On the 80th Anniversary of Alexander Semenovich Kovalev

May 18, 2025 marks the 80th birthday of outstanding theoretical physicist, Doctor of Physical and Mathematical Sciences, Professor A. S. Kovalev. Alexander Semenovich was born in 1945 in Ulan-Ude, Trans-Baikal region, in the family of a military serviceman. In 1949 his family moved to Kharkiv. It is worth noting that Kharkiv became Alexander Semenovich's hometown, and he has maintained his love for it throughout his life.

Alexander Kovalev began his education at the famous Kharkiv School No. 36, which over the years has produced many well-known physicists and mathematicians, such as M. Y. Azbel, E. A. Kaner, A. M. Kosevich, Y. I. Lyubich, and V. M. Tsukernik. During the years when Alexander (and the author of this article) studied there, physics was taught by the remarkable teacher Yuri Anatolievich Sokolovich, who not only loved physics and understood it deeply but also was able to pass the love and enthusiasm for physics on to his students.

A. S. Kovalev graduated from school in 1962 and entered the Physics Department of V. N. Karazin Kharkiv National University, where he attended lectures by I. M. Lifshitz and his colleagues — M. I. Kaganov, E. A. Kaner, A. M. Kosevich, G. Y. Lyubarsky, and Y. I. Lyubich. After graduating from the university in 1967, A. S. Kovalev began working at the Kharkiv Institute of Physics and Technology in the Department of Theoretical Physics led by I. M. Lifshitz, in A. M. Kosevich's laboratory. Here, he once again found himself in the remarkable atmosphere of the school of I. M. Lifshitz, which determined his scientific destiny and played a decisive role in his formation as a scientist. The working style of I. M. Lifshitz's school and one of his closest students, A. M. Kosevich — deep immersion in the subject, scrupulous study of the material, impeccable command of mathematical apparatus — also became A. S. Kovalev working style.

Together with his scientific advisor and Teacher Arnold Markovich, Alexander Kovalev obtained a series of results in what was then a new direction in solid state physics: nonlinear dynamics of crystal lattices. They investigated essentially nonlinear excitations in crystals (solitons, in modern terminology) of various types. They described crowdions (from "crowd"), lattice excitations, which determine the rapid movement of an "extra" atom in the lattice. Such states are not only interesting from a fundamental point of view as an example of a lattice topological soliton but are also important for analyzing the behavior of nuclear engineering materials under strong radiation. The possibility of supersonic movement of crowdions was predicted. They also pioneered the investigation of nonlinear self-localized states of small amplitude in crystals, or breathers in modern terminology, which are stable soliton states in non-integrable systems. To perform this analysis, a new asymptotic method was proposed, generalizing the approach of N. M. Krylov, N. N. Bogolyubov, and Yu. A. Mitropolsky (developed for finite-dimensional systems) to the case of nonlinear evolution

equations. This work played a significant role in the development of soliton physics; it has been used and consistently cited for 50 years. These results formed the basis of A. S. Kovalev's PhD dissertation "The Influence of Nonlinearity on the Dynamics of Localized Excitations in Crystals", which he defended in 1975.

In 1975, Alexander Kovalev transferred to the theoretical department organized by A. M. Kosevich at the B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, and till now, for more than 50 years, his scientific career has been connected with this institute. It was here that Alexander Semenovich and his co-authors carried out pioneering work that effectively laid the foundations of the modern soliton concept in condensed matter physics. The concept of a soliton as a bound state of a large number of quasiparticles of linear theory characterized by given values of integrals of motion such as momentum or angular momentum, was formulated (with A. M. Kosevich and B. A. Ivanov). Two-dimensional localized topological magnetic solitons were discovered (with A. M. Kosevich and K. V. Maslov, 1979). Such solitons, now commonly called skyrmions, are intensively investigated now; in spintronics, they are considered as elements of perspective information recording and processing devices. Multi-soliton states of biaxial ferromagnets were found for the first time (with M. M. Bogdan, 1980). These and other results formed the basis of his Doctor of Science (Dr. habil.) dissertation "Nonlinear Dynamics of Condensed Matter: Magnetic and Elastic Solitons" (defended in 1989). Together with A. M. Kosevich, he began studying the connection between crystal lattice defects in antiferromagnets and topological magnetic solitons (domain walls, spin disclinations). This research generated a series of works devoted to the analysis of complex magneto-structural states of coupled magnetic disclinations with atomic dislocations in AFM and with defects of FM/AFM interfaces, carried out jointly with his student Olga Dudko. A series of works with his student Marina Pankratova was related to the behavior of such states in an external field with a significant contribution to the theory of exchange bias effect, which is of great practical importance. The research on the dynamics of topological excitations (vortices) was conducted by Alexander Semenovich with Frans G. Mertens (vortices in finite systems and their interaction with spin waves), Yaroslav Prilepsky (change of vortex polarity in a field, finite-dimensional analogs of vortices), and Stavros Komineas (interaction of vortices and vortex pairs). Nonlinear surface spin waves and surface acoustic solitons were predicted (with A. P. Mayer). A. S. Kovalev studied the complex problem of soliton propagation in random media (together with S. A. Gredeskul and S. Turitsyn). He investigated gap solitons in various systems, e.g., media with internal structure (together with A. Gorbach and O. Usatenko) and magnetic multilayer films (with M. Johansson). He had paid great attention to the problem of the existence and stability of nonlinear modes localized on crystal defects (with Y. S. Kivshar *et al.*). Despite the constant interest in the soliton problem, Alexander Semenovich was not limited to it. As some examples, mention his analysis (with M. L. Polyakov and A. M. Kosevich) of the conformations of rigid macromolecules in confined volumes (pores and gaps), and the pioneering study (with A. I. Landau) of the connection between chaotic behavior of a dynamical system and the phenomenon of spatial diffusion. The results of A. S. Kovalev's research have been published in two monographs, three review articles, five teaching aids, and more than 200 original papers.

Alexander Semenovich is actively engaged in scientific-organizational and pedagogical work. For many years, he has been a member of the editorial board and Associate editor-in-chief of the journal "Fizyka Nyzkykh Temperatur/Low Temperature Physics", investing much effort in organizing this work. Even now, in very difficult times, the Journal maintains its high rating, and its issues are published without interruption, largely due to the active participation of A. S. Kovalev in this work.

For many years, Alexander Semenovich has been teaching a general course of lectures on theoretical mechanics and a special course "Nonlinear Physics of Condensed Matter" as a professor at the Department of Theoretical Physics in the Physics Faculty of V. N. Karazin Kharkiv National University. He works extensively with young people; seven PhD dissertations have been defended under his supervision, and one of his students became a Doctor of Science. Alexander Semenovich is an authoritative specialist in the field of nonlinear physics; he has been invited for joint research at leading universities in Germany, France, England, Sweden, Poland, and Australia. His scientific work has received well-deserved recognition. He was awarded the A. S. Davydov Prize of the National Academy of Sciences of Ukraine for achievements in theoretical physics (2005) and he is a laureate of the State Price of Ukraine in Science and Technology for a series of works "Nonlinear Waves and Solitons in Condensed Matter Physics" (2013). He has been awarded the Certificate of the Supreme Council of Ukraine for services to the Ukrainian people (2010), a diploma from the Kharkiv Regional State Administration, and the K. D. Sinelnikov scholarship in science for 2015.

Friends and colleagues dedicate the articles presented in this Special Issue to Alexander Semenovich's jubilee birthday and congratulate him on his 80th anniversary, wishing him health, indefatigability, and continued success in science.

B. Ivanov