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A scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on January 19 and 20, 1983 at the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following papers were presented at the session:

19 January

1. *L. P. Gor'kov*, New results in the physics of organic superconductors.

2. *L. N. Bulaevskiĭ*, Magnetic superconductors.

20 January

3. *V. I. Panov, A. A. Sobyanin, and V. A. Khvostikov*, Experimental investigations of superfluidity of helium II near the λ point.

4. *L. V. Keldysh*, Electron-hole liquid in semiconductors.

Brief contents of three of the reports are published below.

L. P. Gor'kov. *New results in the physics of organic superconductors.* During the last decade, a large number of so-called one-dimensional (or quasi-one-dimensional) conductors have been synthesized. From a phenomenological point of view, these include substances which have an anomalously high anisotropy of electronic transport properties. These substances include an enormous number of organic conductors consisting of stacks of large flat molecules, trichalcogenides of transition metals ($NbSe_3$ and TaS_3), conducting polymers, and a number of other materials. A common property of all these materials is the presence of chains of atoms or molecules, along which an electric current flows. Overlapping of electronic states in the transverse direction (tunneling integrals, $t_\perp$) is much weaker and, in the first approximation, can be omitted.

Theoretical models indicate the presence of a number of instabilities in such a system. Thus the interaction of the electrons with the lattice leads to the well-known Peierls instability and a transition into the insulating state with an electronic gap. A more careful study of the role of electron interactions, however, has shown that they either can stabilize the metallic state or lead, instead of a Peierls instability, to a new type of instability, where fluctuations of the structural order parameter develop simultaneously with superconducting fluctuations.

Dielectric instabilities have usually predominated in experiments. The long path to synthesis of new compounds led to the fact that at first substances were found with stabilized metallic states at low temperatures and then superconductivity was also discovered in them. The most important progress in this direction was achieved three years ago with the synthesis of new organic compounds, the so-called Bechgaard salts, $(TMTSF)_2X$-selenium (and sulfur containing compounds, where, for example, $X = PF_6$, ClO_4, NO_3, and SCN. (This class now consists of a large number of compounds that have been investigated.) Under pressure, these substances transform into the superconducting state ($T_c \approx 1$–3 K, $P_c \approx 6$–12 kbar), while the compound $(TMTSF)_2\,ClO_4$ is a superconductor at zero pressure.

It is possible that the stabilization of the metallic phase and the actual phase transition into the superconducting state are responsible for the three-dimensionality (or two-dimensionality) of the electronic spectrum. In other words, the superconductivity observed in $(TMTSF)_2X$ compounds could be the usual superconductivity in an anisotropic metal. These compounds indeed have two-dimensional (layered) features, which is what finally leads to stabilization of the superconductivity as a thermodynamic state. However, the enormous collection of experimental data now indicates that the properties of these compounds are much more interesting and closer to what would be expected in one-dimensional physics. In other words, it is asserted that the superconducting fluctuations of a one-dimensional nature begin at much higher temperatures (20–30 K) and are observed as a three-dimensional phase transition only at low temperatures. If this is the case, then the new compounds open up the way to creation of higher temperature superconductivity. The physical factor working in this direction is the higher frequencies of phonons interacting with conduction electrons in organic compounds than in metals.

There is still no final proof of the correctness of these ideas. Support is found in such facts as the enormous values of the conductivity at helium temperatures, absence of a state of residual resistance, very strong sensitivity of the conductivity to quite strong magnetic fields at temperatures up to 30 K (by the way, a strong field restores the state of residual resistance), and many other circumstances, such as, for example, the sensitivity of superconductivity to defects. Tunneling measurements of the "superconducting gap" ($2\Delta \approx 3.8$ meV), observable up to 20 K on the current-voltage characteristics of tunnel junctions, are the most direct arguments supporting the superconducting fluctuation picture. The facts listed above are now well established and we are talking only about the possibility of the interpretation presented. The latter depends on the degree of one-dimensionality in real $(TMTSF)_2X$ compounds, i.e., on the magnitude of the overlap integrals $t_\perp$, estimates of which are still contradictory.

Together with superconducting properties, the compounds $(TMTSF)_2X$ exhibit many other peculiarities. Thus, at zero pressure and at low temperatures most of them are in an insulating state; not a Peierls state, but a state with antiferromagnetic ordering. Anions play an entirely new role. If the anion is not symmetrical ($X = ClO_4NO_3$, SCN, and others), then order-disorder transitions into the anionic sublattice are observed. The compound $(TMTSF)_2ClO_4$, which is a superconductor at $P=0$, plays a completely unique role, while the degree of disorder and its influence on the magnetic and electronic properties are controlled by the rate of "freezing" of the system. Most of the new experimental facts, which have yet to be interpreted theoretically, have been obtained in this area.

A systematic exposition of the experimental data and the theoretical models is given in the review by D. Jerome and H. I. Schulz, Adv. Phys. 31, 299 (1982).