https://doi.org/10.15407/ujpe68.5.361

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IN MEMORY OF ERNST ANATOLIYOVYCH PASHITSKII (1936–2023)

On February 14, 2023, Ernst Anatoliyovych Pashitskii, brilliant scientist, Professor, Doctor of physical and mathematical sciences, and Corresponding Member of the National Academy of Sciences of Ukraine, passed away in his 87th year.

Citation: Galkina E.G., Pentegov V.I., Semenov A.V., Ryabchenko S.M., Bondar M.V. In memory of Ernst Anatoliyovych Pashitskii (1936–2023). *Ukr. J. Phys.* **68**, No. 5, 361 (2023). https://doi.org/10.15407/ujpe68.5.361.
Цитування: Галкіна О.Г., Пентегов В.І., Семенов О.В., Рябченко С.М., Бондар М.В. Пам'яті Ернста Анатолійовича Пашицького (1936–2023). *Укр. фіз. журн.* **68**, №5, 360 (2023).

E.A. Pashitskii was always distinguished by his independent manner of thinking and an extremely wide (especially for our times of narrow specialization) range of scientific interests. During his more than half a century's scientific life, Ernst Anatoliyovych worked in various domains of theoretical physics, such as the plasma theory; the theory of superconductivity (including high-temperature superconductivity); the solid state theory (including physics of metals and semiconductors); surface physics of solids and liquids (including the surface of liquid helium); the theory of helium superfluidity and its unique properties in acoustic and electromagnetic fields; the theory of layered crystals and heterostructures (including the quantum Hall effect); nanophysics of carbon structures such as fullerites, nanotubes, and graphene; and hydrodynamics of vortices in gases, liquids, and solar plasma. In recent years, E.A. Pashitskii got interested in the problems of cosmology and the origin of our Universe.

This is how Ernst Anatoliyovych wrote about his scholarly style: "I was often simultaneously engaged in solving quite different tasks, and this provided the reliability and stability of my daily scientific work: if a certain problem failed to be solved (this is not uncommon in our activity!), then luck accompanied me in another problem from a completely different field of physics."

E.A. Pashitskii was born on December 16, 1936, in Zhytomyr. His father, Karl Karlovych Bagants, a

German communist and political emigrant, came to the USSR in the early 1930s. In 1937, K.K. Bagants was "offered" to join an international brigade and go to war in Spain, where he was killed in 1938. His mother, Lidiya Fedorivna Bagants, was a music teacher in kindergartens. During the war, little Eric, his mother, and his grandmother were evacuated to Guryev in Kazakhstan. In 1944, they returned to Zhytomyr. Eric remembered very well this terrible journey to Guryev and back, as well as a very difficult, not childlike life in evacuation.

After the war, his mother married Anatolii Yukhymovych Pashitskii, who adopted Erik and gave him his surname and patronymic. In 1951, the family moved to Kyiv. In 1954, E.A. Pashitskii graduated from the school (with a silver medal) and entered the Faculty of Physics at the Taras Shevchenko State University of Kyiv (now the Taras Shevchenko National University of Kyiv). After graduating from the Faculty of Physics in 1959, young scientist began working at the Institute of Physics of the Academy of Sciences of the Ukrainian SSR (now the Institute of Physics of the National Academy of Sciences of Ukraine, IP NASU), where he was engaged in scientific research throughout his life.

Ernst Anatoliyovych Pashitskii began his research activity in plasma physics at the Department of Gas Electronics of the IP NASU. Then he entered the targeted postgraduate course at the Kurchatov Institute of Atomic Energy. There, besides the contacts with his official supervisor A.B. Mikhailovskii, he passed through the theoretical school of the Head of the plasma theory sector, Academician M.A. Leontovich. Later, Ernst Anatoliyovych repeatedly noted that he found himself in an "equidistant" position with respect to the two leading and in many ways competing theoretical schools created by L.D. Landau and N.N. Bogolyubov. He was highly respectful of both masters and maintained excellent relations with the representatives of both schools. At the same time, he liked to repeat that he was a follower of the Landau school.

In 1965, he returned to Kyiv and in early 1966 defended his PhD thesis "Issues in the theory of nonequilibrium plasma stability", where he considered and classified a large number of instabilities in nonequilibrium and simultaneously spatially inhomogeneous plasma embedded into an external magnetic field. In particular, boundary conditions at the interface between a stationary plasma and a plasma with a beam of charged particles were formulated; they are known as the Mikhailovskii–Pashitskii conditions [1].

However, shortly after defending the dissertation, besides plasma physics, Ernst Anatoliyovych became interested in the physics of superconductivity. In 1967, he came to the idea of a non-phonon mechanism of superconductivity due to the interaction of electrons with acoustic plasmons. At that time, few physicists recognized the possibility of such a mechanism, so he had to go to the Ukrainian Institute of Physics and Technology in Kharkiv to A.I. Akhiezer and V.G. Bar'yakhtar. E.A. Pashitskii received their approval. Afterwards he called V.G. Bar'yakhtar his "godfather" in superconductivity, and the superconductivity theory became the main direction of his scientific work throughout his life.

In 1968, E.A. Pashitskii published his first article in the *Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki* [2] on the new non-phonon (plasmonic) mechanism of Cooper electron pairing in degenerate semiconductors (semimetals). It turned out that the referee who opened himself to discuss the results of the paper was G.M. Eliashberg, whom Ernst Anatoliyovych considered his teacher in the superconductivity theory. Later, E.A. Pashitskii comprehensively considered the possibility of the plasmonic (Coulomb) mechanism of superconductivity for various metal–insulator layered systems, including mesoscopic ones, in the context of searching for the (then hypothetical) high-temperature superconductivity (HTSC). In those years, it took great courage to declare the possibility of high-temperature superconductivity. Defending a dissertation on this topic was not an easy task. First of all, the idea had to gain the recognition of the scientific community. A report at the Institute of Physical Problems and the comments of leading theorists V.L. Ginzburg, D.A. Kirzhnits, and G.M. Eliashberg became a serious support in this aspect.

In 1974, E.A. Pashitskii defended his doctoral dissertation "Collective effects and superconductivity in systems with Coulomb interaction". The prediction of the HTSC phenomenon almost 20 years before its experimental discovery and the development of the nonphonon (plasmonic) mechanism of HTSC in semimetals and layered semiconductor structures comprised one of the main scientific achievements that made Ernst Anatoliyovych Pashitskii famous. After the dis-

covery of real HTSC in layered cuprate metal-oxides in 1986, E.A. Pashitskii together with collaborators from the Laboratory of the Theory of Nonperfect Crystals (he headed it 1989–1997) studied various anomalous properties of those compounds with regard for their experimentally observed electronic structure, in the both normal (above the critical temperature) [3] and superconducting (from the viewpoint of the Coulomb mechanism of superconductivity) [4–7] states.

Ernst Anatoliyovych analyzed superconductivity within not only the exotic plasmonic and bipolaron mechanisms [8], but also applied the traditional phonon mechanism, where he proposed some improvements to the well-known McMillan formula for the critical temperature of the superconducting transition and the isotope effect [9]. In the framework of the phonon mechanism, he also considered the possibility of the influence of the Yang–Teller effect on the growth of the critical temperature in doped fullerites [10].

In the domain of superconductivity (this concerns not only the microscopic mechanism, but also many properties at the mesoscopic level), E.A. Pashitskii was a world-class authority. He was invited to work at leading universities in the United States, the United Kingdom, Sweden, and Germany. During his work at the University of Wisconsin (USA), E.A. Pashitskii together with Alex Gurevich developed the theory of critical superconducting currents in epitaxial cuprate HTSC films on substrates with low-angle grain boundaries and their dependence on the misorientation angle [11, 12]. The film regions beyond such boundaries were considered to be quasi-periodic chains of edge dislocations, and the interference of strain fields generated by the nuclei of such dislocations, the dependence of the critical superconducting transition temperature on the pressure in the film material, and the superconducting proximity effect were taken into account.

Those ideas were also engaged to analyze the results of non-contact measurements of critical currents in epitaxial HTSC films, which were carried out at the IP NASU and the Institute of Metal Physics of the NASU [13, 14]. A completely different role is played by the networks of dislocations that are formed because of a mismatch between the lattice constants at the interface between two films of different monochalcogenides (they are narrow-band semiconductors) that were grown epitaxially one on the other. According to the model proposed by E.A. Pashitskii, the emergence of superconductivity in the corresponding superlattices [15] and bilayers [16] occurs due to the formation of a metal layer (also in the form of a network) at a certain distance from the interface due to elastic dilatation fields induced by dislocation nuclei and the corresponding inversion of bands in narrow-band semiconductors such as PbS. It is in this metal layer that the superconducting transition takes place.

Ernst Anatoliyovych also dealt with the problems related to the "Cooper" and "exciton" pairings of charge carriers in two-dimensional (2D) systems in quantizing magnetic fields. Besides the study of the possibility that a superconducting state with a critical temperature T_c periodically depending on the magnetic field [17] and an excitonic phase related to the integer quantum Hall effect [18, 19] can exist, E.A. Pashitskii considered in detail what occurs in ultrahigh fields when the resulting small size and low density of Cooper pairs do not give rise to the appearance of a coherent superconducting state, but they can manifest themselves in transport properties, namely in the fractional quantum Hall effect (FQHE). He showed that the assumption about the coexistence of coupled pairs with free carriers makes it possible to explain almost all fractional values that were experimentally observed for the FQHE, whereas the possibility for coupled triplet "Cooper" pairs to exist in the completely polarized state at the lowest Landau spin level can emerge due to the electron-phonon interaction of 2D electrons with 2D surface acoustic and optical phonons localized near the interface in semiconductor heterostructures [20].

Besides a wide range of effects associated with superconducting and exciton pairings [21], the scope of scientific interests of Ernst Anatoliyovych Pashitskii also included the problems of magnetic ordering. Here, it is worth mentioning the study of antiferromagnetism in narrow-bandgap semiconductors [22], as well as the first theoretical prediction of ferromagnetic ordering in degenerate magnetically dilute (semimagnetic) semiconductors, where the indirect exchange interaction between the spins of magnetic impurities through the degenerate gas of charge carriers turns out to be essential [23].

Ernst Anatoliyovych also left his mark in the theory of superfluidity. Most notably, he proposed the

idea about the decisive role of the pair coherent condensate of strongly interacting Bose particles (together with the one-particle Bose–Einstein condensate) in the formation of the properties of superfluids such as He II [24]. E.A. Pashitskii had been returning to the problem of pair condensates for many years, and he had developed this approach in a series of articles with various co-authors [25, 26]. It is also worth noting the interest of E.A. Pashitskii in the problems of electrical activity of superfluid He II and its interaction with electromagnetic radiation, as well as his works concerning the hydrodynamics of superfluids.

During his scientific life, Ernst Anatoliyovych repeatedly returned to the hydrodynamic problems, which he began to study as long ago as in the 1960s when dealing with the plasma properties. In particular, in a series of papers published since the 1990s, he worked out a hydrodynamic theory describing the emergence and development of nonlinear vortices, the decisive feature of which is the presence of the bulk sink of matter [27]. E.A. Pashitskii used this theory to describe a variety of vortex structures and motions: vortices in ^{3}He–^{4}He mixtures, tornadoes in the Earth's atmosphere, magnetohydrodynamic vortices in the solar atmosphere, and the "solid-body rotation" of the solar core [28–31].

In recent years, Ernst Anatoliyovych with his inherent enthusiasm had turned his attention to a completely new task, the cosmological research. He proposed and developed an original model of the first-order phase transition with respect to the parameter of the scalar curvature in the early Universe followed by its subsequent inflationary expansion [32].

Furthermore, Ernst Anatoliyovych Pashitskii had the pioneering results in surface physics, where his brightest achievement is the creation of the theory of lateral interaction of adsorbed atoms on the metal surface accounting for the peculiarities in the cross-section of the metal Fermi surface (FS) along the directions corresponding to specific atomic planes. In particular, he suggested that the appearance of periodic structures consisting of adsorbed atoms with a period of several atomic lattice constants on certain metal surfaces may be associated with Friedel oscillations of the charge density; the period of these oscillations is determined by the radius of the corresponding FS cross-section, which is small in comparison with the size of the first Brillouin zone [33–36].

Besides solid-state surface physics, Ernst Anatoliyovych also studied instabilities on the surface of liquid metal in strong electric fields. The research was aimed at developing liquid metal cathodes [37]. For his works in surface physics, E.A. Pashitskii together with a team of co-authors was awarded the State Prize of the Ukrainian SSR in science and technology in 1987.

Among the disciples of E.A. Pashitskii, there are six PhDs; later three of them defended their doctoral dissertations. He published more than 200 scientific papers in leading scientific journals. He was a well-known professor at the Taras Shevchenko National University of Kyiv. For 30 years, he lectured on theoretical physics at the Faculties of Physics and Radiophysics. As a deputy editor-in-chief, Ernst Anatoliyovych made a large contribution to the creation of the unique encyclopedic dictionary *Solid State Physics*. For the scientific and organizational work on this publication, he along with other editorial board members was awarded the S.I. Pekar Prize of the National Academy of Sciences of Ukraine.

Ernst Anatoliyovych Pashitskii was known as an excellent popularizer of science. He had a gift for popularization, the ability to describe complicated scientific problems in commonly apprehensible terms. He was the author of the popular scientific book *Superconductivity and Superfluidity in Science and Technology* and the methodological scientific book (the textbook for universities) *Fundamentals of the Superconductivity Theory*, as well as papers in authoritative popular scientific magazines. Ernst Anatoliyovych willingly lectured on modern scientific achievements. He was a member of the well-known scientific society *Znannya* (*Knowledge*) and a consultant at the Kyiv film studio of popular scientific films. His science fiction stories, which were published in the magazine *Tekhnika Molodyozhi* (*Technique for Youth*), and the science fiction book *The Journey Will Be Dangerous*, which was co-authored with O. Rozhen, "infected" many young readers with the love for science and cognition of the world.

Ernst Anatoliyovych was always open for communication. His ability to get close to people easily and for a long time was based on his high friendliness and an ability to empathize and rejoice in the success of others. Many of those who knew Ernst Anatoliyovych called him Erik. He was a very intelligent and widely knowledgeable person. Besides physics, he had been

keenly interested in music and literature. He did not participate in the confrontation between physicists and lyricists, which was fashionable in the 1960s–1970s, probably because he began to write poetry himself in the late 1980s. This began as a game. Ernst Anatoliyovych dedicated his first poems to his colleagues and friends on their anniversaries. But one day a phase transition took place, when physicist realized that poems rather than words sometimes came to him from his internal world. Then he took a chance: when having written a sufficient number of poems, E.A. Pashitskii published his first poetry collection in 2006. In 2011, he published another poetry collection, and in recent years he wrote the autobiographical prose *My Life-Being*. Science was the main muse of his literary activity, and he clearly expressed his admiration for it in a lot of his poems.

Ernst Anatoliyovych Pashitskii was bright, courageous, and uncompromising person with a great love for life. His entire life belonged to science. Despite a grave years-long illness, he continued to work and create, and sincerely enjoyed when communicating with his friends and relatives. Till the end of his days, Ernst Anatoliyovych retained an almost childish admiration for the Universe's beauty and the ability of the human mind to comprehend it. The memory of this outstanding person will be forever preserved in the minds of all who knew him.

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Received 22.05.23
Translated from Ukrainian by O.I. Voitenko