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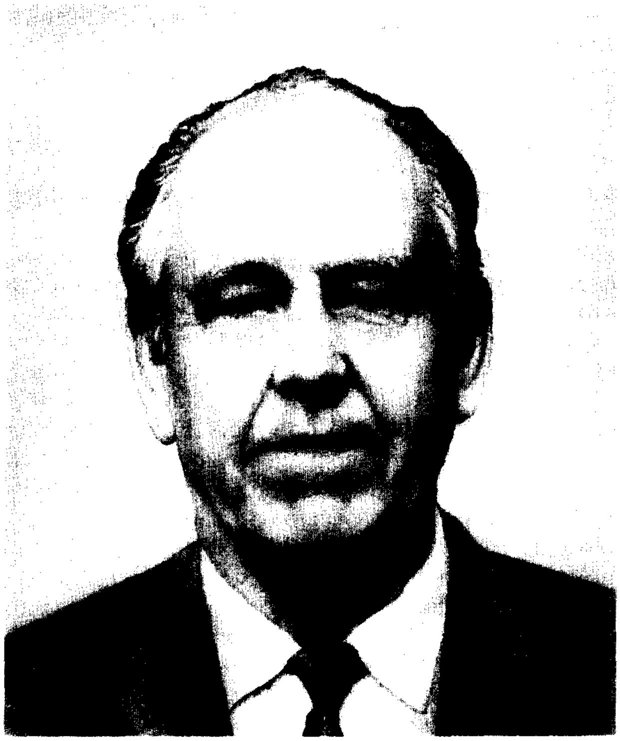
GRIGORII ALEKSANDROVICH TIRSKII (on the occasion of his seventieth birthday)†



On the first of September 1999, Doctor of Physical-Mathematical sciences, Professor and Honoured Scientist of the Russian Federation Grigorii Aleksandrovich Tirskii, an outstanding Russian scholar in the field of mechanics, was 70 years old.

Professor Tirskii was born into a family of peasants in the village of Tira, located on the bank of the Lena at the estuary of the River Tira in the Irkutsk region. His childhood and school years were spent in the town of Yakutsk, where he finished his secondary school education with a silver medal.

His attraction to the exact sciences was combined with an interest in applied problems and therefore, in parallel with his studies in the Mechanics and Mathematics Faculty of Tomsk State University which he entered in 1947, Professor Tirskii also passed all the examinations of the third course for the second, Physics and Technology Faculty, where he studied external and internal ballistics. In 1952, having completed his studies in the two faculties with distinction, he entered the Mechanics and Mathematics Faculty of the M. V. Lomonosov Moscow State University as a post-graduate student. Here, he studied under the supervision of L. I. Sedov. He obtained a number of self-similar solutions in the hydrodynamics of a viscous fluid and, in 1955, defended his candidate dissertation on the theme: "Exact solutions of some problems of free and forced thermal convection". His scientific outlook was formed during his post-graduate studies and during his many years of active participation in the work of the All-Union seminar directed by L. I. Sedov.

On entering the P. I. Baranov Central Institute of Aircraft Motor-Building after his post-graduate studies, Professor Tirskii joined in scientific research of the gas turbine laboratory. In the 1950s and the following years, a system for cooling the blades and discs of gas turbines was being actively developed at the Institute using free convection in cavities filled with special coolants. During four years of work in this laboratory, he solved a number of practical problems in this field, including strength problems and, in 1959, published a paper entitled "The torsion of a hollow rod bounded by Zhukovskii–Chaplygin wing profiles".

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In 1957, Professor Tirskii was invited to work at the Moscow Institute of Physics and Technology in the Department of the Physics of Explosions, directed by Academician M. A. Lavrent'yev, where, at that time, a brilliant group of scientists in the field of mechanics and mathematics (who are now, Academicians B. V. Voiteskhovskii, N. N. Moiseyev, L. V. Ovysannikov, Corresponding Members S. S. Grigoryan, R. I. Soloukhin, Doctors of Science N. V. Zvolinskii, A. A. Deribas, S. V. Iordanskii, Yu. L. Yakimov, *et al.*) were working. The scientific seminars under the direction of M. A. Lavrent'yev, which were rich in content, gave all the participants enormous scientific enthusiasm. After the creation of the Siberian Branch of the Academy of Sciences of the USSR the majority of the coworkers in the department left for Novosibirsk, and Tirskii moved to the Department of Higher Mathematics of the Moscow Institute of Physics and Technology where he initially worked as an assistant, senior lecturer and, then, as deputy director.

In 1964, he defended his doctoral dissertation "The ablation of solids in hypersonic gas flow" in which a new scientific trend was developed, associated with the construction of mathematical models of ablating (due to various physicochemical processes with heat absorption: melting, vaporization, erosion, combustion, pyrolysis, etc.) special heat-protection coatings for spacecraft.

In 1967, Professor Tirskii received the academic rank of professor at the Department of Higher Mathematics of the Moscow Institute of Physics and Technology where, in different years, he gave courses in gas dynamics, theoretical mechanics and led seminars in mathematics theoretical physics, etc. At the present time, he presents the basic course "Mathematical Models of Continuum Mechanics".

In 1961, he was invited to work (thereby holding two offices) at the Institute of Mechanics at Moscow State University as director of the physicochemical hydrodynamics laboratory which he heads to the present day. Here, he expanded the scientific work on hypersonic aerodynamics and the heat exchange of bodies travelling in the Earth's atmosphere and planetary atmospheres at high supersonic velocities. As a result of this activity, which he directed over a period of many years, more than 50 candidate dissertations were defended, 12 of his students became doctors of science, and four prepared doctoral dissertations. Creatively working scientific groups were established in the Moscow Institute of Physics and Technology, the Institute of Mechanics at Moscow State University and the Institute of Applied Mathematics and Mechanics at Tomsk University. A large number of his students are successfully working at the Institute of Problems of Mechanics of the Russian Academy of Sciences, at the Institute of High Temperatures of the Russian Academy of Sciences and in a number of design offices.

During the last three years he has been G. Soros Professor. Twelve of his scholars (among them, four doctors of science) are successfully working abroad.

Professor Tirskii is a scholar with wide interests. He has outstanding achievements in the topical divisions of aerodynamics and heat transfer in flows past bodies at hypersonic velocities, physicochemical gas dynamics, the kinetic theory of gases, the thermodynamics of irreversible processes, as well as computational hydrodynamics. These are reflected in more than 250 scientific publications, two monographs, patents and reviews, which have brought him fame throughout the world.

Already in the early 1960s he had developed a theory of a laminar, multicomponent boundary layer on the surface of thermally ablating heat-protection coatings (plastics). Taking account of the various diffusion properties of the components led, in 1964, to the discovery of the effect of the separation of the chemical elements in a partially dissociated and ionized boundary layer. Using this theory, models of the thermochemical breakdown of the main conventional heat-protection coatings were developed and, on the basis of these models, the total loss of mass from the heat protection of the "Zond-5" and "Zond-6" space probes during their re-entry into the Earth's atmosphere, after having orbited the Moon in 1968, was quantitatively correctly predicted prior to the flight.

The rigorous formulation and solution of the problem of the flow of a thermochemically equilibrium viscous heat-conducting multicomponent gas (taking ionization reactions into account) with different diffusion properties of the components which he presented is a fundamental result. From this, a complete set of effective transport coefficients was developed for the first time. The rigorous formulation led to the discovery of the effect of the separation of elements in flows of a multicomponent gas and plasma which is at local chemical and ionization equilibrium.

The development in the 1980s, together with other workers, of a phenomenological theory of the heterogeneous catalysis of partially dissociated and ionized air on low catalytic activity heat-protection coatings (on silica-based heat-protection tile-like surfaces), which reduce the rate of exothermic heterogeneous recombination reactions and, thereby, reduce the additional heat flux to the surface of the body around which the flow takes place, was an important practical result. Six years later, American experiments confirmed these theoretical results.

In 1986, the first prize of the Ministry of Education was awarded to Professor Tirskii and his coworkers for this research.

Professor Tirskii made a very important theoretical and practical contribution to the development of the kinetic theory of a multicomponent mixture of gases and a plasma. The standard procedure of the Chapman–Enskog method, which is described in the well-known monograph "Molecular Theory of Gases and Liquids" by Hirschfelder, Curtiss and Bird leads to complex equations for the mass flows of the components, for the energy and for the transport coefficients in the form of a ratio of high-order determinants. Calculations using these formulae are extremely laborious and, at the present time, they are not used to solve heat- and mass-transfer problems. This problem had remained unsolved from the 1950s in spite of the many attempts made by foreign scientists to solve it. Tirskii obtained a new exact and simple form of the transport equations with substantially simpler expressions for the transport coefficients. This form of the transport equations completely and elegantly solves the problem of calculating the transport coefficients in higher approximations and is convenient for solving problems in hypersonic aerodynamics and heat transfer.

In 1985, the M. V. Lomonosov prize of Moscow State University was awarded to Professor Tirskii for the formulation and solution of numerous problems of the hypersonic flow of a viscous and heat-conducting gas past bodies, which rigorously take account of non-equilibrium physicochemical processes.

Professor Tirskii made a major contribution to the development of analytical methods for solving boundary-layer equations and numerical methods for solving the simplified Navier–Stokes equations. The original method of successive approximations for integrating the boundary-layer equations, which he proposed at the end of the 1960s, and the method subsequently extended by his students for integrating the system of equations of a hypersonic (thin) viscous (two- or three-dimensional) shock layer, turned out to be extremely efficient for obtaining both analytical and numerical solutions. Together with other scientists, from the end of the 1970s he made a substantial contribution to the development of the numerical method of global iterations for solving the equations for a complete and hypersonic (thin) viscous shock layer, the parabolized and complete Navier–Stokes equations and the Euler equations in problems of hypersonic flow past blunt bodies. The method of global iterations which, in this case, replaces the establishment method, is more than order of magnitude faster than the latter method when solving two-dimensional problems. In recent years, this method has been extended by his colleagues to the calculation of viscous flows in nozzles.

In the middle of the 1980s, Professor Tirskii turned his attention for the first time to the fact that, during the descent from orbit of space vehicles of the "Space Shuttle" and "Buran" type and also during the motion of spacecraft along ricocheting trajectories in the upper layers of the atmosphere, it is necessary to take account of non-equilibrium kinetics, that is, to consider the occurrence of reactions on a non-thermal equilibrium background when the vibrational and electronic degrees of freedom immediately after the bow shock wave have still not reached equilibrium with the translational degrees of freedom. It was shown that, when allowance was made for these effects, there is an additional increase in the equilibrium temperature of the wall due to delay in the shock layer of thermochemical non-equilibrium dissociation and ionization reactions under thermally stressed conditions at the trajectory up to 60–100 K; this increases the heat flux and the stand-off distance of the bow shock wave. Later (at the end of the 1980s and the beginning of the 1990s), these investigations became major lines of research both in the Russian Federation and abroad.

For his researches on thermochemically non-equilibrium gas dynamics, Professor Tirskii was awarded the S. A. Chaplygin gold medal of the Russian Academy of Sciences in 1995. He was also awarded the prize of the International academic publishing company "Nauka" for the best publication in 1997 in the journals which it publishes, the P. L. Kapitsa medal of the Russian Academy of Natural Sciences "To the author of scientific discovery" (1966), and the medal of the International Academy of Sciences on Nature and Society "for the contribution to revival of Russian science and economics" (1999).

The new asymptotic system of the equations of a two-layer model (a viscous shock layer plus a shock wave structure) which he discovered in problems of hypersonic flow past blunt bodies when the Reynolds number tends to zero and the ratio of the densities before and immediately after the bow shock wave simultaneously and more rapidly tends to zero, is an outstanding contribution to hypersonic aerodynamics and heat exchange. Unlike all the classical models obtained when $\mathrm{Re} \to \infty$, the solution of the hypersonic flow problem gives in this case the free molecule limit for the coefficients of friction, heat transfer and drag coefficient. Within the framework of a single mathematical model of a viscous shock layer, it became possible to calculate both the aerodynamic as well as the thermal characteristics simultaneously over the whole of the trajectory of entry of a body into the atmosphere.

The high standard of the research, its topical nature and the novelty of the ideas he developed, together with his many students and colleagues, have made his name well known and recognized not only in

Russia but also abroad. He is an outstanding specialist in his field. He strives towards the most rigorous formulations and efficient solutions of problems, which rank with the great theories and calculations developed in world science.

Professor Tirskii was elected a full member of the Russian Academy of Natural Sciences and a member of the New York Academy of Sciences. He is also a member of a number of Russian and foreign scientific societies.

For more than 15 years he has actively worked for the journal *Applied Mathematics and Mechanics* and, during the last 11 years, has been a member of the Editorial Board of the journal.

Professor Tirskii greets his wonderful anniversary celebrations full of energy and creative ideas. The Editorial Board and the editorial staff of *Applied Mathematics and Mechanics*, his colleagues, students and disciples wish him robust health, happiness and further successes.

A LIST OF THE SCIENTIFIC PAPERS BY G. A. TIRSKII

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1958

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1960

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1961

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1962

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1964

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1965

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1968

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1970

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