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“Electron transport in new conducting and superconducting systems” dedicated to the 70th Anniversary of Yu. A. Kolesnichenko

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A. V. Terekhov and S. N. Shevchenko

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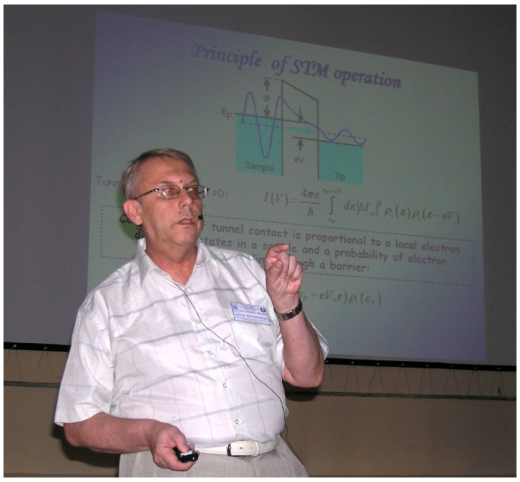

January 6, 2023, we have the 70th anniversary of Prof. Yuriy Alekseevich Kolesnichenko. He works at B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine since 1975, was the Department head for about 20 years, supervised 9 Ph.D. theses, and did and continue to do a lot of scientific and organizational work. Among his broad research interests are the theory of normal and superconducting systems, focusing on electrons in metals with the magnetic field, crystal structure of surfaces, spectroscopy of electron-phonon interactions, kinetic phenomena in layered metal films, Josephson effect in contacts of unconventional superconductors.

The Special Issue includes the papers from the friends and colleagues of Prof. Kolesnichenko, from Ukraine and from abroad; overall from 11 countries and from 24 institutes. After a general introduction below, we introduce all 18 papers, grouping them in four categories, relevant to Prof. Kolesnichenko's research interests: (i) Electronic structure and quantum transport, (ii) Mesoscopic and superconducting structures, (iii) Superconducting quantum systems, (iv) Spintronics and topological states.

Recently, many new materials have appeared with nontrivial conductive properties, including: giant magnetore sistance, quantization of conductivity in nanoscale objects, high-temperature and topological superconductivity, spin transport in compensated and uncompensated metals, quantum and spin Hall effects, strong change in conductivity as a result of the evolution of the band structure topology under the influence of external factors. Most often, such phenomena are observed in low-dimensional systems as well as in strongly correlated and anisotropic conducting systems. These materials are expected to be widely used as elements of future nanoelectronics and spintronics, and also to create qubits in quantum computers. In this Special Issue, the authors present the results of the latest experimental and theoretical studies of the materials noted above, which can help both in explaining existing phenomena and in identifying fundamentally new physical concepts and obtaining new information about processes in these classes of conducting systems.

(i) Electronic structure and quantum transport

- Carbon nanotubes have promising physical properties and can be considered for generating electromagnetic waves in the microwave frequency range. Yu. O. Averkov *et al.* consider the nanotubes with dielectric filling and in the magnetic field. They calculate the impact of the surface currents on the dispersion properties of electromagnetic eigenmodes.
- Unique physical properties of multiwalled carbon nanotubes (MWCNTs) attract the attention of both physicists and technologists. In their work, I. Ovsiienko and co-authors investigated the temperature and magnetic field dependences of electric resistance of functionalized (with a chemically adapted surface for optimal incorporation into polymers) MWCNTs.
- Graphene with impurity atoms embedded can have new interesting features. S. B. Feodosyev *et al.* study this for boron and nitrogen impurities. The local density of states is calculated and this displays the two-level structures, which may be important for quantum engineering.
- One of the perspective cathode materials for batteries is Li_2FeO_3. H. Yousefi-Mahhour *et al.* calculated structural and electrical properties using the density functional theory. Studying the delithiation process allows estimating impact on the lifetime of such batteries.
- Appearance of spatial ordering, leading to the formation of crystal lattice consisting of electrons and dimples, is one of the most interesting phenomena in the system of surface electrons over liquid helium. V. E. Syvokon and S. S. Sokolov applied the method of molecular dynamics to

simulate the behavior of two-dimensional electron clusters of various shapes in a magnetic field.
- Quantum transport phenomena in magnetic fields in a highly mobile two-dimensional electron gas have been intensively studied for several decades. I. B. Berkutov *et al.* studied magneto-quantum and quantum interference effects in two-dimensional hole gas in quantum wells of almost pure germanium in the Si-Ge heterostructure with quantum wells of different widths.

(ii) Mesoscopic and superconducting structures
- In nano-electro-mechanical transistors, the tunneling transport can be by means of electron shuttling. O. A. Ilinskaya *et al.* study this for the case of spin transport in the layout with magnetic contacts. The authors demonstrate the effect of the polaronic shift on recovering the shuttle vibrations.
- The process of cooling superconducting structures in liquid helium is accompanied by boiling; and what matters for small structures relates to single bubbles. A. G. Sivakov *et al.* study this in relation to the formation of phase-slip centers. Observed oscillations on the current-voltage curves are related to the single-bubble formation and the system thermometry.
- One of the methods to create Josephson junctions with reproducible resistance is by means of an electrical breakdown. A. V. Krevsun *et al.* develop this technique using the combined action of a direct-voltage source and a charged capacitor and clarify the role of the cathode-film thickness.

(iii) Superconducting quantum systems
- Quantum engineering often deals with large structures of which the simulation is complicated. In the paper by A. M. Zagoskin a quantitative theory of large quantum coherent structures is discussed. Such theory should determine accessible parameters which control transitions between different regimes of operation.
- For compact superconducting circuits the elements exploiting high kinetic inductance are needed. E. Mutsenik *et al.* demonstrated the first test of hybrid NbN-Al technology with the high kinetic inductance of NbN thin films. An array of Josephson junctions was fabricated, measured, and characterized.
- In general, quantum structures should be described as multilevel systems. M. P. Liul and S. N. Shevchenko use the rate equations to calculate the dynamics of both two- and multi-level systems. Such an approach allows obtaining the interference fringes for a multi-level flux qubit.
- Multigap superconductivity often favors the appearance of exotic mechanisms of superconducting pairing. V. Tarenkov *et al.* presented new evidence obtained by point contact spectroscopy that the Mo-Re alloy with a comparable concentration of the components is a two-band/two-gap superconductor.
- Study of the pseudo-gap in high-temperature superconductors can shed light on the understanding of the mechanisms of pairing in these materials. A. L. Solovjov and co-authors studied the effect of annealing at room temperature on the excess conductivity and the pseudo-gap in the basic *ab* plane of single crystals $HoBa_2Cu3O_{7-\delta}$ with a lack of oxygen.

(iv) Spintronics and topological states
- Topological states of matter are the most intriguing research topics of condensed matter physics. V. N. Antonov *et al.* have studied the structural, electronic, and magnetic properties of the Cr-doped topological insulator Bi_2Se_3 using modern methods of theoretical calculations of band structures. The complex fine structure of Cr $L_{2,3}$ X-ray absorption spectra has been found to be not compatible with a Cr^{2+} valency state and can be explained by the mixed valence state of the Cr ions.
- Superconducting crystallite interfaces of bismuth-antimony bicrystals are an unusual topological quantum material. F. Muntyanu *et al.* investigated quantum transport in $Bi_{1-x}Sb_x$ bicrystals with nano-width interfaces. The authors observed a number of unusual features of quantum transport associated with topological changes of the Fermi surface.
- Various spin-dependent transport phenomena in nonmagnetic metals and semiconductors have attracted wide interest. Yu. N. Chiang (Tszyan) *et al.* investigated the spin contributions to the Nernst-Ettingshausen, and Hall effects in metals with spin-orbit interaction.
- The study of the effect of high pressure on magnetic properties is an effective and useful tool for studying the nature of magnetic interactions in manganites, which exhibit the effect of colossal magnetoresistance. The work of A. S. Panfilov and co-authors is devoted to the study of dc magnetic susceptibility of manganites $RMnO_3$ (R = La, Y) in the region of the paramagnetic phase as a function of hydrostatic pressure.

Editors and authors of this Special Issue congratulate Yuriy Alekseevich on the jubilee and wish him good health and further success in research.

A. V. Terekhov
S. N. Shevchenko