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Preface

In August 2014 a conference on "Model reduction across disciplines" was held in Leicester, UK. As a scientific field, model reduction is an important part of mathematical modelling and data analysis with very wide areas of applications. The main scientific goal of the conference was to facilitate interdisciplinary discussion of model reduction and coarse-graining methodologies in order to reveal their general mathematical nature. This time, however, the conference had an additional personal and more profound mission – it was dedicated to the 60th birthday of Professor Alexander Gorban (albeit with some delay) whose fantastic achievements in applying model reduction techniques to a wide range of disciplines, from physical kinetics and fluid dynamics, to biochemical kinetics and data analysis, are well known in the scientific community.

Alexander N. Gorban is a scientist of Russian origin, who is currently working in the United Kingdom. He was born in Omsk on 19 April 1952. His father, Nikolai Vasilievich Gorban, was a historian and writer of Ukrainian origin exiled from Ukraine to Siberia in 1930s. His mother, Deborah Sapozhnikova, was a literature teacher in Omsk Pedagogical Institute. He entered Novosibirsk State University in 1967 but was excluded from it in autumn 1969 because of his participation, in January 1968, in student political movements against the unjust conviction of Soviet writers Alexander Ginzburg and Yuri Galanskov.

After studying for one year in a vocational technical school and following an individual extramural program at Omsk Pedagogical Institute, he obtained a master thesis diploma under the supervision of Russian mathematician Vladimir B. Melamed. In 1973–1976 he worked in the Omsk Institute of Railway Engineers and published his first scientific works and patents, but his scientific career could not develop successfully because of his past political record. He had several temporary work places from 1976–1978, each time being compelled to resign. He was then able to secure a permanent position in Krasnoyarsk at the Institute of Computational Modeling of Russian Academy of Sciences (Siberian Branch). In 1980 Alexander defended his PhD thesis. Three famous scientists organized his viva: Olga Ladyzhenskaya, Mark Krasnosel'skii, and George Zaslavsky. With the advent of Perestroika he became the head of the Laboratory of Non-Equilibrium Systems in 1989 and completed his habilitation in 1990.

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A.N. Gorban, 1992, Krasnoyarsk, Photo by Alexander Kuptsov.

In 1995 he became the deputy director of the Institute of Computational Modeling of the Siberian Branch of Russian Academy of Sciences and head of the Computational Mathematics Department. At the same time, he taught at Krasnoyarsk State University (1981–1991) and subsequently headed the Neuroinformatics Department at the Krasnoyarsk State Technical University (1993–2006).

In the 1990s and early 2000s Alexander visited several leading institutes in the US and Europe: the Clay Mathematics Institute, Courant Institute of Mathematical Sciences, Institut des Hautes Etudes Scientifiques, ETH Zürich, the Isaac Newton Institute for Mathematical Sciences, Missouri University of Science and Technology, and in 2004 became Professor of Applied Mathematics at the Univerity of Leicester, UK, and the director of the Mathematical Modeling Centre.

Alexander has contributed to many areas of fundamental and applied science, including statistical physics, non-equilibrium thermodynamics, machine learning and mathematical biology. Literally in every single field he was interesed in he created new scientific schools: in non-equilibrium statistical physics, in physical and chemical kinetics, in bioinformatics, and neurocomputing, data mining, and adaptometry with a variety of applications; he obtained remarkable results in mathematics and hydrodynamics. Last but not least, he studied and developed technologies of collective thinking and analytical games, led many large analytical and development projects and even became a part-time Professor in a Department of Psychology.

A very short and incomplete list of his scientific contributions related to model reduction includes

- Methods for model reduction in physical and chemical kinetics. A family of methods was developed for model reduction and coarse-graining in the 1980s-1990s: the method of invariant manifolds, the method of the natural projector, and relaxation methods. All of these methods create reduced models which satisfy the main physical principles. He solved several old problems in gas kinetics, polymer dynamics and chemical reaction kinetics: the non-perturbative derivation of physically consistent hydrodynamics from the Boltzmann equation and from reversible dynamics, for Knudsen numbers around 1; construction of the moment equations for nonequilibrium media and their dynamical correction to gain more accuracy in the description of highly nonequilibrium flows; the kinetic theory of phonons; model reduction in chemical kinetics; derivation and numerical implementation of constitutive equations for polymeric fluids.

- Hilbert's 6th problem. Alexander with his former student Ilya Karlin have received the recognition from the scientific community for a (negative) solution of an important part of the Hilbert 6th problem concerning the reducibility of continuum mechanics to physical kinetics.

- Methods for bioinformatics. Existence of a universal 7-cluster structure in all available bacterial genomes is proved. Methods of genome analysis based on frequency dictionaries are developed and applied to various biological problems (genome redundancy, mosaic structure of the genome, genetic species signature, etc.).

- Data mining and rule extraction. He developed a general technology for extraction of explicit knowledge from data. This technology was implemented in a series of software libraries which facilitated the creation of dozens of knowledge-based expert systems in medical and technical diagnosis, ecology and other fields. More recently, he has developed a new neural network model

for knowledge extraction; principal manifold approximation algorithms; the method of topological grammars for data approximation, as well as many diverse applications areas including medical diagnostics, ecology and geology. A system of methods to reveal hidden tractable models of complex systems was proposed. First of all, hidden geometry is exposed. Alexander invented grammars of elementary transformations allowing creation of tractable models of complex systems by chains of simple steps and dominant systems. Dominant systems approximate complex networks by simple networks, of which the dynamics can be studied analytically. Several biological and medical centres worldwide now use these methods and algorithms in their practice.

- Some medical applications of data mining: stratification of patients and analysis of interrelations of clinical and biochemical data for young people with immunodeficiency; selection of significant features for differentiation between allergic and pseudoallergic reactions; an expert system for forecasting myocardial infarction complications; evaluation of the accumulated radiation dose on the base of immunological, hormonal, and biochemical parameters of human blood; analysis of adaptation of humans to climate change and technology of adaptation control.

Thematic organization of the conference was deliberately made broad to accommodate and reflect a part of Alexander's wide spectrum of scientific interests, and the main body of the meeting was focused around the following non-exhausitve list of topics:

1. Theoretical Approaches (deterministic and stochastic)
2. Computational and Algorithmic Approaches
3. Data analysis and approximation techniques
4. Fields of Applications: Non-equilibrium statistical mechanics, kinetic theory, hydrodynamics and mechanics of continuous media, (bio)chemical kinetics, bioinformatics, systems biology, particulate systems, nonlinear dynamics, nonlinear control, social and economic systems.

In this issue, several thematically linked extended contributions from the conference are collected into a single volume. These contributions can be broadly grouped into the following three areas: methods of model reduction in dynamical systems theory, kinetics, and mathematical modelling of neural systems. Each of these areas was influenced by Alexander, and we are pleased to present a snapshot of the current state-of-the art.

And finally, few words from Members of the Guest Editorial Board as well as his close friends, collaborators, and colleagues:

- "Akademgorodok. Beginning. It was a wonderful time and a wonderful place. Akademgorodok emerged during the Khrushchev thaw. About 20 research institutes were created, a University was opened, and in Akademgorodok talented youth followed swift on the heels of prominent scientists. It seemed that freedom really reigned (in the Soviet Union!), in communication, and in scientific endeavor. Many of the usual domestic problems were absent: all the students lived in a dorm, young scientists quickly received flats, and there were many vacant positions in research laboratories.
  In 1962, on the initiative of outstanding scientists Mikhail Lavrent'ev, Alexei Lyapunov and Gersh Budker, the annual Physical and Mathematical Summer School for teenagers was organised.
  In January 1963, the world's first Physical and Mathematical School – FMSh began, where I was fortunate enough to study. The idea of the Chairman of the FMSh Council, Alexei Lyapunov, was to involve talented youth in real science as early as possible.
  The same year, I met Sasha Gorban. He was then, it seems, 13 years old and he was in the Summer School. After the Summer School his mother, a great philologist, hesitated to let him go into the FMSh. I am very proud that my insistent recommendation convinced his mother to bless the young Alexander's induction into science. After a couple of years, when Alexander was a freshman at the University, the famous physicist Yuri Rumer, a friend and fellow Nobel laureate Lev Landau said about Sasha: "I first met someone more talented than Landau."

But the Khrushchev thaw was soon over, and so started the rotten time of Brezhnev. Then attempts began to try to imprison writers and so on. After one of these nefarious processes (the Ginzburg and Galanskov Trial), protest posters were daubed on the walls in paint posters (8 January 1968). The KGB found the "writers" quickly; the youngest of them and the organizer of the protest was Alexander Gorban. So, after two years of investigation, these young people were excluded from the University.
For several years Alexander wandered around Siberia, and was repeatedly fired from his jobs. These were tragic pages in his life. But "What does not kill us makes us stronger," – this is true sometimes, for some people.
After his expulsion from the University, Alexander developed for himself an extensive educational program in many sciences and followed this program for many years. He began to travel through the various fields of science, regularly getting outstanding results. It is wonderful that in every direction, he created a new scientific school: in non-equilibrium statistical physics, in physical and chemical kinetics, in bioinformatics, and neurocomputing, data mining, and adaptometry with a variety of applications. And yet he has remarkable results in mathematics and hydrodynamics. Moreover, he studied and developed technologies of collective thinking and analytical games, led many large analytical and development projects and even became a part-time Professor in a Department of Psychology.
"God's chosen overcome any obstacles and implement that which is commanded. Mathematician will do it better. Alexander Gorban certainly confirms that these theses are true (Gennady Fridman).

- "After arriving in Krasnoyarsk in 1978 Alexander Gorban proposed and implemented several great initiatives that are still influencing the life of our scientific community. Initially driven by Alexander, these initiatives received broad support from people from different institutes and universities. Being a highly educated scientist and a highly cultured man, he evolved through permanent and continuous self-organization and self-learning. Many of his scientific and organizational ideas were nonstandard and even unexpected. Only with his huge organizational initiative and active support during their early days, many of these ideas have grown to become wonderful traditions. Several generations of Krasnoyarsk scientists are thankful to him for contribution to development of the Krasnoyarsk Summer Schools for high school pupils. This fruitful scientific holiday is further elaborated by many followers and colleagues. He actively participated in the creation and functioning of the Krasnoyarsk Regional Scientific Foundation that played major role in supporting active scientists in difficult 1990s. He established two annual national workshops, in Neural Networks and in Mathematical Modelling. In 2000 he initiated and organized the First All-Siberian Congress of women-mathematicians in Krasnoyarsk. The congress was devoted to the sesquicentennial anniversary of Sofia Kovalevskaya. It attracted active participation of women-mathematicians, from students to professors, and received enthusiastic support from the mathematical community. At present, the biannual Congress dedicated to Sofia Kovalevskaya became international.
  We are happy that Alexander Gorban visits Krasnoyarsk annually, inspiring his colleagues to maintain and develop many traditions created by him (Vladimir Shaidurov).

- "Alexander Gorban is a brilliant researcher with an amazing intellectual breadth and energy. He is also a delightful collaborator with an ebullient sense of humor. It is always a tremendous pleasure and privilege to work with him. He also has a gift for connecting with youth. His students are very lucky (Donald Wunsch).

- "Our joint interest in model reduction of complex dynamic systems and entropy brought us close, and enabled me to learn the work and personality of Prof. Alexander Gorban. His creativity, brilliant ideas and good humour have always inspired me, while I have admired his hard working, dedication, humanity and helpfulness. I am grateful for the times we could work together, and for the inspiration and support I have received from him (Katalin Hangos).

- "Though I came to Alexander Nickolaevich already having some background and achievements, I define his role in my life as being my "scientific father". This was his influence and personality which rewired my brain neural network towards choosing science as profession. The main things I've learned from him is to look at the whole science as a single subject, to distinguish essential from secondary details, to be generous in sharing ideas with others. For already ten years I manage a research group involved in tons of projects, but I continue to learn from Alexander Nickolaevich by listening, asking and imitating his way of approaching problems. Just as a child does (Andrey Zinovyev).

- "I never thought I would be privileged enough to meet Professor Alexander Nikolaevich Gorban in person, not to mention to be able work with him. As a scientist, to me he is a man from the other side of the book, a wizard, creator, and simultaneously a caring host of a wonderful universe of ideas who is always happy to guide and support everyone willing and daring to enter. As a person, he is a role model in every angle and dimension I was able to explore myself (Ivan Tyukin).

- "I have worked with Alexander for the past 10 years and have found him a constant source of great ideas. My philosophy concerning the mathematics I do has changed over that period, and I am now much more focussed on providing solutions to real problems that other scientists, or industrial colleagues, have. I continue to benefit from his wisdom, and the deepest understanding of science of any individual I know (Jeremy Levesley).

- "I feel my 'close encounter' with Alexander Gorban as a very rare event in my life. The main uniqueness is a meeting with a man which personality is unique. Imagine you have met an alien and helped him to find a branch of "Bank of America". You have to help him. It is unavoidable. You will remember that day forever.
  Gorban is a public scientist. In difference from the public politician, the public scientist is extremely difficult to find. A distinguished appearance ... An actor's gift of the special articulation ... An expressive voice ... Gorban has all these features. However the main thing is his ability for pursuing and finding the truth in the front of the big audience, not sitting alone in a silent professor's office. He is a master of intellectual performance which is very impressive (Gregory Yablonsky).

Guest Editors:
Gennady Fridman
Jeremy Levesley
Ivan Tyukin
Donald Wunsch