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Vladimir Evgen'evich Zakharov (on his sixtieth birthday)

Professor Vladimir Evgen'evich Zakharov, an outstanding theoretical physicist, full member of the Russian Academy of Sciences, director of the L D Landau Institute for Theoretical Physics, RAS, has turned 60 on August 1, 1999.

The multifaceted activities of V E Zakharov concentrated on the creation and development of nonlinear physics. His influence was paramount to the solution of current problems in important fields of physics and brought him world-wide recognition, which is reflected in the highest ratings of his publications.

A representative of the illustrious constellation of the first class of graduates of the Physics Department of Novosibirsk University and the school of Professor R Z Sagdeev, V E Zakharov started his work at the Nuclear Physics Institute of the Siberian Branch of the Academy of Sciences of the USSR while still a student. Since 1974 he has worked at the L D Landau Institute of Theoretical Physics of the USSR Academy of Sciences.

Zakharov's scientific interests cover practically all of physics. He is the author of many fundamental results in plasma theory, hydrodynamics, solid state physics, nonlinear optics, oceanology, general relativity, field theory, and in mathematical physics. Zakharov's pioneering results in the theory of integrable systems and the development of the inverse scattering method — a gem of the mathematical physics of the 20th century — brought him the recognition not only of physics theorists but also of mathematicians.

Three of the most important fields of nonlinear physics — theory of wave collapse, theory of solitons and theory of turbulence — owe their coming of age and rapid progress to V E Zakharov. The methodological basis for many achievements in nonlinear physics research, which are now routinely connected to his name, is his use and further development of the Hamiltonian formalism and the generation of new results in mathematics. For example, the equations that describe the interaction between Langmuir and ion-sound waves in plasma are known as the Zakharov equations. In 1967 – 1968 he predicted the Kolmogorov spectra of weak wave turbulence. The corresponding transformations of kinetic equations used to obtain these spectra are known as Zakharov transformation. The spectral Zakharov – Shabat problem is used as a linear problem for integrating the nonlinear Schrödinger equation and its hierarchy by applying the inverse scattering transform. New solutions for integrable models are constructed by the Zakharov – Shabat dressing procedure. Nonlinear plasma theory operates with Zakharov – Kuznetsov and Zakharov – Rubenchik equations.

Zakharov's paper of 1972, in which the Langmuir wave collapse was first described, laid the foundation for the theory of wave collapse. The preceding theory of turbulence, based on random phase wave approximation, predicted the formation of Langmuir condensate at $k = 0$, which was not supported by empirical data. As was shown, such a scenario of development of plasma turbulence was impossible due to the instability of condensate. Langmuir wave collapse, as the nonlinear stage of the instability's development, leads to the compression of the Langmuir wave packet to the size of several Debye radii and is accompanied by the generation of fast electrons. This work dramatically changed the understanding of plasma turbulence and also of mechanisms of dissipation of high-frequency wave turbulence under collective heating conditions — by electron beams or high-frequency electromagnetic fields, for example.

Vladimir Zakharov is one of the founders of the soliton theory, which owes its creation to the development of subtle mathematical techniques for integration of nonlinear partial differential equations using the inverse scattering transform formalism. Together with A B Shabat, Zakharov integrated the nonlinear Schrödinger equation that describes the self-focusing and self-modulation of light in nonlinear dielectrics. In accordance with this theory, solitons behave as particles and remain unaffected when scattered, acting as structurally

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stable coherent entities. This theory has essentially opened the possibility of utilizing optical solitons in fiber-optic communication systems as bits of information. Owing to the work of Zakharov and his disciples, this direction has vastly expanded in recent years and led to numerous applications in the latest telecommunications technologies.

The Zakharov – Shabat dressing method is based on constructing new solutions to nonlinear integrable equations by deforming an arbitrary bare solution. This method casts a defining influence on the modern state of nonlinear wave and soliton theory. Another approach, introduced by Zakharov and his colloquies, is based on the solution of the Riemann nonlocal spectral problem and its modifications. This activity was crowned by Zakharov's solution to the classical problem of describing the orthogonal curvilinear system of coordinates in a Euclidean space of arbitrary dimensions. This problem was posed at the beginning of the 19th century and traces back to the names of great mathematicians such as Riemann, Bianchi and others.

The creation of the theory of wave collapse, beginning with Zakharov's seminal works on the theory of Langmuir collapse and light self-focusing and ending with the research of collapse interaction, weak turbulence and the effect of plasma collapse on particle spectra is a fundamental contribution to the physics of nonlinear wave processes.

Together with his colleagues (V S Lvov, S S Starobinets and others) V E Zakharov authored the theory of parametric excitation of waves by a coherent source, the so-called S-theory. It is based on the original idea of describing the above-threshold turbulent state in terms of normal and anomalous pairwise correlators. In a certain sense, this theory became an analog of the BCS theory of superconductivity. One of its important results was the prediction of a singularity in stationary turbulence spectra, later confirmed in experiments on the parametric excitation of spin waves in ferromagnets. As this work progressed, V E Zakharov and his students also constructed a theory of singular spectra of plasma turbulence caused by induced scattering of electromagnetic waves in plasmas, when the spectra are distributed as jets or are even concentrated at single points of the k space.

The creation by V E Zakharov of the theory of Kolmogorov spectra of wave turbulence, which are found in sea-wave patterns, sound turbulence and excitation of plasma oscillations, proved to be a first-rate contribution to oceanology and plasma physics and to a large degree defined what they are now.

In 1978 V E Zakharov and V A Belinsky solved an important general relativity problem of integrating the Einstein equations for a two-dimensional metric, which made it possible to classify their solutions using spectral methods that operate with variable spectral parameters. In the same year Zakharov, together with V E Belavin, wrote a paper, which became widely known, on the exact integration of the dual Yang – Mills equation which described instantons as tunneling solutions that connect various vacuum states.

Throughout his scientific carrier, V E Zakharov has always devoted much of his attention to the continuation of the scientific tradition, fostering many first-rate scientists. The science school of the physics of nonlinear phenomena that he created is one of the leading in the world, and his students are now successfully doing physics in many countries. Zakharov is chairman of the Nonlinear Dynamics Science Council of the Division of General Physics and Astronomy of the Russian Academy of Sciences, heads the Russian Interbranch Research and Development Program on Fundamental Problems of Nonlinear Dynamics, and created the International Institute of Nonlinear Studies. Since December 1992, he has headed the L D Landau Institute of Theoretical Physics, RAS, the leading Russian center for theoretical physics.

Zakharov's active position as a citizen always had and still has great importance for maintaining the reputation the authority of Russian science both in Russia and outside it. He initiated programs for allowances to outstanding Russian scientists and for support for the leading scientific schools. Zakharov is generous in his efforts to expand the collaboration between scientists in different countries, working as a professor in the leading research centers of the world: the Institute for Advanced Studies (Princeton), Chicago and Arizona Universities in the USA, the Weizmann Institute (Israel), New South Wales University (Australia), the Institute for Science (India), and the Institute for Nonlinear Science (France). He has served as chairman of organizational and program committees of a number of international conferences, symposia and schools on theoretical and mathematical physics. Vladimir Evgen'evich is the Editor-in-Chief of the *Journal of Nonlinear Scienc*e, editor of *Physica D*, one of the organizers and active members of the Soros International Science Fund and of the Open Society Institute.

V E Zakharov's achievements in fundamental studies of nonlinear physical phenomena were rewarded in 1987 and 1993 by State Prizes.

Zakharov's poetic gift proved to be on a par with his universality in science. Selections of his poems, invariably in resonance with the times we live in, were published over the years in *Novyĭ Mir* magazine and various volumes of collected verse lending support to the validity of Anton Chekhov's idea that "... an artist's intuition is sometimes worth a scientist's brain, that both share the same goals, both issue from the same foundation, and perhaps, some day, when their methods reach perfection, are destined to coalesce into one ..."

Friends, colleagues and students of Vladimir Evgen'evich congratulate him on this anniversary and wish him many happy returns of the day and further creative achievements.

A A Galeev, E A Kuznetsov, A V Mikhaĭlov,
Yu E Nesterikhin, S P Novikov, R Z Sagdeev,
Ya G Sinaĭ, G I Smirnov, V E Fortov,
I M Khalatnikov, B V Chirikov, A B Shabat