SVETLANA KATOK

Lecture given by Boris Hasselblatt on August 27, 2022

It is a privilege to open this conference, which celebrates a milestone for a colleague and friend by appreciating the mathematics she has created, the mathematicians she has made, and the profound ways in which she has been serving our community and profession.

44 years ago, the Katoks arrived in Maryland. Within a year, Svetlana enrolled in the doctoral program. Her advisor was Don Zagier, and as a consequence, her academic ancestry includes Hilbert, Gauss, and Leibniz. In 1983 she defended a thesis on *"Modular forms associated to closed geodesics and arithmetic applications"* in which she proved that Poincaré series associated to hyperbolic conjugacy classes of a Fuchsian group of the first kind span the space of cusp forms. A key ingredient was the use of dynamical properties of the geodesic flow of the corresponding factor of $\mathrm{SL}(2,\mathbb{R})$, notably Livshitz theory. The work was announced in the Bulletin of the American Mathematical Society and published in Inventiones.

Since it will be a recurring theme, let me give a little background on Livshitz theory. Consider a smooth flow and a scalar function on a manifold, and the derivative of the function in the flow direction. It defines a function which integrates to zero along each closed orbit of the flow. When a flow has many periodic orbits, as hyperbolic flows do, one may ask whether any function with this latter property must be the derivative of another function in the flow direction. The original Livshitz Theorem is that for transitive Anosov flows this is indeed the case for Hölder-continuous functions. The idea is to define the antiderivative on a dense orbit in the only way possible (up to an additive constant) and then use the assumption to check that the result is uniformly continuous to extend to the closure of that orbit. To learn more, stick around for the next talk.

The next seven years of Sveta's career involved the main campuses of the University of California. She was a Lecturer at UC Berkeley in 1983–84 while Anatole Katok visited MSRI for a special year. The need of the Katoks for two jobs in one region was no secret, and Barry Simon

initiated an offer of a professorship for Anatole from Caltech. They moved in 1984, and Sveta began a 2-year Adjunct Assistant Professorship at UCLA, which led to a collaboration with John Millson on a 1987 paper *"Eichler–Shimura homology, intersection numbers and rational structures on spaces of modular forms"* in the Transactions of the American Mathematical Society, which deepens the insights into how the hyperbolic Poincaré series span the cusp forms. This UCLA stint was followed by two years as NSF Postdoctoral Fellow and Visiting Scholar at UC San Diego and by a tenure-track appointment at UC Santa Cruz from 1987.

Livshitz Theory again appeared in subsequent papers. A 1990 paper *"Approximate solutions of cohomological equations associated with some Anosov flows"* in Ergodic Theory and Dynamical Systems gave quantitative control of how close to null-cohomologous a cocycle is which is only known to vanish over closed orbits *up to some period*. This was done in a different way in *"Finite spanning sets for cusp forms and a related geometric result,"* a 1989 paper in the Journal für Reine und Angewandte Mathematik. An approximate statement is that if a function on the unit tangent bundle of a compact negatively curved surface has unit C^2 norm and zero integrals over all closed geodesics of length up to $1/\epsilon^2$, then its L^2-norm is less than ϵ. That paper also strengthened her dissertation by completely different methods to provide a huge reduction in the number of hyperbolic Poincaré series required to generate the space of weight-$2k$ holomorphic cusp forms—from an exponential of an exponential to an exponential of a polynomial.

Her 1991 paper *"Elliptic operators and solutions of cohomological equations for geodesic flows with hyperbolic behavior"* in the International Journal of Mathematics is a remarkable study of coboundaries for the geodesic flow of a compact negatively curved surface. The space of coboundaries which are eigenfunctions of the infinitesimal generator of the action of SO(2) on SM is finite dimensional, and for constant negative curvature she obtains a complete description of this space.

We are fortunate that the next lecture today will expand upon Sveta's work related to the periods of modular forms.

Her most cited paper dates from 1993. It is seminal joint work with Peter Sarnak on *Heegner points, cycles and Maass forms* in the Israel Journal of

Mathematics, and the Katok–Sarnak formula has been variously reproved, applied, or generalized since.

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The drive from Pasadena to Santa Cruz takes just under six hours on a good day, and Sveta arranged a compressed teaching schedule that allowed her to fly to Santa Cruz for a couple of days mid-week. While the older two children were becoming quite independent by then, Danya was little, and it was natural for the Katoks to seek two jobs in the same place. Santa Cruz made an offer to Anatole, and the Katoks also had a double offer from the University of Arizona in Tucson. But they liked neither enough to accept. In 1990, Richard Herman from the Pennsylvania State University engineered a double-offer that drew the Katoks to State College. Here, they fully engaged from the start, helped by the simultaneous arrival of Yakov Pesin from Moscow via Chicago and Howie Weiss from Caltech. They went on to build this department into the most prominent center of dynamical systems in the country.

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Now is a good time to pause and turn to her earlier life and work. She was born to Boris Abramovich Rosenfeld and Ljudmila (Lucy) Lvovna Davidova. Boris Rosenfeld was a geometer and a historian of mathematics with a wide range of interests, from ancient Greece and the medieval Middle East up to 19th-century non-Euclidean geometry.

Her mother was born in 1919 in Poltava in Central Ukraine. She graduated from the Institute of Fine Chemical Technology with a degree in chemistry of rubber and worked as an engineer at the All-Union Institute of Aviation Materials. Boris and Lucy were both blessed with a long life. Boris lived 1917–2008, and Lucy died only two years ago at the age of 100.

Boris Rosenfeld wrote memoirs that include some of the family history.

"My father Abram Samoilovich was born in Vitebsk... My mother was born in Moscow. In 1916, father and mother moved to Petrograd. In August 1917, I was born, and in October my family moved to Moscow, where at that time the parents of my mother lived...

The younger sister of my father, Berta, was the wife of the famous artist Marc Chagall, who was also born in Vitebsk. In 1916 they had a daughter, Ida, named after Mark's mother." —End quote

For the events that steered Sveta towards mathematics, we have her own words.

"In the summer of 1959 we had a vacation in the Caucasus where I met Ljuda Aramanovich, who was one year older than I and a daughter of the mathematician Isaac Aramanovich. She gave me two pieces of advice that highly impacted my life: to transfer to school N 59 in the Arbat region of Moscow, and to start attending a mathematical circle for 7th graders, although in the fall of 1959 I was only in the 6th grade. The Russian term for this was "kruzhok" (literally, "circle" but a closer English equivalent is probably "workshop"); kruzhki went back to the mid-1930s. They usually met at the university once a week in the evening and were run by dedicated undergraduate or graduate students with a tremendous enthusiasm for mathematics, very often themselves alumni of a kruzhok. The material discussed usually went well beyond the secondary school curriculum and included challenging problems and nonstandard topics from elementary to higher mathematics. During that year 1959–60, Tolya was in the 9th grade, and I first saw him in school. In the fall of 1960 he entered MSU and started a mathematical circle in the new building, and three of us, Askol'd Khovansky, David Bernstein and myself started to attend two circles, one in the old building of Moscow State University on Mokhovaya, and the other in the new." —End quote

In 1964, Sveta graduated from high school with a gold medal and was accepted to the MSU Faculty of Mechanics and Mathematics. Tolya and Sveta married on June 5, 1965, soon after Sveta turned 18. They were married for over 50 years. Their daughter Elena was born in Moscow and is now the Ashbel Smith Professor at the Naveen Jindal School of Management of the University of Texas at Dallas. Their son Boris, also born in Moscow, is a Senior Software Developer and the owner of Coconut Tree Software in Las Vegas. Daniela (Danya) Katok was born in Hollywood and has a doctorate in Musical Arts in Voice Performance; she has performed with the New York City Opera, the Vienna Philharmonic, the Tanglewood Music Center, the Boston Pops, in Hollywood movie sound-tracks, and so on.

Sveta's earliest appearance in the mathematics literature far predates her dissertation. She was the translator (together with Tolya) of Coxeter's *"Introduction to Geometry"* into Russian, which was published while she

was still a teenager. Later, Vladimir Igorevich Arnold invited her to translate Smale's pair of 1970 Inventiones papers *"Topology and Mechanics"* for Uspehi and suggested she also write an Appendix on *"Bifurcation sets and integral manifolds in the rigid body problem,"* which was regrettably never translated into English, and which applied Smale's approach to another mechanical problem.

This was, however, not her first research publication. The first was her diploma work, a 1970 paper *"Linear extensions of dynamical systems and the reducibility problem"* in Mathematical Notes of the Academy of Sciences of the USSR (a translation of Zametki). This uses Moser's KAM method and was reviewed by Moser himself in Mathematical Reviews. It cites two papers by Moser which had been translated into Russian by Anatole Katok and Misha Jakobson, respectively, just a few years previously.

In 1969, a general reactionary turn of government domestic policy and antisemitic/anti-intelligentsia actions had combined with other events to thwart her graduate education in Moscow. The geometer Isaak M. Yaglom, a family friend, helped by accepting her to the mathematics graduate program at the Evening Metallurgical Institute, and, as required, a professor at Moscow State University had agreed to be her doctoral advisor—but severed all contact weeks later, thereby ending her Moscow graduate career.

Sveta worked in the children's club of Moscow State University "Orlyonok," where she taught classes in mathematics with children, and then she got a job at the Research Institute for School Equipment and Educational Technology of the USSR Academy of Pedagogical Sciences.

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In 1972 the Banach Center in Warsaw was established with the aim to promote and stimulate international cooperation in mathematics, especially between the East and West. Tolya's first trip abroad was for a 1975 conference there. By then, the family's tolerance for life in the Soviet Union was wearing thin, and they decided to leave the country. He returned to Warsaw in 1977 for an international conference that provided a major encounter between "the East" and "the West." Tolya made no secret of the plans to emigrate. Several people brought this to the attention of the mathematics department chair at Maryland, William Kirwan (later provost, president, and chancellor), suggesting that Tolya was a rising star with the potential to become a superstar and that he would have many

offers from prestigious universities. The department had great ambition to become one of the best mathematics departments in the country among public universities, and Kirwan told me that

"I had a fax of his vita that included his telephone number in Moscow. So one afternoon I said, what the heck, let me try and beat everyone to the punch and reach him in Moscow. So I placed a call. In those days, such a call had to go through an international operator, who told me she would try and reach the party but it would take about 30 minutes. Sure enough, 30 minutes or so later the phone rings and the operator puts me through to Tolya. He had no idea who I was. I explained that I was chair of UM's Math Department, that I knew he was about to leave the Soviet Union and that I wanted to offer him a job, initially as a visitor but almost assuredly as an endowed professor once the got here and we could follow the process. Ironically, he didn't know how much in demand he was. From his perspective, he had a wife and two children, they were leaving their home and he had no idea how he would be able to support them. So my offer sounded very good to him, especially at the salary I proposed. Believe it or not, he said "yes" and the deal was done on that phone call. When he got to Maryland, my wife and I took the Katoks under our wing and helped them get settled." —End quote

The family applied for emigration in July 1977, and on February 15, 1978, they left the Soviet Union. Per Wikipedia, *"Early on, Vienna became the first stop for all Jews exiting the USSR. There they were greeted by a representative of the Jewish Agency for Israel (JAFI) and by HIAS (a Jewish American nonprofit organization founded as the Hebrew Immigrant Aid Society, which provides humanitarian aid and assistance to refugees), and were asked to determine their final destination. Those who were going to Israel were assisted by JAFI; those headed for the U.S. or elsewhere were processed by HIAS. After a short stay in Vienna, those destined for the U.S. were transferred to Rome, where they were processed by the U.S. Immigration and Naturalization Service." —End quote*

In Vienna, they stayed with Karl Sigmund and his family. He and they long recalled their joy at discovering during their wanderings around town a restaurant that offered a unique winning combination of cleanliness and price—but when they reported their discovery, Sigmund asked suspiciously, whether the name of the restaurant was, by any chance,

McDonald's. In fact this was the first McDonald's in Vienna, and had just opened (in the magnificent Palais Wertheim on Schwarzenbergplatz). Twenty years later, we made a pilgrimage there together.

In Rome, the Katoks learned that since Tolya was born in the US, he was not eligible for refugee status and had to apply for a US passport instead. He had thought that this option had gone away when he turned 18, but it had not, because this was the very first opportunity to do so. And they learned that this might take well over a year! Since his appointment at Maryland was to start in August, this was a problem. Brit Kirwan came to the rescue and worked some connections in the State Department, which got Tolya his passport within 35 days! Sveta and the children were now family of a US citizen and hence eligible for Green Cards. Just then, Tolya received an invitation from the Institut des Hautes Études Scientifiques in Bures-sur-Yvette near Paris, and the family decided to go to Paris and get the documents there. There was one hitch: except Tolya, they were stateless because the Soviet authorities had taken away their passports and only given them "exit visas." But they were able to obtain suitable travel documents in Rome; it helped that Boris Rosenfeld's cousin Ida Chagall sent a private invitation to Sveta. They traveled first to Milan (as guests of Jean-Marie Strelcyn's collaborator Luigi Galgani), then to Geneva, where they visited Tolya's uncle (a cousin of Boris Lazarevich Katok who worked for many years at the UN in Geneva) and his American wife.

Sveta told me the following. *"We arrived in Paris by train and were greeted at the railway station by Jean-Marie Strelcyn and Michel Herman, who took us to the Residence Ormaille at the IHES, where the refrigerator was full with food. I will never forget their hospitality.*

There was an office of HIAS in Paris headed by a Hungarian Jew named Ivar Svartz, unlike the office in Rome, almost deserted. Our Green Cards were processed there in a couple of months, but most importantly, Tolya discovered a new and much more comfortable way of emigration for mathematicians from the USSR: through Paris HIAS in conjunction with an invitation to IHES. Several mathematicians followed this route: definitely Mityagin and Brin, but probably more." —End quote

I will add that Soviet emigration soon ceased for about a decade until a greater wave started in the waning days of the Soviet Union. During my

1990 visit at the IHES the staff complained: *"There are too many Russian visitors. We can no longer find any mushrooms in the institute forest."*

In August 1978, the family was picked up at Dulles airport by Sasha Gruz and Dora Katok, who had moved to Rockville a little earlier. After staying with them for several days, the Katoks moved to a rental apartment in College Park and settled in. Sveta was finally able to fully pursue mathematics. She wasted no time. Her next paper appeared in the proceedings of a 1979 conference at Northwestern University on Global theory of dynamical systems. Entitled *"The estimation from above for the topological entropy of a diffeomorphism,"* it provides what the title says, with the upper bound being the logarithm of the largest Jacobian determinant of the diffeomorphism on any subspace of any tangent space. And that brings us to where I began today, her first twelve years in the US.

I will add that in the late eighties, Sveta's younger sister Julia and her family emigrated and joined the Katoks in California before moving to Maryland, where Julia's husband Michael worked at AOL for 14 years. For a decade now, he has been a consultant to large international companies in the financial services and internet security space. Julia has worked at HIAS to help Jewish immigrants from Russia and other countries. The art of their daughter Alexandra Rozenman, a painter, graphic designer, and book illustrator, is among the most prominently displayed in the Katok household.

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It is here at the Pennsylvania State University that Sveta first held and still holds a permanent faculty appointment. With this come opportunities and incentives for much broader contributions to mathematics. She seized these with such alacrity that within about a decade the Eberly College of Science honored her with a Alumni Society Distinguished Service Award, making her the only faculty member to be so recognized in 2002. This award is presented annually to individuals who have made exceptional leadership and service contributions to the college over a sustained period of time. Past recipients of the award have included active and retired faculty and administrative staff, alumni, and friends of the college. It is a pleasure to quote her citation.

"Svetlana Katok, a member of the Department of Mathematics faculty since 1990, has a combined career as a research mathematician, an educator of young mathematicians, and a contributor to the department, national, and world mathematics communities. Katok served as an associate chair for graduate studies in mathematics from 1994 to 2000. She played a key role in organizing Penn State's Mathematics Advanced Study Semesters (MASS) program, which assembles undergraduate mathematics majors from all over the country for a unique and mutually reinforcing blend of learning and research experiences. She designed and taught several courses in the MASS program, and developed the innovative Math 471 "Geometry for Teachers" course. She served as a member-at-large of the American Mathematical Society Council from 1993 to 1996, and since 1995 was a founder and managing editor of the first electronic-only AMS journal, Electronic Research Announcements of the AMS." —End quote

The MASS program was very much the right thing at the right time in the right place. George Andrews publicly acknowledged the department's gratitude for the creation of this program.

"This occurred at a time when I was a freshly installed department head, and I was under great pressure to do something to improve mathematics education. Most of what was being suggested by upper levels of the administration horrified me. However, it was clear that we had to do something. To my great delight, Anatole and Svetlana came to the rescue by proposing the creation of MASS. This wonderful program is a major contribution to mathematics education and has provided a spring board to graduate education for many students from small colleges who otherwise would have been inadequately prepared for graduate education." —End quote

For over two decades, the program assembled undergraduate mathematics majors from all over the country for an intensive one-semester immersion of specially designed courses, seminars, and research-oriented projects. The closest counterpart elsewhere is the Budapest Semesters in Mathematics program. The core principles and structure of MASS were inspired by what the Katoks recalled as the strengths of mathematics education in Moscow, but without some of its weaknesses and informed by the best the US had to offer. It was widely recognized by those who sent students there, and it was featured in an article in the Mathematical Intelligencer, where the Katoks describe

"the Russian tradition where interested students are exposed to a variety of mathematical endeavors, often of nonstandard kind, at an early age. By their senior undergraduate years such students are already budding professionals. The US educational system is built on completely different principles, and interested young students are routinely encouraged to progress quickly through the required curriculum. Here a typical mathematically gifted high school student takes courses in a local university and often is considered a nerd by his peers. The founders felt that there was a way to combine some of the best features of both traditions within the US academic environment, namely, to gather a group of mathematics majors and to expose them to a substantial amount of interesting and challenging mathematics from the core fields of algebra, geometry, and analysis, going way beyond the usual curriculum." —End quote.

In fact, Sveta's first intensive program for US undergraduates was the Mills College Summer Mathematics Institute for mathematically gifted undergraduate women in the San Francisco Bay area, an NSF Special Project with Lenore Blum and Leon Henkin in which she was involved at the start of the 1990s as PI, as instructor, and as co-director. This inspired a precursor of MASS, the Summer Undergraduate Research Initiative at Penn State, which ran in the summer of 1993. The Katoks had seen that there was a competition in the College of Science for a summer program for undergraduates, and Sveta decided to submit a proposal. It was funded, and even when she had to go to the dean to request additional funds, she easily got them. But for starting the MASS program, it took 3 years to get the original financial commitment from the Penn State administration and to solve numerous logistical problems before the program could begin, such as, securing in-state tuition for all participants, a dedicated room for the program, and a full-time secretary.

The core courses were custom designed for the program and available only to its participants. Each course addressed a fundamental topic not likely to be covered in the usual undergraduate (and, in many cases, even graduate) curriculum. They were complemented by a MASS seminar, a MASS colloquium, and by research projects in a unique full-immersion semester. It was transformative for many.

The *Intelligencer* article quotes Suzanne Boyd, a former participant:

"The MASS program has been the best semester of my life. I was immersed in an environment of bright motivated students and professors and challenged as never before. I was pushed by instructors, fellow-students, and something deep inside myself to work and learn about mathematics, and my place in the mathematical world." Suzanne wrote to me this month to further say *"I know that the MASS program is one of the main reasons that I was accepted to prominent graduate programs and ended up at Cornell, thus launching the rest of my career. I am now a tenured professor at the University of Wisconsin Milwaukee, which is a Research One Carnegie classification institution. I just finished 3 years as department chair." —End quote*

Kaiyi Wu is an advanced doctoral student in applied mathematics at Tufts, and she was in Sveta's Honors Combinatorics class in her sophomore year at Penn State as well as her Hypercomplex Numbers class in the 2016 MASS semester. She writes:

"I not only want to be her student, like I want to be a student of many other great professors that I have met, I also want to be like her. I hope to show others the same commitment and loyalty to Math and to teaching/delivering Math, just as she has shown me.

I reached out to Dr. Katok to ask about MASS and undergraduate research in general, and expressed my concerns about how productive I can be in a research project with my limited Math background as a sophomore. I had heard from others that it is never too early to start research, and I expected her to give me similar encouragement as a long-time advocate of undergraduate research. She did, yet at the same time, she told me how happy she was to see me recognize and value the long-term accumulation of Math. I will always remind myself of her words, "planning ahead ensures slow yet steady progress." I believe this is the reason for her confidence and proficiency in her delivering of Math.

I learned not to say no to some pure Math classes even though I might choose to dive deep in applied Math, and I learned to balance digging deeper in my focused research and keep being curious about other fields. Different Math echoes in unexpected ways." —End quote

Sveta's doctoral student Daren Wei was the teaching assistant for her in the 2016 MASS program. He says

"I learned a lot about how to be a good teacher from her. In order to provide a more comprehensive understanding for students about the hypercomplex numbers, she wrote detailed lecture notes by herself instead of using other existing textbooks. Moreover, her office is always open to students and she is very patient with students' questions. She also cares about students' feedback on the lecture and adjusts the lecture notes based on their feedback. During the lecture, she always started from the most basic example; by adding new structures and conditions, the key features of the object are demonstrated to students with a family of interesting examples and detailed explanation, which can be understood as a "rising sea" process that helps students understand the material." —End quote

The inspiring perspectives of her MASS courses made it into the published record. Specifically, she co-edited *"MASS selecta—Teaching and learning advanced undergraduate mathematics,"* a book published by the American Mathematical Society in 2003. It is remarkable for the list of contributors and topics. It includes an article by John Horton Conway as well as one by Gregory Galperin on *"Billiard balls count π,"* which is now hugely famous on YouTube. Her own papers are the longest ones in the volume by far, and her article *"p-adic analysis compared with real"* was expanded to an eponymous 2007 book in the Student Mathematical Library of the American Mathematical Society (which in turn was soon translated into Russian). This is an introductory course on elementary p-adic analysis, motivated by comparing elementary analysis in the p-adic numbers and the real numbers. The p-adic numbers are constructed by completion, the homeomorphism between p-adic integers and certain Cantor sets is constructed explicitly, and the book goes all the way to a study of the notion of differentiability.

Another book of hers is even better known, the 1992 book on *"Fuchsian Groups"* in the Chicago Lectures in Mathematics (which was translated into Russian ten years later). From the publication date it is clear that it was conceived in California days; indeed, it is based on graduate courses she taught. It is a beautiful and much cited introduction to Hyperbolic geometry, Fuchsian groups, Fundamental regions, and Geometry of Fuchsian groups. A final chapter is a brief introduction to a study of subgroups

of finite index of the modular group and some groups derived from quaternion algebras. To me it is the best introduction to the basics of this subject, and I believe many agree. In fact, I believe that it contributed significantly to the vitality of this book series. Between 1973 and 1990, only four volumes were published in this series. Bob Zimmer undertook to reinvigorate the series, and the nineties began with his own book on *"Essential results in Functional Analysis"* and Sveta's book; this seems to have established a lot of credibility with potential authors, and in 1995 alone, 5 volumes appeared in the series. In 1997 both Yakov Pesin and Patrick Eberlein published in this series as well. I should give credit as well to her son Boris, who provided the illustrations for the book and in an outstanding way. They are cleanly and compellingly done, and Tolya and I promptly recruited him for a similar but rather larger job. We were happy that we did.

Alena Erchenko is an alumna of the MASS REU program as well as a former doctoral student at the Pennsylvania State University. She wrote to me:

"I took a class on Fuchsian groups and a graduate seminar with Svetlana. What I can point out is that she is very organized in her lectures and easy to follow. She was assigning homework for the class on Fuchsian groups, and always was timely giving feedback on it. I (and I am sure other students as well) learned a lot. It was amazing to have an opportunity to learn it right from the specialist in the subject. For the graduate seminar, she suggested interesting topics for practicing a talk that were considering the interest of all students in the class. Also, she was professionally navigating us. I remember that I first thought to choose a topic in logic (as I had some knowledge in it from my undergraduate classes and it could be fun to recall), but she pointed out that it would be more beneficial for me to pick something in dynamics. Thinking now, I am glad that I listened to her as it was more helpful to learn more dynamics theorems at that moment. Also, she gave useful comments on organizing the talks. I remember it was my first time giving a slide talk, and I went too fast. And now I always remember that experience if I need to give a slide talk." —End quote

Sveta had a number of doctoral students over the years:

Tatyana Barron (Foth) graduated in 1998,

Ilie Ugarcovici in 2004,

Arseny Egorov in 2011,
Adam Abrams in 2018, and
Daren Wei in 2020.

Daren deeply appreciates how Sveta mentored him not only as a whole mathematician, but supported him in every respect.

"It is my great honor to be one of the students of Prof. Svetlana Katok. She is not only a great mathematician but also a great mentor. She helped me a lot in both academic life and daily life. Every time I finish a paper and send it to her, she gives me detailed feedback very quickly (only in 1–2 days) and the feedback always improved the quality of the paper a lot. She also explained to me very patiently for many years what is a good mathematics project and helped me to formulate my own mathematical taste.

She also always helped me no matter what difficulty I meet. During the June 2020, I was in a dilemma due to the pandemic, visa issues and moving problems. Once she learned about my situation, she tried her best to help me with visa issues (she filled many forms in a very short time) and even provided a temporary position without any hesitation. With all her help, I finally successfully completed all visa issues and moved to new place without any delay." —End quote

In service of supporting mathematicians as full human beings, frequent social events hosted by the Katoks have been an important center of a community, and this served a sometimes urgent need. Renato Feres appreciates that to this day:

"I'm very fond of the memories of the many social events, dinners, parties. . . the many interesting people I came to know through both of you. From the very beginning, as an international student with no family members in the US, the social and emotional support these events provided are perhaps much more important than you may estimate." — End quote

Sveta has also generously served the profession and this University. From 1994–2000 and again 2011–2017 she was Associate Chair for Graduate Studies and on the Personnel Committee. Currently, she is on the Promotion and Tenure Committee. She further served on the Awards for undergraduate and graduate students committee, the GTA Oversight Committee, the Graduate Studies Committee, the Examinations Board/Panel,

the Eberly College of Science Graduate Fellowship Committee, the University Senate, and the GRADS Advisory Committee. Nationally, she has served on panels for the National Research Council and the National Science Foundation, on the AWM Emmy Noether Lecture Selection Committee, the Siemens Westinghouse Science and Technology Competition Initial Judging Panel, the Israel Science Foundation, and the Banff International Research Station Scientific Advisory Board. And I am hidebound to recognize her ample service to the American Mathematical Society: on the Council and the Committee on Publications of the AMS, 1993–1996, the Short Course Committee, 1998–2001, the Frank and Brennie Morgan Prize Selection Committee, 2002–2005, the AMS-IMS-SIAM Ad Hoc Executive Committee of the Evaluation Panel for NSF Postdocs, 2002–2003, and the Math in Moscow Program Travel Committee, 2016–2019.

As with teaching and mentoring, she has not only invested time, but energy and wisdom. The latter can be seen in an article the Katoks wrote jointly for the Notices of the American Mathematical Society. It describes the sad overall situation of *Women in Soviet mathematics*, framing the subject with sociological context, highlighting outstanding women mathematicians, and describing the paths into mathematics. It includes a comparison of the mathematical culture with that of the US as well as attempts at analysis and prediction.

But it is her editorial service and impact that deserves more detail. Until a good quarter century ago, the Bulletin of the American Mathematical Society included research announcements, but in 1995 the Society decided to publish these separately as Electronic Research Announcements of the American Mathematical Society. Sveta was its managing editor from the start, and she was involved in creating a stellar board. This experience became invaluable when the Journal of Modern Dynamics was founded in 2006, and she has been its managing editor throughout. Its quality in content and appearance owe much to her. And so does the survival of Electronic Research Announcements. The AMS discontinued the journal in 2007, and this gave rise to the need for a new home. It became Electronic Research Announcements in Mathematical Sciences with the same publisher as the Journal of Modern Dynamics, and Sveta served as its managing editor throughout. And yet again, the need for a rescue arose when the publisher made fundamental and unilateral changes with which

the board disagreed. The board walked and started a new journal with the same scope, Mathematics Research Reports. Sveta has served on its board from the start, and she has played an outsize role in making this new journal a reality. There was an enormous amount of learning as we scrambled to save the journal, and her insight and attention have been absolutely essential ever since to keep it going. Accordingly, everyone joining the banquet will be required to submit at least one article to Mathematics Research Reports.

I previously described the arc of her research prior to her arrival here as well as the extended strand centered on Livshitz Theory. This strand overlaps with a new direction. When the Katoks moved here, Tolya's interests turned to higher-rank actions, and together, they published two papers on *Higher cohomology for abelian groups of toral automorphisms* in Ergodic Theory and Dynamical Systems ten years apart. The first assumes hyperbolicity of the automorphisms, the second, partial hyperbolicity—which they had conjectured possible in the earlier paper. There they noted that this would provide a crucial step in the construction of the spanning sets for cusp forms on some locally symmetric spaces of higher rank. Those cusp forms are generalizations of relative Poincare series associated with closed geodesies which in this case are associated with maximal compact flats. The main result is that for k-cocycles over rank-k abelian actions there is a Livshitz theorem, while all lower-order cocycles are cohomologous to a constant. The latter is quite different from rank-1 actions. And handling partial hyperbolicity required them to develop a parabolic method due to Bill Veech.

The Katoks also joined forces with Klaus Schmidt for a 2002 paper on *Rigidity of measurable structure for $\mathbb{Z}^d$-actions by automorphisms of a torus* in Commentarii Mathematici Helvetici, a rather broad study of rigidity phenomena which has since been extended by Kalinin and coauthors. In their context, a measurable conjugacy or factor has to be essentially algebraic; a key idea is that a measure pushed forward by the conjugacy or factor must itself be homogeneous. And in great contrast to the Ornstein theory for rank-1 actions, they produce actions with the same entropy functions which are not isomorphic, and actions that are weakly isomorphic but not isomorphic.

A decade later, they joined with Federico Rodriguez Hertz for a 2014 GAFA paper *The Fried average entropy and slow entropy for actions of higher rank abelian groups*. The entropy notions in the title are pertinent because if one extends the notion of entropy to higher-rank actions in the most direct way, then it is always zero for smooth actions because the denominator is the *volume* of a ball in the group. The Katok–Thouvenot slow entropy replaces that denominator by the *radius* of the ball. The Fried average entropy instead averages the entropies of rank-1 subactions. For rank-k actions on a given $k+1$-manifold they show that each of these entropies determines the other, and the values are related to number-theoretic properties—so there are only countably many possible values. The main result is that for a given action either both of these are zero, or both are bounded below by constants that depend on the dimension (exponentially for the Fried entropy, linearly for the slow entropy).

In the mid-1990s a broad strand of research began at the interface of geodesics, geometry, coding, cutting, continued fractions, attractors, bundary maps and flexibility, much of it carried out with Ilie Ugarcovici. A 1996 solo paper in Geometriae Dedicata connected arithmetic coding (that is, by continued fractions) of geodesics on the modular surface and geometric coding (that is, by cutting sequences) to indicate exactly when a natural reformulation of the two codes into strings of integers coincide. The geodesics for which this is the case are called positive geodesics, and a 2001 paper with Boris Gurevich in the Moscow Mathematical Journal establishes that the topological entropy of the restriction of the geodesic flow to positive geodesics is less than 1, that is, is less than that of the full geodesic flow. So these two are not measurably isomorphic.

The first paper with Ilie also appeared in the Moscow Mathematical Journal, in 2005. Entitled *Geometrically Markov geodesics on the modular surface*, it first established that the geometric codes do not constitute a finite-step Markov chain, then identified a maximal 1-step topological Markov chain of admissible geometric codes, and finally gave a lower bound of the topological entropy of the geodesic flow on the set of corresponding geodesics. In the same year they published a broad comparison of arithmetic reduction algorithms with geometric coding. They synthesized this in a large and oft-cited review article in the 2007 Bulletin of the American Mathematical Society

At the 2004 Joint Mathematics Meetings, Sveta gave an invited address on *Symbolic dynamics for geodesic flows*. This was the Emmy Noether Lecture of the Association for Women in Mathematics, which was established in 1980 to honor women who have made fundamental and sustained contributions to the mathematical sciences.

Together, she and Ilie next turned to the theory of (a,b)-continued fraction transformations and applications, announced in 2010 in Electronic Research Announcements in Mathematical Sciences and published in a 2010 Journal of Modern Dynamics paper and a 2012 Ergodic Theory and Dynamical Systems paper. This work continues jointly with Adam Abrams, who will showcase this recent research topic in a lecture later this morning.

In 2012 Svetlana became a Fellow of the American Mathematical Society, a distinction that recognizes members who have made outstanding contributions to the creation, exposition, advancement, communication, and utilization of mathematics.

This recognition is well deserved, and how proper for us to celebrate just those qualities this weekend. Happy birthday, Sveta, and many happy returns!