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FOREWORD

Foreword

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The conferences "Fundamental Problems of High Temperature Superconductivity" (FPS) have become traditional since the first one in 2004. The problem of high-temperature superconductivity remains highly topical: quite regularly, novel HTS materials come on stage (copper oxide high-T_c superconductors in 1986, magnesium diboride in 2001, iron pnictide and iron chalcogenide compounds in 2008, FeSe monolayers in 2012, and sulfur hydrides in 2014–2015). Achieving progressively higher superconducting transition temperatures remains an encouraging motivation for researchers in the field. Up to now, the highest T_c, 203 K, is achieved for $H_2S(H_3S)$ pressurized at ~ 2 Mbar. Nevertheless, a commonly accepted approach to the problem of high-temperature superconductivity is still missing.

Discovery of superconductivity in iron pnictides with T_cs up to 56 K introduced a new family of high-T_c superconductors. Their study and comparison with copper oxides provide an excellent chance to reveal the mechanism of high-T_c superconductivity in general and in the two families in particular. Cuprate superconductors are strongly correlated materials. The correlations lead to the anomalous properties of cuprates in the normal state and to the inapplicability of the Fermi-liquid model to their normal properties. In contrast, the iron-based pnictides in the superconducting state show signatures of moderate rather than strong coupling. In the normal state, they seem to behave in accord with the Fermi-liquid model. Contrary to the cuprates, where an effective one-band electronic conduction model is sufficient to describe the low-energy electronic excitations, in the Fe-based compounds, at least four bands contribute to superconductivity. Both cuprate and FeAs-based high-T_c superconductors are quasi-two-dimensional compounds where Cooper pairing occurs in the CuO_2 layers and FeAs layers, respectively. The stoichiometric parent compounds are antiferromagnetic insulators and antiferromagnetic metals for cuprates and pnictides, respectively. Studies of the novel superconducting materials constituted one of the major topics of the FPS'15 conference.

This special issue of *Journal of Superconductivity and Novel Magnetism* collects 15 experimental and theoretical contributions to the FPS'15 conference selected for journal publication. Traditionally, the four main topics of the FPS conference are as follows: (M) Mechanisms of high-temperature superconductivity, (P) Physical properties of superconducting materials and superconductor structures, (N) Novel superconducting materials, and (A) Applications of high-temperature superconductors.

Some of the leading contributions are briefly mentioned below.

N. Plakida introduces a microscopic theory of superconductivity for systems with strong electron correlations such as cuprates in the framework of the extended Hubbard model where the intersite Coulomb repulsion and electron–phonon interaction (EPI) are taken into account. P.A. Volkov

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and K.B. Efetov studied particle–hole instabilities within a 2D model of fermions interacting with antiferromagnetic spin fluctuations (spin-fermion model). Under the assumption that neighboring hot spots overlap in the antinodal region, they found that the leading particle–hole instability becomes a Pomeranchuk-type deformation of the Fermi surface breaking the C4 symmetry of the system. Depending on parameters of the interaction, either d-wave superconductivity or charge density wave with modulations along the bonds of the CuO lattice is possible, which may explain the charge modulations observed recently. M.Yu. Kagan, V.A. Mitskan, and M.M. Korovushkin demonstrate an instability of the normal state of purely repulsive fermionic systems towards the transition to the Kohn–Luttinger superconducting state. Within the framework of the Hubbard and Shubin–Vonsovsky models on the square and hexagonal lattices, they show that an account for the long-range Coulomb interactions, as well as the Kohn–Luttinger renormalizations, leads to an increase in the critical T_c value in various materials, including HTSC. V.V. Val'kov et al. studied the origin of the spin polaron quasiparticles and their Cooper instability in high-T_c superconductors. They show that accounting for strong spin–charge fluctuations between holes of copper and oxygen ions in cuprate high-T_c superconductors leads to the formation of the Fermi spin polaron quasiparticles.

I.A. Nekrasov, N.S. Pavlov, and M.V. Sadovskii present a theoretical explanation of recent angle-resolved photoemission spectroscopy (ARPES) experiments for a new iron-based superconductor, NaFeAs. Using the LDA + DMFT calculations, they demonstrate that the mass renormalization by a factor of 3, in good agreement with ARPES experiments, can be achieved taking into account only correlations on Fe-3d orbitals and ignoring additional interactions with “bosonic” modes. M.M. Korshunov, Yu.N. Togushova, and O.V. Dolgov consider theoretically the rather controversial issue of disorder effect on the pairing symmetry. They study the special case of disorder with equal values of intra- and interband impurity potentials in the two-band s$\pm$ and s++ models and show that this case can be considered as an isolated point and T_c there has maximal damping for a wide range of parameters. I. S. Blokhin, · S. Yu. Gavrilkin, et al. report measurements of the irradiation effect on superconducting T_c of the BFCoA films. They found that suppression of superconductivity by nonmagnetic defects is noticeably slower than that expected from a theory assuming s$\pm$ symmetry of the superconducting order parameter. E.Z. Kuchinskii et al. studied theoretically disorder influence on the density of states, optical conductivity of the normal phase, superconducting transition temperature, and Ginzburg–Landau coefficients within the attractive Hubbard model and using the generalized DMFT + Σ approach. The disorder found can either suppress T_c (in the weak coupling region) or significantly increase T_c (in the strong coupling region). All changes of superconducting critical temperature are essentially due only to the general disorder spreading of the conduction band. V. A. Dravin, Y. Zhou, V.A. Sidorov, A.E. Petrova, et al. report high pressure studies of the superconducting Gd-1111.

From SnS Andreev reflection measurements for various high-T_c superconductors, S.A. Kuzmichev et al. estimated relative electron–boson coupling constants and eigen BCS ratios for the two condensates in Sm-, La-, and Gd-1111 and also MgB2 and LiFeAs superconductors. A.L. Rakhmanov, A.S. Akzyanov, and A.V. Rozhkov study theoretically the electron states localized at the edge of a superconducting island placed on top of a topological insulator in a transverse magnetic field. In such systems, Majorana fermions emerge when an odd number of vortices is hosted by the island. By varying gate voltage and magnetic field, one can experimentally distinguish the edge Majorana fermion from the conventional Dirac fermions.

We hope this issue of the selected contribution will acquaint the readers with the research performed in Russia, and will be useful to researchers working in the field of high-temperature superconductivity.

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Guest editors

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