Leonid P. Shilnikov

December 26, 2011, died a great mathematician, one of the greatest experts on the theory of dynamical systems and bifurcation theory, laureate of Lyapunov of the Russian Academy of Sciences and MALavrentiev National Academy of Sciences of Ukraine, Humboldt Professor, Department of Numerical and Functional Analysis, Head. Department of Differential Equations Institute of Applied Mathematics and Cybernetics, Nizhny Novgorod University, Leonid Pavlovich Shilnikov.

Leonid Pavlovich was born December 17, 1934 in Kotelnich Kirov region in a working class family. After graduating from high school in 1952, he joined the Physics and Mathematics Gorky State University, graduating in 1957, after completing graduate studies (1957-1960) he defended in 1962 his thesis on "The Birth of periodic motions from singular trajectories" , in which generalized to the multidimensional case nonlocal bifurcations studied for systems in the plane AA Andronov and EA Leontovich.

Shortly thereafter, he became interested only when the nascent theory of systems with a complex (chaotic) dynamics. By this time there has been the example of the Smale horseshoe map (1961), which started a new era in the theory of dynamical systems, and left a note DV Anosov (1962) of the geodesic flow, which was formulated by the hyperbolicity property and found it of paramount importance. Building on the results of his dissertation, Shil'nikov found (note to Dan, 1965) that an infinite number of Smale horseshoes and hence complex dynamics exist in the neighborhood of a homoclinic loop of a saddle-focus. Today we know that shilnikovskaya loop determines the chaotic dynamics of a wide range of models from different fields of science. However, for the time the result that the complex dynamics arise near such a simple and familiar object, as the separatrix loop, was totally unexpected. Shilnikov realized that the study of homoclinic bifurcations gives him a unique opportunity to study the complex dynamics of multidimensional systems, and dedicated this work all my life.

Already in 1965-67 gg. he published a complete solution of the classical, going back to Poincare and Birkhoff problem of the structure of the rough neighborhood of a homoclinic curve of saddle periodic motion. Shil'nikov considered this result is especially important, and never tired of emphasizing that the rough gomoklinika - the basic "building block" of chaos. He did not dwell on the case gomokliniki only to the periodic trajectory and immediately published a paper on the structure of a neighborhood family of trajectories homoclinic to an invariant torus (in particular, the quasi-periodic motion). Later studied the general nonautonomous infinite-dimensional case (with LM Lerman). Today, there are many methods to solve the problem of Poincare-Birkhoff periodic case is easy. Shilnikov itself developed a "method of cross-mapping," which was, in particular, is very convenient for obtaining asymptotic formulas for solutions of nonlinear in the vicinity of the saddles and formed the basis of research on the theory of homoclinic bifurcations.

This was followed by a series of papers, both the Leonid Pavlovich, and with the students, which, in essence, created a new section in dynamical systems theory - the theory of global bifurcations. All such bifurcations were classified into three broad classes: the bifurcation is not putting out of the class of Morse-Smale, the bifurcation

of Morse-Smale systems to systems with complex dynamics, a bifurcation in a class of systems with complex dynamics. Major (codimension one) bifurcation of the first type non-local in the multivariate case were studied by Shil'nikov. He has also been discovered and described by nonlocal bifurcation of the second type: in particular, historically the first example of a bifurcation of Morse-Smale systems to systems with complex dynamics become homoclinic loops bifurcation of the bouquet of the equilibrium state of saddle-saddle (1969). A little later he and his first disciple, NK Gavrilov started studying homoclinic tangency, and at VS Afraimovich and VI Lukyanov - periodic perturbations of autonomous systems with a separatrix loop, a bifurcation of homoclinic orbits of saddle-node and the destruction of invariant tori (ie, the phenomenon of transition from two-frequency modes in chaos and intermittency). In this now classic works have been studied various types of chaotic behavior, and it was found that complex dynamics are not described by the hyperbolic sets - chaotic regimes often coexist with the stable. Shilnikov later proposed the concept of "quasi-attractor" (attracting set, which along with hyperbolic subsets may contain stable periodic orbits of large periods) as the most adequate mathematical way of dynamic chaos observed in many applied problems.

While systems with complex dynamics are interested in physics and scientists from other fields. The question of how open mathematicians dynamic chaos is needed for science was discussed very widely, and Shilnikov took an active part in the discussions. The turning point, as we do, and in the West, in fact - proof that dynamic chaos - one of the fundamental phenomena of nature, was the discovery of a strange attractor in the Lorenz system. In contrast to the hyperbolic attractors, whose theory was already well developed, the Lorenz attractor (not open at the tip of the pen, but "on the remote computer") does not retain its structure when the parameters - it bifurcates. Shilnikov, recalled that as soon as he learned of the Lorenz attractor, it became instantly clear that here the necessary methods of bifurcation theory have been created by him and his school. He immediately began a series of remarkable studies on the Lorenz attractor, written jointly with VS Afraimovich and VV Bykov. In these studies (1977-83 gg.) Clearly demonstrated a deep understanding of the dynamics of Leonid Pavlovich, bifurcation theory, the ability to create an adequate mathematical model. Without this it would be impossible to investigate such details with the whole picture of the appearance and disappearance of an attractor and its structure changes with variation of parameters. To this day the theory Afraimovich-Bykov-Shil'nikov remains the most complete and convenient for practical analysis of the structure and evolution of the Lorentz type attractors in various models.

In 1982 he was replaced by Shilnikov Eugenia A. Leontovich-Andronov in the post head. Department of Differential Equations Research PMK. He spearheaded the friendly team, which informally adjoined closely knit circle of students and colleagues. Led by Shil'nikov weekly seminar has always been the center of the living and the intense debate and act on it was a great school. In addition to directly shilnikovskoy subjects, studies were conducted in the department on a variety of ways: flows and foliations on surfaces, two-dimensional attractors of A-diffeomorphisms and higher-dimensional Morse-Smale systems, one-dimensional maps, integrable systems, local bifurcations, algebraic curves, field theory. Leonid

Pavlovich often able to find the right setting goals, even in far away areas of knowledge, he was distinguished by a special intuition - many of his colleagues noted that communication with the Shil'nikov had a huge impact on their entire academic career. He attached great importance to the promotion of new ideas and discoveries in the theory of dynamical systems specialists in radio and biophysics, hydrodynamics, meteorology, and was among the organizers of several conferences and workshops on nonlinear topics, he has actively promoted at such conferences. Experts from various fields of science supported and appreciated the close contact with Leonid Pavlovich and his school. When, after 1990 it became possible to travel abroad, Shilnikov was invited lectures at numerous international conferences (including the International Congress of Mathematicians in Beijing) and universities in the U.S., Belgium, France, Germany, Italy, Israel, he became a member of the editorial board of several international journals. For many years, collaboration with Nobel laureate IR Prigogine and his colleagues started with this great conference, "Homoclinic chaos" (Brussels, 1991), dedicated to the work of Shil'nikov.

Shilnikov particularly interested in the problem of the mathematical description of the bifurcation scenarios of turbulence. He has published several papers on this topic, which showed how the initial local bifurcations of regular dynamical regime leads to the formation of geometric structures responsible for the subsequent global bifurcations and chaos. Another, coming from the area of physics was the study of spatial chaos. Here, in a large series of joint work with department staff and the Moscow group of physicists, V. Olives have been studied by various local and global bifurcations in conservative and Hamiltonian systems, construct infinite series of localized solutions of non-trivial structure, discovered and studied a new type of homoclinic orbits - gomokliniki to homoclinic loops.

The main topic of scientific research have always been global Shil'nikov bifurcations and strange attractors. Together with his son Andrew and DV Turaev he continued research on the Lorenz attractor, in particular, have been discovered and studied the global and local bifurcations leading to its emergence. Discovered a new class of multi-dimensional strange attractors - wild pseudo-hyperbolic attractors, ie, attracting sets that include homoclinic tangency, but do not contain stable trajectories. Solved the problem of periodic perturbation of systems of Lorenz type.

In a series of papers with S. Gonchenko and DV Turaev has continued the study of homoclinic tangencies and systems from Newhouse regions dense structural instability. There were many interesting results, but the most important discovery, he considered himself Shilnikov, was that the bifurcation of systems with quadratic tangencies give rise to homoclinic tangencies of arbitrarily high order. Thus, it was clearly shown that traditional logic investigation of bifurcations of codimension magnification, extending from the singularity theory, does not work in the study of many systems with complex dynamics. In particular, if the system depends on a finite number of parameters and their significance for some a homoclinic tangency, then a complete description of all changes in the system is basically impossible to get!

One of the most popular among the specialists on nonlinear dynamics began work on the so-called Shil'nikov crash of blue sky. At the time, this type of

bifurcation for flows on two-dimensional surfaces has been detected, VS Medvedev. In studies of LP Shil'nikov (with DV Turaev, Shilnikov AL, NK Gavrilov) were constructed new examples of multidimensional and developed a general theory of bifurcations, which, as it turned out, may also lead to the birth of non-trivial hyperbolic attractors. From the practical point of view is particularly interesting that the blue-sky catastrophe plays an important role in the dynamics of slow-fast systems, in particular, the dynamics of neurons.

A total of Shil'nikov published more than 160 articles and several books, including two volumes of "Methods of qualitative theory in nonlinear dynamics," written with D. Turaev, L. Chua and A. Shilnikov and published in English, Russian and Chinese. He continued to work and do research until the very end. In recent articles, he returned to his favorite theme - the Lorenz attractor and its multidimensional generalizations.

LP Shilnikov was one of the most prominent specialists in the theory of dynamical systems, the founder of the theory of global bifurcations. In Shilnikova had many students who themselves have become well-known specialists in the theory of dynamical systems, and they, in turn, appeared students. Under his leadership, was protected by 16 master's theses, and four of his students became doctors of science. A very important quality of Leonid Pavlovich - his scientific courage. In addressing the important but difficult problems he resisted the temptation to follow the popular or fashionable direction, and went his own way, creating new methods of research.

LP Shilnikov was the clear leader of the Nizhny Novgorod mathematical life, he was one of the initiators of the Nizhny Novgorod Mathematical Society (1995) and its first president. The main location of the Leonid Pavlovich was PMK Institute - Institute of Applied Mathematics and Cybernetics, Nizhny Novgorod University (Institute of PMK to the organization in 1963, he worked in the math department of the Gorky Research Physical-Technical Institute) where he was successively Senior Research Fellow, Head. Laboratory (since 1967), and head. Department - from 1982 until late in life. He taught at the University of Nizhny Novgorod, read both regular and special courses. Up until last year he taught a course in "bifurcation of multidimensional dynamical systems", which was popular with students of mathematical and physical faculties. He always tried to arouse interest and to show the beauty of mathematics, so students interested in science, very much appreciated it. To him were always strong students, others he simply could not work. It was felt from a young age some power. Getting into his circle, a man once found himself in an unusual atmosphere of intense interest in science.

Leonid Pavlovich was a lively and interesting man, a great family man.
Back in college, he met his future wife, Ludmilla Ivanovna and had lived with her 55 years, was always her faithful companion and friend, and for their children and grandchildren was always attentive and loving family head, worthy of respect and ultimate role model. He was very fond of history, especially the history of science, had read a lot about these topics, alos very fond of football and knew all fne details of the game. Fishing in the country during the summer was his special passion.

For all of us Leonid Pavlovich will be a great scholar, teacher and wonderful

person. We will always remember him, develop his ideas and move on in science. He left us a new world that we must not lose. Eternal memory of him and thank you for all that he did.

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