a wide range of mentioned above high-T_c compounds, reaching qualitative and qualitative agreement between the theory and the experimental results.

Thus, in this communication the results of the following researches are presented: 1) the influence of impurity on superconductivity through the bands' filling degree factor and scattering of carriers on impurity potential (*s*- and *d*-type symmetry of order parameters; 2) the properties of superconducting systems with lowered dimensionality, transition from BCS scenario to the Schaffroth's one for condensed state of localized pairs of electrons; 3) the superconducting properties of systems with lowered charge carrier density when strong electron correlations are taken into account; 4) the superconducting state in disordered non-adiabatic systems: the role of magnetic and non-magnetic impurities, coexistence of superconductivity and magnetism; 5) the microscopic theory of thermodynamic properties of inter-metallic MgB_2 compound with a variable carrier density in tight-binding approximation; 6) the description of the behavior of upper critical field H_{c2} in isotropic and anisotropic two-band systems as a function of temperature and charge carrier doping; 7) the magnetic state of spin density wave (SDW) and the influence of magnetic field on commensurable and incommensurable states of SDW; 8) the theory of coexistence of superconductivity and SDW in the case of umklapp processes in layered systems; 9) theoretical description of the properties of new FeAs-based high-temperature superconducting materials at temperatures $T \leq T_M$ through the analysis of behavior of charge density waves and spin density waves.

Bibliography

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