



IOSIF IZRAILEVICH VOROVICH (ON THE OCCASION OF HIS 80TH BIRTHDAY)†



On the 21 June 2000, Iosif Izrailevich Vorovich, Academician, director of the Institute of Mechanics and Applied Mathematics of Rostov State University and holder of the Chair in the Theory of Elasticity at Rostov State University, was 80 years of age.

A renowned representative of the Russian school of mathematics who was awarded the highest academic distinctions, Vorovich was also the author of many first class results in many branches of mechanics and mathematics, as well as an outstanding scientific organizer and teacher. The scientific advice of Vorovich determined the main areas of investigations by many of his pupils, including the authors of this tribute. He possesses enormous erudition and surprising intuition as well as insight into science and life.

Vorovich was born into a middle class family in the small, ancient town of Starodub in the Bryansk region. He was 10 years old when his mother died. In 1937, having finished school, he entered the department of mechanics in the Mechanical-Mathematical Faculty of Moscow State University (MGU) which, already at that time, was one of the leading centres of science and education in the world.

His university education was interrupted by the war. In determining the fate of students taking higher courses at the better universities who had been called up for service in the Red Army, the Soviet Government took the decision to form educational groups from them after they had gone through rapid training at military academies. In this way, Vorovich also became a student at the N. Ye. Zhukovskii Air Force Academy. On one course, the young people who studied with him were shortly destined to contribute to the fame of national science and technology. It is recorded in the annals of the history of the Academy that, on this brilliant course, he was the first to receive thanks, having solved an internal ballistics problem which had been formulated by General D. A. Venttsel'.

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During the years of the Great Patriotic War (World War II), the students underwent practical training at air bases which were close to the fronts. In 1942, he was an aircraft mechanic on the Volkhov front. In 1944, having left the Academy with distinction, he was retained for further service and, subsequently, sent to work on probation in a line unit.

In May 1945, without taking off his military uniform, senior technician-lieutenant Vorovich passed his final examinations at Moscow State University. The main area of his scientific work had been decided. It was the theory of elasticity.

He spent the end of the war with Japan on the Zabaikal'skii front where he served as an aircraft technician and, later, as an aircraft engineer. Here, in the short months of a relatively peaceful life on the Liaotung peninsula not far from Port Arthur, he wrote his first published scientific paper on improved methods for the designing buffer springs. The young officer noted down in his diary plans for future papers, ideas and preparations for the future. Many of these notes refer to technical problems which were topical at that time and, by many of them, he had written "solved". It is interesting to trace how the young scientist in shoulder-straps passed from actual technical problems involving calculations on internal combustion engines, slave control systems and centrifugal regulators to the formulation of fundamentally scientific problems. During the following decades, the dreams and plans of this time were realized in numerous papers, monographs, the dissertations of pupils and followers and in investigations for the needs of industry.

These notes contained formulations of problems in the non-linear theory of elastic shells and plates, both static and dynamic contact problems in the theory of elasticity, ideas on the development of the theory of the stability of motions of continua and the global analysis of periodic motions, the formulation of a problem concerning the development of a statistical theory of elasticity and a multitude of problems concerning asymptotic methods and stability.

It was here that a remarkable quality became apparent, that is, his ability not only to define the main trends of the development of mechanics and mathematics and to make progress with far-reaching plans but, also, doggedly to realize these plans over many years of work while creating and teaching with this aim in mind and instilling whole groups of workers with enthusiasm.

In 1947, he was recalled from the front line unit and sent to the N. Ye. Zhukovskii Airforce Engineering Academy in order to continue his training. Here, he began to work under the guidance of the outstanding academic and future academician V. S. Pugachev. His interests were the action of random perturbations on the stability and the accuracy of the functioning of automatic control systems. In 1950, he brilliantly defended his candidate dissertation on control theory. A substantial part of this dissertation was published, on presentation by A. N. Kolmogorov, in *Izvestiya Akad. Nauk SSSR* (1956). Further development of these ideas led Vorovich to the creation of a statistical theory of the stability of elastic shells which describes the behaviour of a shell, its stability and possible snapping accompanying random external perturbations.

From 1950 up to the present day, Vorovich has been working at Rostov University. The scientific school which he heads has received world-wide recognition. Twenty five doctors of science have graduated from this school.

During the course of his first years of working in Rostov, Vorovich solved a number of interesting problems and wrote papers on the asymptotic behaviour of the solutions of linear differential equations, on the branching of the equilibria of a loaded plate and on a stochastic approach in the theory of stability. At Rostov University, the university reader, N. N. Moiseyev, who was later to become an Academician, was also engaged in closely related problems at this time. Vorovich had been together with him both at Moscow University, the N. Ye. Zhukovskii Academy and on the Volkhov front. They also arrived in Rostov together.

Gradually, the non-linear theory of elastic shells, together with the corresponding mathematical arsenal of the tools of functional analysis, calculus of variations and topology and the theory of the imbedding of functional spaces, became the centre of his attention. In fact, his results in this field (or, more accurately, some of them) formed the content of a doctoral dissertation which he splendidly defended in 1958. Few papers are awarded such a good appraisal as that given to this dissertation by Yu. N. Rabotnov, V. V. Novozhilov, O. A. Ladyzhenskaya, S. R. Mikhlin and M. A. Krasnosel'skii. The work has remained topical up to the present time and it is to be regretted that it only appeared as a book as late as 1990 (the English edition was first published in 1999). Vorovich, together with other academics, was awarded the State Prize for these papers.

The non-linear dynamics and statics of elastic shells lead to extremely difficult initial-boundary-value and boundary-value problems. It is therefore not surprising that the approaches and plans he developed also continue to work and to yield results in all areas of the non-linear mechanics of continua and, above all, in hydrodynamics and the theory of plasticity and viscoelasticity.

From 1960, he was in charge of the Chair of the Theory of Elasticity which had been set up on his initiative and mainly consisted of his pupils. In 1970, he was elected a corresponding member and, in 1990, a full member of the Academy of Sciences of the USSR (now the Russian Academy of Sciences). It is difficult to do justice to all his diverse scientific activity during the following decades. We shall describe some of the main areas.

Contact and mixed problems in the theory of elasticity constitute a second field which he continued to investigate from the very outset of his scientific life, after course work carried out under the supervision of A. Yu. Ishlinskii. Two books and numerous papers, written in co-authorship with his pupils, were the end result. Constant striving for a comprehensive consideration of a selected range of problems and a rigorous treatment of the formulations of the problems and the results gained him and his school great authority among specialists the world over.

Vorovich, together with his pupils, made a significant contribution to the solution of the problem of transferring from a three-dimensional problem in the theory of elasticity to the two-dimensional problem. A new asymptotic method was developed which forms the foundation of refined methods of analysing plates and shells which are extensively used at the present time. By considering boundary-value problems in the case of semi-bounded bodies, he arrived at the need to study the n -fold completeness of special subsystems of the root vectors of the polynomial operator of a pencil of degree $2n$. This problem, which is intimately related to the trend started in the papers by Keldysh in the spectral theory of non-self-adjoint operators, has subsequently become the subject of numerous investigations by mathematicians.

Vorovich formulated the fundamental principle for the stability of the natural unstressed state of a viscoelastic material, which gives the principal constraints on the possible form of the equation of state. The dynamic stability of polymer shells was determined and studied in a number of his papers.

He put considerable effort into solving problems in the dynamic theory of elasticity. He was involved in the development of numerous fields of investigation – dynamic contact problems, the qualitative investigation of mixed boundary-value problems for semi-bounded domains with an unsmooth boundary, the propagation of waves in cylindrical bodies, inverse problems in acoustics and the theory of elasticity. He put forward a rigorous mathematical theory of isolated resonances in a system consisting of a semi-bounded elastic medium and a massive body and, in particular, predicted the possibility of the existence of resonance frequencies at which the energy increases in an unbounded manner. These isolated resonances were called V -resonances. Their study is of particular practical significance since they correspond to comparatively low frequencies so that it is necessary to know how to predict both harmful effects (in particular, during earthquakes) and useful effects associated with them. Subsequently, he, together with V. A. Babeshko and I. F. Obraztsov, discovered high-frequency resonances in semi-bounded bodies with inhomogeneities in the form of cracks and inclusions. At the resonance frequencies, the vibrations are localized close to the inclusions, and their amplitude increases sharply. Priority in this discovery, which furthered the development of new principles for the excitation of powerful vibrations of the deep zones of the Earth, was confirmed by American scientists.

In the field of inverse problems, efficient methods were developed for reconstructing the shape of a defect of complex form located inside an elastic body.

During the whole of his scientific activity, Vorovich, side-by-side with his theoretical studies, carried out investigations, closely related to his theoretical work, to satisfy the immediate needs of production industry.

He managed one of the first self-financing contractual schemes at Rostov University on designing the rimmed wheels of the reducers in rolling mills and mining hoists (the results are summed up in his first monograph). His papers on dynamic contact problems were intimately related to problems of vibrational seismic prospecting. Academician N. S. Solomenko characterized Vorovich's investigations in the field of the hydro-elasticity of shells as making an outstanding contribution to domestic ship-building.

Coinciding with the opening in 1971 of a division of mathematical methods in ecology and economics in the Scientific Research Institute of Mechanics and Applied Mathematics, Vorovich started to work actively in this field. His efforts together with those of his colleagues were concentrated on problems concerned with the mathematical modelling of the ecosystem of the Azov Sea, due to the need for urgent measures to safeguard against irreversible changes in its state. Over the course of more than 15 years work with the mathematical models that had been constructed, which included extensive computational experiments, general rules governing the behaviour of complex ecological systems were formulated and, in particular, an analogue of the thermodynamic Le Chatelier–Braun principle was established by him and Yu. A. Zhdanov. We particularly mention the concept of critical states in ecological systems which he developed. The approach of a system to the critical state as a result of external actions leads to a sharp increase in the time required for its relaxation to equilibrium or to it becoming catastrophically unstable.

The results of these investigations served as reference point in developing a strategy for the efficient use of water in the region. For this work, Vorovich and his colleagues were awarded the State Prize of the USSR in 1983. The experience which had been acquired was subsequently successfully used in solving nature conservation problems in the Baikal and Sevan Lakes and the Black, Okhotsk and Arctic Seas. For the last 20 years the Vorovich school has held annual international conferences on *Mathematical Modelling and the Rational Exploitation of Nature*.

He is an outstanding teacher. His lectures hold the attention of his audience not by virtue of superficial tricks or jokes (although the wit and rapidity of his repartee are well known) but by the beauty of the subject, the depth of the approach and the perfect logic in developing the principal ideas. His main course in theoretical mechanics is the basis of a fundamental textbook which should appear soon. He is the G. Soros Professor.

Science is, always was and always remains an important factor in the rapprochement of people of different countries and nationalities. Professor Vorovich, who did much to unify the different divisions of science, also helped to unite people and foreign scholars from near and far working in fields close to his own. In all republics of the former Soviet Union, there are mechanicians and mathematicians with whom he maintained and continues to maintain fruitful scientific contacts and he is a friend to many of them.

His many pupils, the editorial board and the editorial staff of *Applied Mathematics and Mechanics* and his friends and admirers heartily congratulate him on his Birthday. We wish him robust health and happiness and success in his creative work.

V. A. Babeshko, A. V. Belokon' and V. I. Yudovich

A LIST OF THE PRINCIPAL SCIENTIFIC PUBLICATIONS
BY I. I. VOROVICH

1945

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1953

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1954

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1959

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1964

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