

PHENOMENON OF TWIN-BROTHERS-PHYSICISTS MOSKALENKO IN THE WORLD AND MOLDOVA SCIENCE

(Academicians Svyatoslav and Vsevolod Moskalenko at the wise age of 85)

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On September 26, 2013 twin-brothers physicists Svyatoslav and Vsevolod Moskalenko reached an honorable age of 85 years. This anniversary is an occasion for scientific community of Moldova to share our admiration for our outstanding colleagues and teachers. Their inquiring mind and passion for science, professionalism and scientific courage, will-power and diligence have earned them appreciation and esteem among colleagues. Both brothers are theoretical physicists; this label is too narrow and restrictive to describe their output and methods of working, somebody who with safety and elegance trod forward at the boundary between mathematics and physics, mastering the subtleties of the former and understanding deeply the meaning of the latter.

Their openness to new ideas, readiness for a discussion, and deep erudition always attracted people. A fresh idea or an original point of view would immediately raise their enthusiasm, their faces flashed with light, "It is interesting, very interesting." As teachers, they are ever learning persons, eager to explore new perspectives, full of new ideas, willing to share them with the others. There is no doubt that professor Vsevolod Moskalenko together with his twin brother professor Svyatoslav Moskalenko are bright scientists both of the World and the Moldovan physical community.

The future scholars were born in the village Bravicea, Orhei district, Romania (today the Republic of Moldova), which is an old village located between streams of Cula and Ichel about 70 km from Chisinau. In terms of physics, that year was also particular: a new and unordinary paradigm of modern physics was born—quantum mechanics. The findings from this field, which were signed by Erwin Schrodinger (1887–1961), Max Born (1882–1970), Werner Heisenberg (1901–1976), Enrico Fermi (1901–1954), Oskar Klein (1894–1977), VA Fok (1898–1952), J.I. Frenkel (1894–1952), Hans Kramers (1894–1952), Ernst Jordan (1902–1980), John van Vleck (1899–1980), Peter Debye (1884–1966), Ralph Kronig (1904–1995), and others, originate from that year. In addition, in 1928, Louis de Broglie (1892–1987), being confident (the year before, in 1927, the idea of wave-particle duality was experimentally confirmed), begins to take serious courses of quantum mechanics at the University of Paris. What great times in physics!

Over the years, quantum mechanics will become the main working tool for the brothers Moskalenko, through which they will have made significant contributions to condensed matter physics after graduation from the State University of Moldova, Faculty of Physics and Mathematics in 1951. The road of twin-brothers Moskalenko in science was not easy. The family did not have scientific traditions. Their way to science was paved by themselves. The profession of physicist was chosen according to their nature of free thinkers. Physics, thanks to academician P.L. Kapitsa (1894–1984), was not affected by the negative impact of primitive lisenkism (named after Lysenko) that haunted fully politicized Soviet science, particularly in the field of genetics and cybernetics. Brothers Moskalenko have always felt free and good in physics. The

profession of physicist allowed them to vent their thoughts. Later, they themselves became physicists of the level of Kapitsa in Moldova and watchmen of high standards and moral climate in science. In places attended by them, the atmosphere is truly scientific. Going through hard experience of life, they had the intuition to choose the subjects for their graduate and postgraduate studies from the most promising and intensely explored branches of physics; they have independently formulated scientific issues and successfully solved them under the supervision of research advisors.

Under their own steam, they have passed the entire path from a student to a scholar. The heights they succeeded in life can be achieved through hard and honest work, perseverance and patience. They have gone thorough many trials in life, but they knew that to avoid disappointment, it is necessary to always go the way that they have chosen for themselves following the biblical belief *"Plough and seed .and you will be right."* People who have so much pleasure from their work, like them, are rare in occurrence. They work from morning until late evening and on weekends. This "disease" was caught up by them from their colleagues.

After graduating brothers Moskalenko separated for a while. Vsevolod Moskalenko remained to work at the State University, while Svyatoslav Moskalenko was assigned to the Agricultural Institute in Chisinau. After 1961, they worked together again in the Academy of Sciences of Moldova. Although they worked in different institutions for some time, their activities were always correlated. Brothers Moskalenko understood from youth the biblical admonition to *gnaw the wise men thresholds*. Therefore, they decided to continue studies (post-graduate) in the largest scientific centers in the Soviet Union where modern physics was extensively developed and where the greatest scholars in the fields of their interests worked, as they knew from scientific papers of those scientists.

Vsevolod Moskalenko went to Moscow to post-graduate studies at the scientific school of acad. N.N. Bogoliubov (1909–1992), who was a world-renowned scientist in the field of physics of superconductivity, quantum field theory, etc. Just at that time, there, researchers were working hard on finalizing the microscopic theory of superconductivity, the basic idea of which was formulated by American physicists J. Bardeen (1908–1991), L.N. Cooper (1930), and J.R. Schrieffer (1931), and, independently, by N.N. Bogoliubov, who had previously developed the microscopic theory of superfluidity. Thus, young Vsevolod Moskalenko has found himself in the epicenter of great scientific events. Many solutions to the examined problems have been found; many physical phenomena of condensed matter physics have been explained; many previously developed physical concepts have been refined. It has been found that both the phenomenon of superfluidity of liquid helium and superconductivity are based on the same physical phenomenon of Bose–Einstein condensation (BEC). Strongly correlated motions of helium atoms create the phenomenon of superfluidity, while Cooper pairs of electrons (coherent collective motion of electronic gas particles with the same energy, velocity, and phase) are responsible for the phenomenon of superconductivity. Furthermore, the Bose–Einstein condensation phenomenon proved to be universal: it also occurs in nuclear matter in the atomic nuclei at the microscopic level and in neutron stars at the macroscopic level. The case in hand is a specific state of condensed matter. In this segment of physics, there are some points of contact between the spheres of scientific interests of brothers Moskalenko.

At that time, many pioneering works were developed at the laboratory of acad. Bogoliubov; one of them appertains to young physicist Vsevolod Moskalenko. He has generalized the theory of superconductivity for metals with overlapping energy bands. In the superconductivity investigations Professor V. Moskalenko has found his scientific niche and

world recognition related to multiband theory of superconductivity. In this theory, both intraband and interband interactions between electrons are taken into account and they lead to new features of superconductor behavior. The first paper of these investigations remains one of the most quoted among the articles of Moldovan scientists. The new developed theory has been shown to more adequately describe physical phenomena in known superconducting materials than the old one. In addition, high-temperature superconductivity has been discovered, and it has been proved that the theory can be successfully applied for this phenomenon. In Moscow, a favorable influence on training of Vsevolod Moskalenko as a scientist has been exerted by other illustrious representatives of physics: university professors D.N. Zubarev (1917–1992), who specialized in mechanics and statistical thermodynamics, and S.V. Tyablikov (1921–1968), who was an expert in the field of magnetism.

Professor S. Moskalenko, in turn, entered the post-graduate courses at the Institute of Physics of the Academy of Sciences of Ukraine in Kiev under the supervision of renowned physicist K.B. Tolpygo (1916–1994), who was an expert in solid state physics and physics of polaritons and excitons. Svyatoslav Moskalenko had scientific interactions with renowned physicist A.S. Davydov (1912–1993) known owing to a wide spectrum of his scientific concerns and the fact that, prior to tackle a new area, he wrote a book referring to this field, because, as he said, when you teach others, you penetrate deep into the essence of the phenomena you want to explain. Owing to the high scientific level of those books and the clear language in which they were written, they soon became "classics." This issue has planted taste for problems of biophysics in scholar Svyatoslav Moskalenko. His very early papers on the individual properties of excitons in semiconductors were appreciated by the physics community. In those works, he explained a vast variety of peculiarities of absorption spectra of excitons in the Cu_2O crystals as well as the effect of permanent electric and magnetic fields and deformation fields on the properties of the exciton states.

Invention of laser in the 1960s allowed using it for the higher excitation of semiconductors and putting forward new problems related to the physical properties of crystals at this high level of excitation. The investigations of S. Moskalenko dealing with the collective properties of excitons at a high level of excitation of crystals have brought him the world recognition. Great interest in the biexciton problems was observed in the 1970s and 1980s, when the scientific school of Professor S. Moskalenko reached impressive scientific results in this area and acquired international recognition. New collective effects of the exciton-light interaction, the new absorption and emission bands, which were provided by the exciton-exciton, exciton-electron, exciton-hole, exciton-biexciton and biexciton-biexciton interactions, were predicted and investigated.

An important role in the transformation of twins Moskalenko into highly skilled specialists has been played by acad. L.V. Keldysh (1931), who is a great expert in solid state physics and semiconductor physics and whose name was given to a whole range of physical phenomena, acad. R.V. Khokhlov (1926–1977), who was the founder of nonlinear optics, acad. V.L. Ghinzburg (1916–2009), who was the author of the pioneering works on superfluidity and superconductivity and also in astrophysics, later Nobel Laureate, Prof. L.E. Gurevich (1904–1990), who was the founder of physical kinetics, and others.

Vsevolod Moskalenko became a Candidate of Science (at present, doctor of science) in 1959 and a Doctor of Science (now, doctor habilit) in 1968, while Svyatoslav Moskalenko obtained these scientific degrees in 1960 and 1970, respectively.

Academicians Moskalenko have published numerous monographs and hundreds of

scientific papers in the most prestigious journals in the world. However, they do not specify the number of papers they wrote, saying that, for a true scholar, it does not matter what the number of his works is; of importance are their value, originality, and depth of ideas that they promote. According to reviews of the disciples of the scholars, they jointly have published over 550 scientific papers and participated with reports at more than 150 conferences (each of the twins covers about half the record). The scientific papers of brothers Moskalenko concern a wide range of problems of solid state physics. Having a special love for mathematics, physicists Moskalenko have promulgated and implemented the most advanced computational methods in solid state physics, especially in condensed matter physics.

Acad. Vsevolod Moskalenko is known for his fundamental works in the quantum theory of solid state and condensed matter, in the theory of polyphononic transitions, particularly the theory of polarons, the theory of disordered magnetic systems (spin glasses), the theory of spin-glass systems and quadrupole glass, in the theory of low-temperature superconductivity, the theory of strongly correlated electronic systems, the theory of superconductors with multiple energy bands, and also through the extensive use of mathematical apparatus of Green functions in superconductivity and Feynman diagrams. The theory of superconductors with overlapping bands developed by him has been widely used in describing high-temperature superconductivity, in explaining a lot of experimental data (impurity concentration dependence of the critical temperature, electronic Raman effect, etc.), and in predicting new phenomena (e.g., thermoelectric effect amplification). The mathematical apparatus developed by Vsevolod Moskalenko to describe strong electron correlations allows physicists to obtain valuable information about the electron and phonon spectra. The scientific community considers Vsevolod Moskalenko to be a scientific founder of a scientific school in the field of superconductors with multiple energy bands and strongly correlated electronic systems.

Acad. Svyatoslav Moskalenko published papers on mathematical physics, solid state physics, nonlinear optics, and quantum electronics; he has discovered new ways in condensed matter physics. He studied in detail the phenomena produced by excitons (quasiparticles formed in semiconductors and dielectrics composed of an electron and a hole bound in a pair), which form the basis of many phenomena in optical physics and energy transfer in the above materials. A special renown was brought by the theoretical substantiation of the possibility of formation of biexcitons (binding of two excitons in a "molecule," in common with two atoms of hydrogen/helium bound into a hydrogen/helium molecule) and Bose–Einstein condensation of excitons and biexcitons, which generates the phenomenon of superfluidity of excitons and biexcitons. Studying the potential energy of exciton-exciton interaction, S. Moskalenko came to the conclusion that the Coulomb interaction can result in the binding of the excitons into a biexciton at low temperatures and moderate exciton density. This leads to a significant change in the absorption and luminescence spectra of the crystal. Soon afterwards, this prediction was confirmed experimentally; since that moment, the biexciton, as well as the exciton, triumphally marches in the world science greatly evidencing itself in the properties of semiconductors.

For the discovery and study of multiexciton complexes, Svyatoslav Moskalenko and eight other Soviet scientists were awarded the USSR State Prize in science and technology in 1988. His ideas had been waiting for experimental evidence for almost 30 years, until biexcitons and Bose–Einstein condensation of excitons and biexcitons were discovered experimentally in semiconductors and various structures based on them. The pioneering works of Svyatoslav Moskalenko in this field have been recognized by the international scientific community and formally at a scientific conference dedicated to the issues in question, which took place in Italy in 1993. In 2000, the prestigious publisher of the University of Cambridge issued a valuable

monograph written together with Prof. D.W. Snoke at the University of Pittsburgh (United States): S.A. Moskalenko and D.W. Snoke "Bose–Einstein Condensation of Excitons and Biexcitons and Coherent Nonlinear Optics with Excitons." He is the founder of a scientific school in the field of coherent nonlinear optics, physics of excitonic, biexcitonic, and photon-laser processes in semiconductors.

In the 1990s, emergent fields of physics of low-dimensional solid-state structures provided great successes in the semiconductor high technologies, which today are referred to as nanotechnology, led to the fabrication of the semiconductor low-dimensional micro- and nanostructures, such as the quantum wells, quantum wires, and quantum dots. A lot of intense researches of the properties of excitons and biexcitons in these systems related to studying the energy spectrum of excitons and biexcitons in dependence on the structure configurations and dimensions have been carried out by S. Moskalenko and his scientific team. A possibility in principle of simultaneous existence of two induced Bose-condensations of excitons and biexcitons in GaAs/AlGaAs quantum wells has been proved.

Note that the studies of physicists Moskalenko are always synchronized with the pulse of the world's science, have a high level of professionalism, always contain new elements, often open new directions, and sometimes are ahead of time; some of them have become classics.

According to the scientific papers that they have published, they are among the first researchers from Moldova who have integrated into the global scientific community, thereby demonstrating that we can be competitive in this top area of human activity. We can say unequivocally that physicists Moskalenko serve an example of scientific and ethical conduct for the family of physicists in Moldova. The scientific works of brothers Moskalenko are appreciated by the scientific community; scientists from around the world make references to their papers; the scientific schools founded by them are well known in the world; therefore, they are often invited to carry out research and conduct scientific reports and lectures in prestigious scientific centers in the world; this fact provides still more evidence that the results obtained by brothers Moskalenko are competitive at the global scientific market.

Today it is clear to everyone that it is impossible to conduct research activities without being involved in the international circuit and that progress does not exist without advanced science; there can be no modern technology without developed basic science.

Vsevolod Moskalenko conducted lectures at universities in China (Changchun in 1990, 1992, 1993), Italy (Salerno, 1999, 2001), and Germany (Duisburg, 2000); he won a German government grant (Heisenberg-Landau) 12 years in a row. For 15 years, he has been the plenipotentiary of the Republic of Moldova to the Joint Institute for Nuclear Research in Dubna. Svyatoslav Moskalenko took special courses at the University of Uppsala, Sweden, in 1995, 2000, and 2004.

In addition to scientific research, physicists Moskalenko devotedly participate in training of highly skilled scientific personnel. For many years, they have been members of the Specialized Scientific Council (which provides scientific degrees) or members of the Committee of Experts in physics of the National Assessment and Accreditation Council in the Republic of Moldova. Their contribution to the training of highly skilled scientific staff in Moldova is enormous (together they prepared about 10 doctors habilitated and 50 doctors of science, each covering about half the record).

Brothers Moskalenko are always striving to train young physicists to be competitive at the global scientific market. Hundreds of other scientists indirectly felt their creative influence when the prominent physicists were official reviewers of their theses. We say with all responsibility

and without exaggeration: theses on theoretical physics are most highly praised in Moldova, and this is largely due to exactingness and fidelity to principles of brothers Moskalenko. Doctoral and doctor-hability theses that have passed through the sacred fire of the scientific schools of physicists Moskalenko, or the Specialized Scientific Council in which they are involved, bear the impress of quality, durability, honesty, youthful ardor, and responsibility of scientists and personalities Moskalenko. If a post-graduate student manages to pass the "quality threshold" imposed by brothers Moskalenko, one can say for sure that his thesis is of high quality. The climate of responsibility cultivated by brothers Moskalenko matters a good deal. Academicians Moskalenko train new Pleiades of physicists by the example of their own research and ethical behavior. Their work follows high standards: strict self-exactingness, hard work, an insatiable thirst for knowledge of everything that is new in their domain, and dedicated self-sacrificing service to scientific truth.

All these qualities result from their upbringing in the family, from their spiritual independence in the large and in the small, in science and in everyday life. It is these features that have made them well-known scholars, living examples of scientific and moral conduct. They require all these things from their disciples, whom they warn from the very beginning that there are no easy ways to assert oneself in science.

Brothers Moskalenko devotedly participate in the cultural life of the country. They have made major contributions to editing "Moldavian Soviet Encyclopedia," in the part related to physics. With exactingness that is characteristic of them, they have coordinated and participated as authors in the preparation of articles in physics; each item, before being sent to the press, was subjected to public discussion to the smallest detail in a committee of experts in the field. Brothers Moskalenko also participated in popularizing science through the "Știința" society and in preparing new generations of physicists in the "Viitorul" society.

A proper development of research cannot take place without adequate and timely information on new scientific discoveries and without a modern library provided with necessary literature and equipped with up-to-date communication facilities in order to make the latest scientific results obtained in the world available to the readers in the shortest time—the things without which science would not have had a chance to succeed. Aware of this fact, brothers Moskalenko, like no other, have made a strong contribution to the modernization of the library of the Academy of Sciences, to the complementation of its funds with books and scientific journals from around the world, and to a change in the mentality of the colleagues with respect to this significant link of research. Acad. Svyatoslav Moskalenko has been a member of the Information Librarian Board of the Academy of Sciences since 1961.

The activities of brothers Moskalenko in research and training of highly skilled scientific personnel have been appreciated by the scientific community and the society. Both of them are full members of the Academy of Sciences of Moldova, laureates of the State Prize of the Republic of Moldova; they were awarded government decorations "Order of the Republic" and "Om Emerit," and medal "Dimitrie Cantemir." Svyatoslav Moskalenko is a laureate of the USSR State Prize.

Novelty and originality of ideas and concepts of brothers Moskalenko were appreciated by the leading experts in physics from abroad; they were elected members of the Editorial Boards of a few international journals and members of the organizing committees of prestigious international conferences, which were awarded various diplomas and medals.

On May 28, 2003, academicians Moskalenko were awarded decoration "Honorary Citizen of Bravicea village." Brothers Moskalenko are always bearing the image of the place where they grew up in their soles. They have taken root in Bravicea as a tree takes roots in a rock mountain.

Based on the results of their work, we can compare brothers Moskalenko with toilers of the fields looking at freshly harvested wheat in their hands with their faces irradiating both labor fatigue and joy of fulfillment. Einstein once said that people of labor and honor should be treated with respect even if their beliefs differ from ours. Brothers Moskalenko fully agree with the saying of the creator of the relativity theory.

At the honorable age of eighty five years, academicians Moskalenko are full of ideas and forces, ever before, continuing and developing original investigations, they are closely collaborating with many scientific groups from all around the world. With the same enthusiasm as 40–50 years ago, they are continuing the activity of education and training of a new generation of physicists.

The editorial board of the Moldavian Journal of the Physical Sciences and the physics community of R. Moldova sincerely congratulate physicists Moskalenko—prominent members of the Academy of Science of Moldova—with their honorary anniversary and wish them health and new successful climbing on the enormous mountain of modern condensed matter theory.

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