Ludwig D. Faddeev

(March 23, 1934 – February 26, 2017)

On February 26, 2017, after a long fight with cancer Ludwig Dmitrievich Faddeev passed away. For the authors of this article Faddeev was a teacher and a constant source of scientific inspiration for many formative years.

First steps

Ludwig Faddeev was born in Leningrad (now St. Petersburg), USSR (now Russian Federation) on March 23, 1934, to a family of mathematicians Dmitrii Konstantinovich Faddeev[4] and Vera Nikolaevna Faddeeva[5]. From childhood Ludwig was exposed to classical music, to piano in particular, and he seriously considered attending the Leningrad Conservatory as an alternative to the university.

D. K. Faddeev playing piano.

Ludwig playing piano.

At the time of his graduation from high school in 1951 his father was the Dean of the Mathematics Department at the Leningrad State University, and so young Ludwig decided to go to the Physics Department. When he was a junior, a new Chair [6] of Mathematical Physics was established at the Physics Department. The first graduating class in mathematical physics had five students, two young men and three young women, among whom were L. D. Faddeev and N. Uraltseva.

At the time O. A. Ladyzhenskaya was a young energetic professor at the department and had great respect among students. She was lecturing on the theory of functions of complex variables, operator algebras, partial differential equations, and other subjects. When Ludwig was in the fourth year of his studies, she organized a student seminar based on the book by K. O. Friedrichs, "Mathematical aspects of the quantum theory of fields" [1]. Ladyzhenskaya had learned about this book from her colleagues at Courant. Faddeev was a key participant in the seminar. The book was translated and studied in every detail. According to his recollections, Faddeev was particularly impressed by the last chapter (the appendix) of the book, which

[4] D. K. Faddeev was one of the leading figures in algebra in the Soviet Union. Among his many results was the invention of group cohomology. This work was done while evacuated from Leningrad, mostly in Kazan, during the Siege of Leningrad (Leningrad Blockade) by the German Army Group North during World War II, when Ludwig was 7 to 9 years old. Due to the unfortunate timing this work was noticed only later, after the works of Eilenberg and MacLane.

[5] V. N. Faddeeva (maiden Zamyatina) was an applied mathematician working on numerical methods. Unfortunately, very few photos of her exist, and we did not find any that would be representative.

[6] Administratively the Physics Department (as any other department at any other university in the USSR) consisted of more specialized groups (called Kafedras, or Chairs, or Branches). Typically, each Chair was an umbrella unit for several professors.

was focused on scattering theory. He successfully used Friedrichs's perturbation theory of the continuum spectrum many times. It was an important tool in his study of scattering and inverse problems. At this time Ladyzhenskaya became his adviser. She also suggested to him to study the work of N. Levinson [2] on inverse scattering theory and to present it at the seminar. This was a very profound moment: inverse scattering problems influenced Ludwig's research for very long time. Regarding these times he wrote about O. A. Ladyzhenskaya: "I am forever grateful for the direction she gave me..."

O. A. Ladyzhenskaya.

He graduated from the University with the equivalent of a master degree in 1956 and continued to graduate school. At the time quantum mechanics and quantum theory were still a relatively young subject. Indeed, from the time when the Schödinger equation appeared in 1926 only thirty years had passed.

By that time important results in understanding the radial part of the three-dimensional Schrödinger equation had started to appear. In particular various aspects of the inverse problem for the s-channel of the Schrödinger equation, i.e. the Sturm-Liouville problem on a half line, were solved by Gelfand and Levitan [6], Marchenko [7] and Krein [8]. In 1958, at the suggestion of Ladyzhenskaya, N. N. Bogolyubov invited Faddeev as a speaker at the opening conference of the Theoretical Physics Laboratory in Dubna to present a survey and recent results on the one-dimensional Schrödinger equation. In the audience were I. M. Gelfand, B. M. Levitan, M. G. Krein,V. A. Marchenko, and other prominent mathematicians and physicists working in this field. The talk was very well received by the experts and Ludwig was invited to write a survey on the subject for the *Uspekhi Mathematicheskikh Nauk* (the central mathematical journal in the country) [22] where, among other things, he demonstrated the equivalence of the approaches by Gelfand-Levitan, Marchenko and Krein. This survey became a handbook for generations of people working on this subject. It is interesting that Ludwig's presentation at this conference initially was prepared as the report for his PhD qualifying exam.

Ludwig defended his PhD thesis in 1959. In his dissertation he solved the inverse scattering problem for the Schödinger equation on the line with a rapidly decaying potential and found dispersion relations for scattering amplitudes[7].

The three-body problem and the quantum inverse scattering problem in three dimensions

After defending his PhD and settling as a researcher at LOMI[8] he focused on two problems: inverse scattering for a three-dimensional Schrödinger operator and the three-body scattering problem[9]. At the time he was reading a lot, especially on scattering theory. In particular, he studied the approaches by Lippman and Schwinger, Gell-Mann and Goldberger, Epstein and others. There was also the work by Skornyakov and Ter-Martirosyan, where the three-particle scattering problem was solved for δ-potentials.

Gradually, the outlines of Faddeev's work on three-particle scattering started to emerge. One of the technical tools important for his work is the reconstruction (regularization) of integral kernels. As he recalled, the idea of regularization came to him in 1960. His study of the Thirring model and of Epstein's paper [9] were important steps to come up with this idea. He discussed it with Gribov, which gave him confidence that the approach was new to physicists. The complete solution of the three-particle problem with rapidly decaying potential was published in a series of papers in 1960-1963. In 1962, Faddeev gave a sectional talk on the solution of three-particle scattering at the International Congress of Mathematicians in Stockholm, where among other participants from the Soviet Union were Gelfand, Kolmogorov, Linnik, Novikov, Patetsky-Shapiro, and Shafarevich. As he recalled his result went largely unnoticed. Ludwig's work on three-particle scattering was truly appreciated only after a paper by C. Lovelace [10], in which practical aspects of Faddeev's equations were developed. Immediately afterwards it was widely recognized as a milestone. Now it is commemorated by the Faddeev's medal [11], which is awarded for the best work on multi-particle scattering.

In 1963 Faddeev defended his habilitation degree. His dissertation was based on his work on three-particle scattering. The defense was in Moscow at the Stekov Mathematical Institute. His referees ("opponents" in Russian) were I. M. Gelfand, A. Ya. Povzner and V. S. Vladimirov.

The inverse problem for the three-dimensional Schrödinger operator was solved in a series of papers [12] where he described necessary and sufficient conditions for reconstructing the potential from the scattering data. After he completed this work he never returned to the analysis of the Schrödinger operator. Several of his students and colleagues completed various aspects of the program he outlined and extended the scope of the results, most notably V. S. Buslaev, D. R. Yafaev, S. P. Merkuriev, O. A. Yakubovsky.

[7] Landau and Lifshitz in their famous textbook "Quantum mechanics" (chapter XVII, section 130) outlined the proof of the dispersion relation for forward scattering and noted: "The idea of the proof belongs to L. D. Faddeev (1958)."

[8] LOMI is the abbreviation of Russian Leningradskoe Otdelenie Matematichesogo Instituta, or in English translation, Leningrad Branch of the Mathematical Institute (of the Steklov Institute of the Academy of Sciences).

[9] He recalled this period in an interview [4].

Yang-Mills and Faddeev-Popov ghosts

One of the main goals of Ludwig, after developing the theory of three-particle scattering, was to understand the quantum theory of fields (the preferred name is now *quantum field theory*) and apply it to gravity. Quantization of gravity was his main goal at this time. He did a lot of reading, studying classical papers of Feynman and Schwinger. One of his favorite books at the time was Lichnerovich's *Théories rélativistes de la gravitation et de l'électromagnétisme. Rélativité générale et théories unitaires* [13].

During this time a problem in quantum electrodynamics, known as the Landau pole, was discovered by Landau and Pomeranchuk. This cast doubts on concepts of local quantum field theory. Just before his tragic accident Landau wrote an influential article [15] in which he said[10]: "We are driven to the conclusion that the Hamiltonian method for strong interaction is dead and must be buried, although of course with deserved honor." In 1961, Faddeev published a joint paper with Berezin where he studied the renormalization of the wave function of the Schrödinger operator with zero radius [16]. One of their conclusions was that renormalization is not necessarily an artifact of perturbation theory, but that it can be approached by different methods. In their paper the non-perturbative method was the theory of self-adjoint extensions. This was one of the reasons for Ludwig to continue with Hamiltonian field theory despite widespread belief at the time that this path would lead to a dead end.

In 1964, a collection of translated papers, including the original paper by Yang and Mills, was published in Russian [17]. It immediately caught Ludwig's attention. By chance at the time Ludwig came across another book by Lichnerovich, on connections [14]. He immediately recognized that Yang-Mills fields are connections, and decided to focus on Yang-Mills theory first instead of more complicated Einstein gravity. During this time he already started collaborating with V.N. Popov. Soon this collaboration resulted in the famous article [18] setting out the correct perturbation theory (Feynman rules) for quantum Yang-Mills theory.

The main observation there was that because the transformation laws of non-abelian connections are nonlinear, the Jacobian of the mapping between gauge orbits and the gauge-fixing local section of the gauge group action needs to be taken into account. In perturbation theory this can be realized by the introduction of a non-physical fermionic "ghost" field, which became known as Faddeev-Popov ghost.

This revolutionary observation had great impact on the Yang-Mills theory. It defined a working perturbative expansion in terms of Feynman diagrams. The next step was the proof of the renormalizability of the Yang-Mills theory and the discovery that it is asymptotically free, i.e. free of the Landau's zero-charge paradox. Ultimately, it lead to the construction of Hamiltonian quantum field theory (the Standard Model) unifying all interactions except gravity. All computations in these developments were done using the Faddeev-Popov technique, for details see [20].

[10] This period of developments in quantum field theory is described clearly and concisely in the Nobel lecture by D. Gross [20].

Soliton equations as integrable systems

In 1971, Ludwig gave a talk at a symposium in Novosibirsk on his work on inverse scattering problem for three-dimensional Schrödinger equation. At the time V. E. Zakharov was working in Novosibirsk and after Faddeev's talk he explained to him the remarkable paper by Gardener, Green, Kruskal, and Miura on the method for solving the KdV equation and about Lax's interpretation of this work. This discussion led to the joint paper [23] by Faddeev and Zakharov, where they proved that the KdV equation is an infinite-dimensional completely integrable Hamiltonian system.

Finite-dimensional completely integrable Hamiltonian systems have their origin in classical papers by Euler, Lagrange, Jacobi, and Kovalevskaya on the rotation of a rigid body. But by the middle of the 20th century this subject was almost dead: there were no new finite-dimensional examples and not a single infinite-dimensional nonlinear example. In [23] Faddeev and Zakharov gave a very interesting infinite-dimensional example and laid the foundation for a new class of completely integrable systems which can be solved by the inverse-scattering method. In this sense it was a result of fundamental importance.

During his trip to the US in 1972, Faddeev gave a talk on his work with Zakharov. J. Klauder, who attended this talk, explained to Faddeev that there is another important equation which is relativistically invariant, the sine-Gordon equation[11]. It captured Faddeev's attention as a candidate for a classical relativistic nonlinear integrable field theory and in 1973 he started the search for a Lax pair with his new student L. Takhtajan. Remarkably, such a Lax operator was found [26][12]. In the subsequent works [28] and [29] the complete theory of the sine-Gordon equation as an infinite-dimensional completely integrable Hamiltonian system with a topological charge was developed.

The study of infinite-dimensional completely integrable systems was continued by Faddeev's students in the Laboratory of Mathematical Methods of Theoretical Physics in LOMI. Among them were P. P. Kulish, A. G. Reyman, N. Yu. Reshetikhin, M. A. Semenov-Tian-Shansky, E. K. Sklyanin and L. A. Takhtajan. Their body of work is summarized in the monograph [30].

These results built foundations for the theory of Poisson-Lie groups and Lie bialgebras later developed by V.G. Drinfeld [31]. This framework, together with Kostant's ideas and with [32], was developed in [33] into a scheme which produces integrable systems out of Poisson-Lie groups and solves their dynamics in terms of the factorization of Poisson-Lie groups.

Quantization of solitons

From the very beginning of the study of soliton equations Faddeev had in mind their potential for quantization, for constructing non-perturbative two-dimensional quantum field theories. From this point of view the sine-Gordon equation, being a relativistic invariant, was especially interesting. Faddeev correctly anticipated that the quantization of this infinite-dimensional Hamiltonian completely integrable system would be a relativistic quantum theory with rich

[11]This equation is a classical differential equation which describes embeddings of surfaces with constant negative curvature in $\mathbb{R}^3$. It also appears in nonlinear optics and superconductivity.

[12] It was also discovered independently in [27].

mass spectrum, where particles correspond to soliton solutions to the classical sine-Gordon equation. The first step in this direction was the semiclassical quantization with the hope that the quantum system would be an integrable local quantum field theory.

In 1974, Kulish demonstrated that in the semiclassical framework the SG model has infinitely many local conservation laws, which implies that the scattering must be purely elastic. This unexpected result was proven in perturbation theory by Arefieva and Korepin. This result, together with the locality of integrals of motion led to the conclusion that the multiparticle scattering in such systems reduces to a sequence of two particle scattering. Similar results were obtained in the paper by Faddeev, Kulish and Manakov [34] for the nonlinear Schrödinger equation which can be regarded as a non-relativistic limit of SG. The account of the semiclassical quantization of solitons is given in the review article by Faddeev and Korepin in [37].

Factorized scattering appeared earlier, in the pioneering work by C.N.Yang [35], who constructed eigenvectors and eigenvalues of the Hamiltonian of one-dimensional non-identical point particles with δ-function interactions. In this paper the Yang-Baxter equation first appeared, but in this case the scattering was non-relativistic.

The idea of factorized scattering in the relativistic setting was immediately picked up by physicists, and the wonderful paper by Zamolodchikov and Zamolodchikov [36] appeared immediately after the first convincing results on quantization of solitons.

From quantum integrable systems to quantum groups

Now we come to the Baxter part of the Yang-Baxter equation. Motivated by works on the Bethe ansatz and diagonalization of Hamiltonians of spin chains, Faddeev and several people in his Lab, including Kulish, Sklyanin and Takhtajan, started to study Baxter's papers [40] on the solution of the 8-vertex model in the late 70s [13]. At first the linear-algebra manipulations involved in [39] seemed far from what he had been doing before. Then a beautiful picture emerged where the inverse-transform method used in the theory of solitons merged with the core element of Baxter's work, and as a result a deeper understanding of what Baxter did and a method for quantizing Hamiltonian soliton equations emerged. In particular, eigenfunctions of the transfer-matrix of the 6-vertex, which had earlier been constructed by Lieb using the coordinate Bethe ansatz, now got a new algebraic interpretation through the "algebraic Bethe ansatz" [43, 45].

The first examples were the nonlinear Schrödinger model [42] and the sine-Gordon model [43]. Eigenstates for the quantum sine-Gordon model were constructed in [43] using an approximation consistent with a ultra-violet regularization of the model. The exact ultraviolet regularization was later constructed in [44].

On these two examples a general method for constructing quantum integrable systems emerged and became known as the quantum inverse transform method, formulated in [42, 43, 45]. It is based on solutions to the Yang-Baxter equation[14].

[13] The book by Baxter [39] was translated into Russian in 1985.

[14] The term "Baxter-Yang" equation was introduced in [45] (in alphabetical order); it later became "Yang-Baxter" equation (in chronological order).

L. D. Faddeev, C. N. Yang and R. J. Baxter.

This also gave a new intuition for the classical Hamiltonian structures for completely integrable systems, when Sklyanin introduced the notion of classical r-matrix. In 1982 Faddeev gave very influential lectures at the Les Houches summer school in Theoretical Physics on quantum integrable systems, solutions to the Yang-Baxter equation, and the Bethe ansatz. A number of other important models were solved, for example in [46] new integrable spin chains were discovered, etc.

It was a very exciting time: Faddeev's Lab was bustling with new ideas and with new results, and with many interesting people visiting from other institutions in the Soviet Union and from abroad. The method of classical r-matrix evolved into the factorization scheme for solving soliton equations [33] and eventually to the notions of Lie bialgebras and Poisson-Lie groups [31]. The quantum inverse transform method, involving solutions to the Yang-Baxter equation, gave rise to the theory of quantum groups [31] and to a new chapter in representation theory. Faddeev (with Reshetikhin and Takhtajan) gave a framework for quantum groups based on solutions of the Yang-Baxter equation, which followed closely the original ideas rooted in the theory of quantum integrable systems [47]. Nowadays, this approach is used in theory and applications of quantum groups and similar algebraic structures.

Another important idea created in the Lab at this time was the theory of form-factors in quantum integrable field theories. This lead to the implementation of Wightman's program of constructing relativistic quantum field theory axiomatically. The details can be found in [48]. We will not go into details of the work that was done in the Lab by Faddeev's students and colleagues. All this work was done under enormous intellectual influence of Ludwig with his encouragement and interest.

Other works

We did not give a complete account of Faddev's research. This is done in [49], so here we mention just a few of his other works.

Faddeev wrote important papers on the Riemann zeta-function and scattering, some with B. Pavlov. This was a very elegant attempt to give a spectral proof of the Riemann hypothesis. See [49] for a detailed description of this work.

Inspired by nonliear field theory and the interpretation of particles as quantization of localized solutions to Euler-Lagrange equations, he constructed nonlinear field theories with stable soliton-like solutions.

In 1986 Faddeev (with Shatashvili) returned to gauge symmetries and studied anomalies, with the key observation that anomalies are 1-cocycles for certain cohomology theories. (See [49] for details.) His desire to quantize gravity led to the study of the quantum Liouville equation, which was thought to be related to 2D gravity.

He had an important series of works on the quantum dilogarithm, the most important one with R. Kashaev [50]. This work led Faddeev to the construction of a modular double, the "double" of two Morita equivalent algebras [51]. Interestingly, the quantum dilogarithm first appeared in Faddeev's work on semiclassical quantization of solitons.

Recollections and opinions

Mathematical physics is a broadly defined field that emerged in 1950's-1960's. There are many views on what mathematical physics is. The consensus seems to be that it lies between mathematics and theoretical physics, having a non-empty overlap with both. At the same time, opinions vary on how much rigor should be present in mathematical physics research and how close it should be to physics.

According to Faddeev, the goal of a mathematical physicist is *not to make rigorous what is already understood, to the extent of being true beyond reasonable doubt, by physicists, but to achieve something they could not do with physical intuition, and do it on the basis of mathematical knowledge and mathematical intuition*.

In one of the articles aimed at a general audience, Ludwig noted: "If someone asked me who among the twentieth-century physicists impressed me most, I would answer: P. A. M. Dirac, H. Weyl, and V. A. Fock."

On the physics side he thought of himself as continuing in the tradition of V. A. Fock. He was in touch with the theory group at the Ioffe Physical Technical Research Institute, in particular with V. Gribov. In late 1970's and 1980's there were essentially two places in Leningrad where quantum field theory was developing: Faddeev's seminar, with more mathematical flavor, and Gribov's seminar, which was a physics seminar.

On the more mathematical side, as a student, he was under the strong influence of O. A. Ladyzhenskaya and was influenced by V. I. Smirnov's famous mathematical physics seminar in Leningrad. In many ways, Faddeev was a descendent of the St. Petersburg mathematical school, which goes back to Euler and includes such names as Ostrogradsky, Bunyakovsky, Chebyshev, Lyapunov, A. Markov, Krylov, Steklov, Smirnov, Vinogradov, Linnik, among many others.

Being one of the first mathematical physicists in the modern sense of this notion was very rewarding, but at the same time it was not easy. He was between two camps: physics and mathematics. Relations between mathematicians and physicists in the Soviet Union were sometimes complicated. Physicists had a lot of political leverage during the first, nuclear, period of the Cold War. The importance of applied mathematics and numerical methods was recognized slightly later with the development of rockets and the exploration of outer space. It is a well-known anecdote that in the late 50's P. Kapitza and L. Landau were joking: ”Where should we move the Division of Mathematics from the Academy of Sciences? Perhaps to the Committee for Sport, somewhere closer to chess?” That was the attitude of the time towards mathematics and mathematical directions in theoretical physics.

Ludwig mentioned in [52] and in the interview [53] that in 1960's, when mathematical physics, as a modern notion, was just emerging, he was very pleased to be in the company of his friends F. Berezin, V. Maslov, and R. Minlos, who were like-minded mathematicians with a deep interest in physics.

A. Sedrikyan, V. Garzadyan, A. Polyakov, A. B. Migdal, R. E. Kallosh, A. A. Migdal and L. D. Faddeev at a conference in Tsaghkadzor, Armenia, 1983.

Ludwig had many friends and colleagues around the world. P. Lax, L. Nirenberg, I. Singer and J. Moser were among mathematicians whose friendship Ludwig particularly valued.

To the question about the directions in mathematical and theoretical physics Faddeev always answered: “there is only one direction and one goal: understanding of the structure of matter and space-time.”

L. D. Faddeev and I. Singer, Cambridge, Massachussets.

Work for science in the Soviet and post-Soviet period

All his life Ludwig worked at LOMI. He travelled a lot, especially after the end of the Cold War, but he was more or less free to travel even before, which was great for the Lab: we were getting fresh news. Of course, at the time it was very unfortunate that many other outstanding scientists in the Soviet Union were not allowed to travel abroad.

In 1972, he became the head of the Laboratory of Mathematical Methods in Theoretical Physics in the Leningrad Branch of the Mathematics Institute of the Academy of Science (LOMI) in Moscow. In 1976 he was elected a full member (academician) of the Soviet Academy of Sciences, and became the director of LOMI.

There is an interesting episode which took place immediately after these events. He was called to the local Communist Party committee and was rather pointedly asked why he was such a prominent figure but not a Party member. He answered that he was so busy working on mathematics that he did not have time to prepare to join in the Party [15]. To an urgent invitation, he replied that he does not want to, because then he will be asked to do a lot of administration and this will slow down his work. With some resentment local party bosses said OK, but every year a report on the scientific progress had to be submitted to the local party headquarters, which is what the scientific secretary of LOMI A.P. Oskolkov did for many years.

To be a director of any academic institute in the Soviet Union after 1968 was not easy. It was particularly difficult to be a director of a branch of the Mathematical Institute with headquarters in Moscow, where all the final decisions would be made anyway. Ludwig did

[15] Privately, he was very proud that neither he nor anyone in his family were ever Party members.

his best to maintain the excellence of the Institute during these somewhat administratively challenging times.

From 1986 till 1990 Faddeev was the president of the International Mathematical Union, which was a great distinction and a manifestation of the high prestige of Soviet mathematics.

Mathematical Physics Group at the Physics Department of Leningrad University, 1984. Sitting from left to right Faddeev, Birman, Bouldyrev. Faddeev was the Head of the Group during 1973-2001.

During the catastrophic dismantling of the Soviet Union, State-funded science became the first victim of privatization. Around this period many scientists left the Soviet Union or left science, as it was impossible to make a living on the meager salary offered for researchers. Ludwig was one of the very few people of his stature who did not leave the country for long periods at a time and he continued to work. Ludwig was offered at the time the directorship of the Institute for Theoretical Physics at Stony Brook, where the director was C. N. Yang, who was about to retire. Although Ludwig was very pleased with the offer, he declined it.

During this period, he was active in organizing exchange programs which would support young scientists remaining in St. Petersburg. One such program, which is remembered by many, was the exchange program with the University of Helsinki. Ludwig was also given a special grant from the Finnish Academy of Sciences to stay and work in Helsinki at any time in the early 90's. According to him it gave him a nice refuge during several years when he most needed it. He recalled this offer with gratitude many times.

From 1988 Ludwig was working on the creation of the Euler International Mathematical Institute in St. Petersburg. Against all odds the Institute started to operate in 1990, its renovated building opening in 1992. In 1992, he was elected Academician-Secretary of the Division of Mathematics of the Russian Academy of Sciences (known as the Division of Mathematical

Sciences after 2002)- a position he kept until his final days. This position allowed him to support the St. Petersburg mathematical community during those difficult times.

Ludwig was a great teacher. He gave an outstanding lecture series on quantum mechanics for mathematicians which resulted in a wonderful textbook for mathematics undergraduates [21]. His Thursday Seminar at LOMI was the center of modern mathematical physics in Leningrad and St. Petersburg. He wrote many survey articles which became standard reading material. One example, as mentioned before, was his lectures given in Les Houches in 1976 [38].

Recognition

For his numerous contributions to science, Ludwig Faddeev was elected to leading academies including the Royal Academy of Sweden (1989), the National Academy of the USA (1990), the French Academy of Sciences (2000) and the Royal Society of London (2010). He was awarded many prizes and other distinctions, among which were the Dirac Medal (1995), the Max Planck Medal (1996), the Euler Medal (2002), the Henri Poincaré Prize (2006), the Shaw Prize (jointly with V. Arnold, 2008), and the Lomonosov Medal (2014).

Farewell

Ludwig will be missed by his friends, pupils, and colleagues, for whom he was a constant source of inspiration for his passion for mathematics and physics.

Ludwig Faddeev is survived by his wife Anna M. Veselova, his daughters Maria Faddeeva and Elena Evnevich, his grandchildren Elena and Sergej Voklovy and Maria and Nikolai Evnevich, and by their families.

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