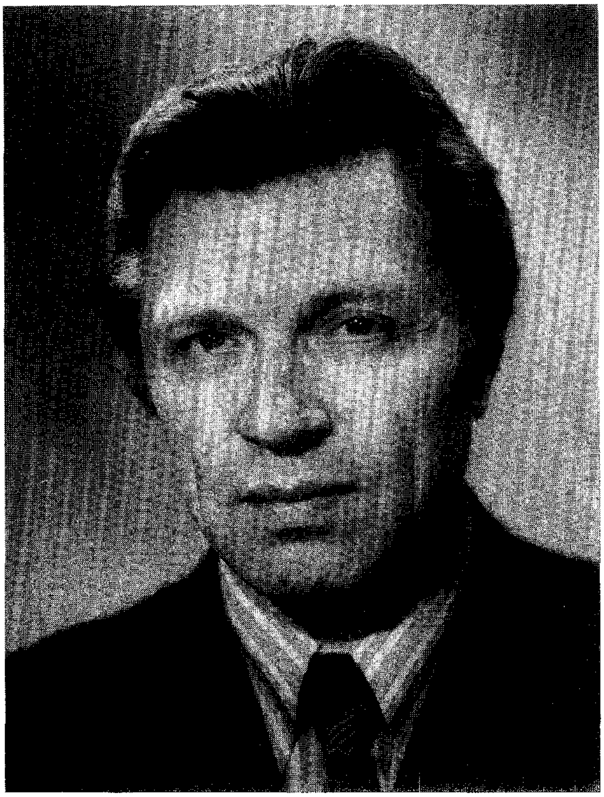
Pergamon
www.elsevier.com/locate/jappmathmech

PII: S0021-8928(03)00011-X

J. Appl. Maths Mechs, Vol. 67, No. 1, pp. 1–10, 2003

0021-8928/03/$—see front matter

GORIMIR GORIMIROVICH CHERNYI (80th birthday tribute)†



Gorimir Gorimirovich Chernyi, the outstanding aerodynamics expert of our time, celebrated his 80th birthday on 22 January 2003. The research carried out by himself and his many students and successors has had, and continues to have, an often decisive influence on the development of fluid and gas mechanics, and hence on the development of aviation and rocket technology.

Chernyi is an outstanding member of those heroic prewar generations to whom Russia owes so much of its success and greatness in the war and in the following peaceful decades. At the very start of World War II, when an undergraduate at the M. V. Lomonosov Moscow State University, he volunteered for the home guard and found himself serving in the front line. Experiencing the bitter taste of defeats, losses of fellow soldiers, retreats, and narrow escapes, and spending practically the entire war as a private in the front line, he ended the war as a sergeant with wounds and war medals.

His scientific activity began in the years when progress in jet engine and rocket technology was giving rise to a whole range of problems that required urgent investigation and solution. In 1952, 3 years after graduating from Moscow State University, to which he had returned in 1945, he was appointed Head of the new Laboratory of Gas Dynamics of the P. I. Baranov Central Institute of Aviation Motors (CIAM), founded on the initiative of his teacher, Leonid Ivanovich Sedov. He remained as Head of this laboratory until 1970. In 1960, without interrupting his work at CIAM, he became Director of the Institute of Mechanics at Moscow State University, and he stayed in this post until the beginning of the 1990s. He is now in effect the Scientific Supervisor of this institute.

We will list his most important personal scientific achievements.

In the mid-1950s, he developed an asymptotic method for integrating gas dynamics equations as applied to hypersonic flow with strong shock waves. Both then and much later, until computers and

---

†*Prikl. Mat. Mekh.* Vol. 67, No. 1, pp. 3–14, 2003.

numerical methods became efficient, this method was widely used. It gave rise to an extensive literature, numbering hundreds of publications, throughout the world. All the main qualitative results of the theory of hypersonic flow, then confirmed by the results of computational gas dynamics, were originally obtained using his methods. Using the non-stationary analogy, Chernyi employed this method to investigate features of the hypersonic flow of bodies with slight blunting. The similarity parameters found by him are now considered to be universal. His investigation of three-dimensional flow past wings enabled him to provide a complete classification of the possible types of hypersonic flow past delta wings at high angles of attack.

Slightly earlier (in 1954), he constructed a theory of motions in a viscous boundary layer containing phase state discontinuity surfaces of the substance, combustion fronts, condensation, and change in the state of aggregation. This theory has found many applications in the work of Russian and foreign scientists, in particular in the development of methods for calculating the ablation of bodies in high-temperature gas flows (during the re-entry of spacecraft), the steam condensation on cooled surfaces, and the heat-proofing of combustion chamber walls and turbine blades by blowing gas through porous surfaces. In connection with the boundary-layer approximation, his research in the 1970s on viscous flow past a plate whose surface, with a fixed leading edge, is moving upstream, is of considerable interest. In the development of problems of multiphase boundary layers, at the start of the 1990s he constructed a mathematical model of the penetration of hot bodies into a melting solid medium. Whereas the problems enumerated above were examined in the purely hydrodynamic approximation, the model proposed by Chernyi almost at the same time (1989) of the anomalous penetration of high-speed microparticles into a solid target required the use of the theories of elasticity and microcrack formation.

He made a considerable contribution to the gas dynamics of flows with detonation wavers. He examined a wide range of self-similar problems, starting with the problem of the supersonic flow of a detonating gas past a cone, and established asymptotic laws of the behaviour of detonation waves. Under his supervision, and with his active participation, using the simplest model of combustion delay, the first numerical solutions of non-self-similar problems of the supersonic flow of a combustible mixture past blunted bodies were obtained for a zero-thickness detonation wave. His work played a key role in understanding the gas-dynamic problems of detonating mixtures and in arousing interest in them. In the 1980s, from a common point of view, he carried out several analytical reviews of the results of theoretical and experimental investigations of exothermic waves in continua in connection with different applications (chemical detonation and deflagration, laser-detonation waves, thermonuclear detonation, crystallization and polymerization waves). Problems of stability were examined, and the emergence of regular three-dimensional structures in self-sustaining exothermic waves was analysed. In 1999, Chernyi, with his colleagues, proposed a fundamentally new layout of an airbreathing detonation jet engine – a supersonic pulse detonation ramjet engine. It differs from existing pulse detonation engines in having no periodically cutting-in ignition source, which is required only for start-up, and in the fact that the detonation wave always propagates upstream the supersonic flow, and the pulse detonation process is initiated by periodic changes of the fuel supply mode. Exceeding its stationary analogues in specific impulse, the new engine is noted for lower heat fluxes to the wall of the flow duct.

He carried out investigations that played a key role in the design and development of simple ("engineering") flow models. In relation to the quasi-one-dimensional description of flows in channels by Chernyi and Sedov (1954), a procedure was developed for averaging parameters while retaining the integral characteristics of the flow. By linearizing the equations of swirling flow, in 1956 he obtained a criterion determining the flow-rate and thrust coefficients of the nozzle. As shown much later by two-dimensional calculations, this criterion is applicable in the case of swirls reducing the flow-rate coefficient by tens of percentage points. In the same period, using a model of radially balanced flow, he formulated and solved a number of problems of the stage optimization of turbomachinery.

At the very start of his scientific activity (in 1950), he solved the problem of slightly perturbed supersonic flow past wedge-like bodies. The solution he constructed was used in numerous applications, such as the design of supersonic jet engine components, an analysis of noise generation when flow inhomogeneities pass through shock waves, and in other problems. On the basis of this, he found the first accurate solution of the variational problem of gas dynamics concerning the construction of the leading part of a body of minimum drag. In cases when the reflection coefficient of pressure disturbances from the leading shock wave is zero, a wedge proved to be the optimum leading part of a plane body. The original method of "variation in characteristic bands" that he developed to prove this result is widely used in solving variational problems of gas dynamics.

In 1953, he solved the extremely important problem, for describing the operation of supersonic air intakes, of flow stability in a channel with a terminal shock wave. Its urgency was dictated by the need to achieve effective retardation of supersonic flow in the air-intake duct of jet engines. This presupposed a shock close to the minimum cross-section of the duct, where the flow Mach number is slightly greater than unity. According to the equations of quasi-one-dimensional flow with a fixed pressure at the channel exit, a stationary shock may occur both before and after the minimum cross-section. The existence of two stationary solutions, the closeness of the Mach number to unity before the shock, and the closeness of the shock position to the minimum cross-section, resulted in the need to analyse the stability of such flow. As he established, when there is no reflection of disturbances from the channel exit, flow with a shock in a diverging channel is stable, while in a converging channel it is unstable. He also showed that it is possible to stabilize the flow by means of perforated walls and added volumes.

At the start of the 1960s, in an approximate formulation using Newton's drag law, Chernyi and his student A. L. Gonor found the first solutions of problems of constructing three-dimensional bodies of minimum drag. In 1976, he proposed a method for constructing near-optimum three-dimensional leading parts adjacent to a circular base. All of the most interesting results obtained to date in this area are due to Chernyi and his school.

While supervising experimental and theoretical research on the interaction of shock waves with a boundary layer, Chernyi in the precomputer age (1952) in a non-linear approximation solved the problem of the interaction of a skew shock with a near-wall subsonic flow.

Recently, he has been concerned with the control of the aerodynamic characteristics of bodies by supplying energy to the supersonic flow past them.

The contribution Chernyi has made to the development of aerodynamics is not confined to the results obtained by him personally. His undoubted achievements include the scientific schools he set up at CIAM and at the Institute of Mechanics of Moscow State University, which can be credited with important breakthroughs in practically all areas of gas dynamics.

Along with the development of Chernyi's ideas, his students have obtained interesting and important results in aerodynamics in areas with which Chernyi personally has not been involved (for example, in numerical methods, in magnetohydrodynamics and electrohydrodynamics, multiphase flows, and in turbulence theory). However, here again his influence has been enormous, for all results of some significance have been discussed at seminars led by him, and most of the work has at least started under his guidance. Herein, and also in his teaching (at the Moscow Institute of Physics and Technology and Moscow State University, where he has been a professor since 1958), lies his importance as an educator of scientists. The most up-to-date textbook on gas dynamics is Chernyi's book *Gas Dynamics* (Nauka, Moscow, 1988). His book *Hypersonic Gas Flow* (Fizmatgiz, Moscow, 1959) has been published twice in the United States (in 1961 and 1969).

The year 2000 saw the 70th anniversary of the founding of the CIAM and May 2002 marked the 50th anniversary of the founding of the Laboratory of Gas Dynamics at CIAM of which he was the first Head. In connection with these anniversaries, a two-volume collection of papers written by colleagues during their work in this laboratory was published (*Gas Dynamics. Selected Papers*, Fizmatlit, Moscow, 2000 and 2001). This splendid collection gives a fairly complete picture of the first 20 years of Chernyi's fruitful scientific activity. Since most of the authors are either his students or students of his students, the collection both characterizes one of Chernyi's schools, not only in the past but also at present, and shows Chernyi himself as an outstanding educator of scientists.

For his achievements in aerodynamics and mechanics, Chernyi has been awarded Russia's most prestigious scientific prizes. For his work on hypersonic aerodynamics, in 1959 he was awarded First Prize and the N. Ye. Zhukovskii Gold Medal. His research on hypersonic flow past wings was awarded the M. V. Lomonosov First Prize (1965). In 1976 his research on detonation theory was recognized with the S. A. Chaplygin Prize. For his work in the area of applied gas dynamics, he was awarded the USSR State Prize three times (in 1972, 1978 and 1991), and in 1985 he was awarded the Prize of the Council of Ministers of the USSR. For his work and scientific achievements, he was awarded the Order of Honour (1957), the Order of the Red Banner of Labour (1975), the Order of the Friendship of Nations (1980), and the Order of Honour of the Russian Federation (1999). In 1962 he was elected corresponding member and in 1981 as a full member of the USSR Academy of Sciences.

Recognition of his role and influence is indicated not only by his numerous awards and titles but also by the fact that he has for many years headed the Russian National Committee on Theoretical and Applied Mechanics, the Department of Aerodynamics of Moscow State University, and the editorial board of the journal *Izvestiya Ross. Akad. Nauk Mekhanika Zhidkosti i Gaza*, and, from the end of 2001 and the start of 2002, the two new journals *Aeromekhanika i Gazovaya Dinamika* and *Uspekhi Mekhaniki*. Chernyi is an authoritative member of the editorial boards of the journals *Prikladnaya Matematika i Mekhanika* and *Doklady Ross. Akad. Nauk* and of the abstract journal *Mekhanika*. For many years he has represented Russia on the International Council on Theoretical and Applied Mechanics and at the International Astronautical Federation.

The editorial board and editorial staff of *Prikladnaya Matematica i Mekhanika*, his numerous students and, in turn, their students, and his colleagues, friends, and readers send him hearty birthday greetings and wish him robust health and new scientific achievements.

LIST OF G. G. CHERNYI'S PRINCIPAL SCIENTIFIC PUBLICATIONS

1950

Supersonic flow past a wedge-like profile. *Tr. TsIAM im. P. I. Baranova, 1950, 197.* See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 443–462.

Investigation of the most favourable operating conditions of a profile grid. In *Collected Papers on Aerodynamics*, Edited by M. V. Keldysh. Izd. Akad. Nauk, SSSR, Moscow, 1950, 20–52.

1952

The onset and form of discontinuity surfaces in gas flows. In *Theoretical Hydromechanics*. Edited by L. I. Sedov. Oborongiz, Moscow, 1952, No. 2, 42–62.

The influence of the subsonic part of the boundary layer on the position of shock waves. In *Theoretical Hydromechanics*. Edited by L. I. Sedov. Oborongiz, Moscow, 1952, No. 2, 63–96.

1953

The influence of viscosity and heat conduction on gas flow behind a strongly distorted wave. Coauthor with SEDOV, L. I. and MIKHAILOVA, M. P., *Vestn. MGU. Ser. Fiz.-Mat. i Yestestv. Nauk*, 1953, 3, 95–100. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 188–194.

Modes of maximum work of a turbomachine stage. In *Theoretical Hydromechanics*. Edited by L. I. Sedov. Oborongiz, Moscow, 1953, No. 3, 115–151.

Unsteady motions of a gas in channels with permeable walls. Shock wave stability in channels. *Tr. TsIAM im. P. I. Baranova*, 1953, 244, See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 590–609.

1954

Investigation of the influence of boundary layer control on the retardation of supersonic flow in a diffuser channel. Coauthor with NEKRASOV, I. P. and SLAVYANOV, N. N., *Tekhn. Byulleten' TsIAM*, 1954, 8, 1–8.

Laminar motions of gas and liquid in a boundary layer with a discontinuity surface. *Izv. Akad. Nauk SSSR. OTN*, 1954, 12, 38–67. See also *Theoretical Hydromechanics*. Edited by L. I. Sedov. Oborongiz, Moscow, 1956, 7, 3–40 and *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 195–222.

Gas flow in a tube in the presence of a flame front. In *Theoretical Hydromechanics*. Edited by L. I. Sedov. Oborongiz, Moscow, 1954, 4, 31–36.

A case of the steady motion of an ideal fluid. In *Theoretical Hydromechanics*. Edited by L. I. Sedov. Oborongiz, Moscow, 1954, 4, 37–39

The averaging of non-uniform gas flows in channels. Coauthor with SEDOV, L. I. In *Theoretical Hydromechanics*. Edited by L. I. Sedov. Oborongiz, Moscow, 1954, 4, 17–30. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 23–34.

1955

Boundary layer with a discontinuity surface. Flow past a plate with seepage of fluid through its surface. *Dokl. Akad. Nauk SSSR*, 1955, **100**, 5, 867–870.

Condensation of moving steam on a plane surface. *Dokl. Akad. Nauk SSSR*, 1955, **101**, 1, 39–42.

1956

Umströmung von Körpern durch Gase mit sehr hocher Überschallgeschwindigkeit. In *Intern. Tagung über Staustrahlen and Raketen*. Edited by E. Saenger and I. Saenger-Brendt. Verlag Flugtechnik, Stuttgart, 1956, 221–236.

Mode of maximum work of a stage without a guiding apparatus at the input of a working impeller and with a limited speed of exit from it. In *Theoretical Hydromechanics*. Edited by L. I. Sedov. Oborongiz, Moscow, 1956, 7, 137–146.

The gas flow past bodies at hypersonic speed. *Dokl. Akad. Nauk SSSR*, 1956, **107**, 2, 221–224.

One-dimensional unsteady motions of an ideal gas with strong shock waves. *Dokl. Akad. Nauk SSSR*, 1956, **107**, 5, 657–660.

Swirling flows of a compressible gas in channels. *Izv. Akad. Nauk SSSR. OTN*, 1956, 6, 55–62. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 35–44.

1957

The problem of a point explosion. *Dokl. Akad. Nauk SSSR*, 1957, **112**, 2, 213–216.

Adiabatic motions of an ideal gas with shock waves of high intensity. One-dimensional unsteady motions. *Izv. Akad. Nauk SSSR. OTN*, 1957, 3, 66–81. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 261–278.

The flow of an ideal gas past bodies at hypersonic speed. *Izv. Akad. Nauk SSSR. OTN*, 1957, 6, 77–85. See also *Gas Dynamics. Selected. Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 279–291.

The effect of slight blunting of the leading edge of a profile in the hypersonic flow. *Dokl. Akad. Nauk SSSR*, 1957, **114**, 4, 721–724.

Flow past a slender blunted cone at hypersonic speed. *Dokl. Akad. Nauk SSSR*, 1957, **115**, 4, 681–683.

On bodies of minimum drag at hypersonic speeds. Coauthor with GONOR, A. L. *Izv. Akad Nauk SSSR. OTN*, 1957, 7, 89–93.

1958

The effect of slight blunting of the leading edge of a body on the hypersonic flow about it. *Azv. Akad. Nauk SSSR. OTN*, 1958, 4, 54–66. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 292–308.

1959

Steady flow of a detonating gas past a cone. Coauthor with KVASHNINA, S. S. *Prikl. Mat. Mekh.*, 1959, 23, 1, 182–186. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko, A. B. Vatazhin and A. N. Sekundov. Fizmatlit, Moscow, 2001, Vol. 2, 27–33.

Hypersonic Gas Flows. Fizmatgiz, Moscow, 1959.

1960

Application of integral relations in problems of the propagation of strong shock waves. *Prikl. Mat. Mekh.*, 1960, **24**, 1, 121–125. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 315–320.

Gas dynamics. In *Encyclopaedic Dictionary of Physics*. Sovetskaya Entsiklopediya, Moscow, 1960, Vol. 1, 359–361.

Effect of slight blunting of the leading edge of an immersed body on the flow around it at hypersonic speeds. NASA, 1960, TTR-35.

1961

The method of integral relations for calculating gas flows with strong shock waves. *Prikl. Mat. Mekh.*, 1961, **25**, 1, 101–107.

Introduction to Hypersonic Flow. Academic Press, New York, 1961.

1962

Tip-bluntness effects in hypersonic flow. In *Proc. 4th Intern. Symp. on Space Technol. and Science*, Tokyo, 1962, 43–46.

The determination of body shapes of minimum drag using the Newton and Busemann pressure laws. Coauthor with GONOR, A. L. In Sypm. on *Extrem. Probl. in Aerodynamics*, Scattle, Washington. Boeing Scientific Research Laboratories, 1962, 1–17.

1963

The analogy with an explosion of the hypersonic flow around a slender body with a blunted front edge. *Dokl. Akad. Nauk SSSR*, 1963, **151**, 2, 302–305.

Moment relations on discontinuity surfaces in dissipative media. Coauthor with BARENBLATT, G. I. *Prikl. Mat. Mekh.*, 1963, **27**, 5, 784–793. *Archiv Mech. Stosow*, 1964, **16**, 3, 829–830, and *Gas Dynamics. Selected. Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 223–232.

1964

Hypersonic flow past wings at high angles of attack. *Dokl. Akad. Nauk SSSR*, 1964, **155**, 2, 302–305.

The investigation of bodies of minimum drag at high supersonic speeds. *Prikl. Mat. Mekh.*, 1964, **28**, 2, 387–389.

The emergence of unclosed three-dimensional detached zones during supersonic gas flow past bodies of complex shape. Coauthor with AVDUYEVSKII, V. S. ZUBKOV, A. I., MEDVEDEV, K. I., and PANOV, Yu. A. Discovery No. 298. Priority from 17.01.1966. Registered on 29.11.1984.

1965

Transversal contour of minimum pressure drag. In *Theory of Optimum Aerodynamic Shapes*. Coauthor with GONOR, A. L. Edited by A. Miele. Academic Press, New York, 1965, 283–295.

Nonslender shapes of minimum pressure drag. In *Theory of Optimum Aerodynamic Shapes*. Coauthor with GONOR, A. L. Edited by A. Miele. Academic Press, New York, 1965, 373–385.

A flat wing in hypersonic flow. *Dokl. Akad. Nauk SSSR*, 1965, **161**, 4, 791–794.

Supersonic flow. In *Encyclopaedic Dictionary of Physics*. Sovetskaya Entsiklopediya, Moscow, 1965, Vol. 4, 470–473.

Wings in hypersonic flow. *Prikl. Mat. Mekh.*, 1965, **29**, 4, 616–634. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 321–344.

1966

Flat wings in hypersonic flow. In *Proc. 11th International Congress on Applied Mechanics*. Springer, Berlin, 1966, 763–767.

Self-similar problems of the flow of a combustible gas mixture past bodies. *Izv. Akad. Nauk SSSR. MZhG*, 1966, 6, 10–24. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko, A. B. Vatazhin, and A. N. Sekundov. Fizmatlit, Moscow, 2001, Vol. 2, 34–53.

Supersonic flow of a combustible gas mixture past a sphere. Coauthor with GILINSKII, S. M. and ZAPRYANOV, Z. D. *Izv. Akad. Nauk SSSR. MZhG*, 1966, 5, 8–13. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko, A. B. Vatazhin, and A. N. Sekundov. Fizmatlit Moscow, 2001, Vol. 2, 54–62.

1967

A wing at high angle of attack in hypersonic flow. In *Fluid Dynamics Transactions*. PWN, Warsaw, Vol. 3, 485–492.

The asymptotic law of the propagation of a plane detonation wave. *Dokl. Akad. Nauk SSSR*, 1967, **172**, 3, 558–560.

Asymptotic laws governing the behaviour of detonation waves. Coauthor with LEVIN, V. A. *Prikl. Mat. Mekh.*, 1967, **31**, 3, 393–405. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko, A. B. Vatazhin, and A. N. Sekundov. Fizmatlit, Moscow, 2001, Vol. 2, 63–77.

Mechanics. Coauthor with SEDOV, L. I. In *Moscow University in the 50 Years of Soviet Power*. Moscow State University, Moscow, 1967, 185–204.

1968

Supersonic flow of a combustible gas mixture past a sphere taking into account the ignition delay time. Coauthor with GILINSKII, S. M. *Izv. Akad. Nauk SSSR. MZhG*, 1968, 1, 20–32. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko, A. B. Vatazhin, and A. N. Sekundov. Fizmatlit, Moscow, 2001, Vol. 2, 78–90.

Supersonic flow past bodies with the formation of detonation and slow combustion fronts. *Astronaut. Acta*, 1968, **13**, 5/6, 467–480.

One-dimensional unsteady flows of a combustible gas mixture taking into account the finite rate of chemical reactions. Coauthor with BISHIMOV, Ye., KOROBEINIKOV, V. P., and LEVIN, V. A. *Izv. Akad. Nauk SSSR. MZhG*, 1968, 6, 7–19.

1969

Supersonic flow past bodies with the formation of detonation and combustion fronts. In *Problems of Hydrodynamics and Continuum Mechanics*. SIAM, Philadelphia, 1969, 145–169.

Development of oscillations associated with the attenuation of detonation waves. *Prikl. Mat. Mekh.*, 1969, **33**, 3, 465–475.

Introduction to Hypersonic Flow, 2nd edition. Academic Press, New York/London, 1969.

High speed motion of a body in chemically active gases. Coauthor with GILINSKII, S. M. In *Fluid Dynamics Transactions*. PWN, Warsaw, 1969, Vol. 4, 458–500.

1970

Theory of supersonic gas flows. In *Mechanics in the USSR over a 50 Year Period*. Nauka, Moscow, 1970, Vol. 2, 153–206.

One-dimensional unsteady motions of combustible gas mixtures associated with detonation waves. Coauthor with KOROBEINIKOV, V. P., LEVIN, V. A. and MEDVEDEV, S. V. *Vestn. MGU. Ser. Matematika, Mekhanika*, 1970, 2, 125–134. See also *Astronaut. Acta*, 1970, **15**, 5/6, 259–266.

Development of oscillations associated with the attenuation of detonation waves. Coauthor with MEDVEDEV, S. A. *Astronaut. Acta*, 1970, **15**, 5/6, 371–375.

High velocity motion of solid bodies in combustible gas mixtures. Coauthor with GILINSKII, S. M. *Astronaut. Acta*, 1970, **15**, 5/6, 539–545.

On the main problems and trends in fluid mechanics. Coauthor with SEDOV, L. I. and STRUMINSKII, V. V. In *Proceedings of Anniversary Scientific Session*. General Meeting of the Department of Mechanics and Control Processes of the USSR Academy of Sciences, Moscow, 1970, 5–16.

1971

The nose part of a body. Coauthor with GUSAROV, A. A. and LEVIN, V. A. Inventor's Certificate No. 486571. Priority from 22.12.1972. Registered on 09.06.1957.

1972

The propagation of blast waves in a combustible gas. Coauthor with KOROBEINIKOV, V. P., LEVIN, V. A. and MARKOV, V. V. *Astronaut. Acta*, 1972, **17**, 4/5, 529–537.

1973

Lectures on the Theory of Exothermic Flows behind Shock Waves. Springer, Vienna, 1973.

Lifting body configurations for sustained hypersonic flight. Coauthor with GONOR, A. L. In *Astronautical Research*. Edited by L. Napolitano. D. Reidel Publ. Co., Dordrecht, 1973, 137–146.

Motion of blunted bodies at high speed in a mixture of hydrogen and oxygen. Coauthor with CHERNYAVSKII, S. Yu. *Dokl. Akad. Nauk SSSR*, 1973, **212**, 2, 316–319.

The boundary layer on a plate with a moving surface. *Dokl. Akad. Nauk SSSR*, 1973, **213**, 4, 802–803.

The formulation of problems of the gas flow with discontinuity surfaces. *Nauch. Trudy Inst. Mekhaniki MGU*, 1973, 21, 128–149.

1974

The boundary layer on a moving surface. In *Selected Problems of Applied Mechanics*. VINTI, Moscow, 1974, 709–719.

1975

On problems involving gas flows associated with gasdynamics discontinuities. *Astronaut. Acta*, 1975, **2**, 9/10, 839–865.

1976

The boundary layer on a moving surface. In *Aeromechanics*. Nauka, Moscow, 1976, 99–104.

Investigation of the flow in the neighbourhood of the point of transition of an overdriven cylindrical and spherical detonation wave to a Chapman–Jouguet regime. Coauthor with LEVIN, V. A. *Izd. MGU*, Moscow, 1976.

1977

Exothermic waves in gases. In *Theoretical and Applied Mechanics*. Edited by W. T. Koiter. North-Holland, 1977, 343–362.

1978

Boundary layer on a moving surface. Non-self-similar solutions. Coauthor with ZUBAREV, V. M. In *Some Problems of Continuum Mechanics. Izd. MGU*, Moscow, 1978, 48–54.

The initiation of a detonation process in an H–Cl mixture. Coauthor with VOLAN'SKII, P., VUITITSKII, S., LEVIN, V. A. and TEODORCHIK, A. *Arch. Thermodyn. Spalania*, 1978, **9**, 4, 613–622.

Special theme. Coauthor with GONOR, A. L., NEPOBEDIM, S. P., MININ, V. F., OSTAPENKO, N. A., PISHCHULIN, V. S. and RYUTIN, V. B. Discovery No. 010. Priority from 13.07.1978. Registered on 08.02.1990.

Special theme. Coauthor with LEVIN, V. A., SERIKOV, R. I., and STARIK, A. M. Certificate No. 133127. Priority from 09.10.1978. Registered on 06.08.1979.

1979

Theoretical and experimental investigation of the aerodynamic characteristics of three-dimensional bodies. Coauthor with GUSAROV, A. A., DVORETSKII, V. M., IVANOV, M. Ya. and LEVIN, V. A. *Izv. Akad. Nauk SSSR. MZhG*, 1979, 3, 97–102. See also *Gas Dynamics. Selected Papers*. Edited/compiled by A. N. Kraiko. Fizmatlit, Moscow, 2000, Vol. 1, 424–430.

The evaporation of a moving body on contact with a heated plate. In *Gas and Wave Dynamics. Izd. MGU*, Moscow, 1979, 3, 35–41.

1981

Special theme. Coauthor with CHERNYAVSKII, S. Yu., BAULIN, N. N. and GILINSKII, M. M. Inventor's Certificate No. 1091669. Priority from 04.06.1981. Registered on 08.01.1984.

1982

Exothermic waves in continua. In *Selected Problems in Modern Mechanics*. Edited by G. G. Chernyi, Izd. MGU, Moscow, 1982, Part 2, 3–56.

1983

Gas Dynamics. Part 2. *One-dimensional Unsteady Motions*. Izd. MGU, Moscow, 1983.

1984

Gas Dynamics. Part 1. *The Fundamental Concepts of Gas Dynamics and the Elements of Applied Gas Dynamics*. Izd. MGU, Moscow, 1984.

Gas Dynamics. Part 3. *Steady Motions. Izd. MGU*, Moscow, 1984.

Three-dimensional detached flows. Coauthor with GLAGOLEV, A. I., ZUBKOV, A. I., LYAGUSHIN, B. Ye. and PANOV, Yu. A. In *Present Problems in Mechanics*. Edited by G. I. Petrov. Izd. MGU, Moscow, 1984, 22–29.

Aerodynamics of star-shaped bodies at supersonic speeds. Coauthor with GONOR, A. L., ZUBIN, M. A., OSTAPENKO, N. A. and SHVETS, A. I. In *Present Problems in Mechanics*. Edited by G. I. Petrov. Izd. MGU, Moscow, 1984, 30–38.

1985

The motion of a melting solid between two elastic half-spaces. *Dokl. Akad. Nauk SSSR*, 1985, **282**, 4, 813–818.

1986

Fluid dynamics. In *Scientific Principles of Progressive Engineering and Technology*. Mashinostroyeniye, Moscow, 1986, 127–141.

1987

The entry of slender bodies into a compressible fluid. Coauthor with GONOR, A. L., OSTAPENKO, N. A. and PORUCHIKOV, V. B. In *Mechanics and Scientific and Technical Progress*. Vol. 2. *Fluid Mechanics*. Nauka, Moscow, 1987, 185–199.

On compressor and turbine efficiency. Coauthor with SEDOV, L. I. In *Mechanics. Present Problems*. Edited by G. G. Chernyi. Izd. MGU, Moscow, 1987, XIII–XVI.

Special theme. Coauthor with ZINCHENKO, Zh. F., IVLIYEV, S. A., LEVIN, V. A., AFANAS'YEV, A. A. and BELYAYEV, A. V. Inventor's Certificate No. 296393. Priority from 27.04.1987. Registered on 03.07.1989.

1988

Gas Dynamics. Nauka, Moscow, 1988.

1989

The mechanism of anomalously low resistance to the motion of bodies in solid media. *Proc. the Steklov Inst. of Math.*, 1991, 1, 45–52.

1991

The motion of bodies in a solid melting medium. Preprint No. 2–91. Institute of Mechanics of Moscow State University, Moscow, 1991.

The motion of a plate in a solid melting medium. *Prikl. Mat. Mekh.*, 1991, **55**, 3, 355–367.

1992

The asymptotic method in problems of the motion of bodies in a melting medium. *Prikl. Mat. Mekh.*, 1992, **56**, 3, 368–385.

Luigi G. Napolitano's contribution to the high speed gasdynamics. In *Luigi G. Napolitano. Gli Scitti*. Instituto di Aerodinamica "Umberto Nobile", Ateneo Fridericano, 1992, 49–61.

1993

Numerical modelling of chemically and thermodynamically non-equilibrium flows in problems of hypersonic flow at low and moderate Reynolds numbers. Coauthor with GLAZKOV, Yu. V. and TIRSKII, G. A. In *Mathematical Modelling*. Izd. MGU, Moscow, 1993, 114–121.

Mathematical modelling of the action of a medium on a rigid body. Coauthor with OKUNEV, Yu. M., SADOVNICH II, V. A. and SAMSONOV, V. A. In *Mathematical Modelling*. Izd. MGU, Moscow, 1993, 186–193.

An astronomical telescope. Coauthor with BOYARCHUK, A. A., BELKIN, N. D., KASPER, V. B., SYCHEV, Vikt, V. and TRAVUSH, V. I. Russian Patent No. 2082198. Priority from 18.11.1994. Registered on 20.06.1997.

1995

Modelling the process of process of continuous casting of gasdynamic solidification mould. Coauthor with AFONINA, N. Ye., GROMOV, V. G., ZAKHARCHENKO, V. F., KATS, A. M., LEVIN, V. A. and SIDNYAYEV, N. I. *J. of Advanced Materials*, 1995, **2**, 2, 106–114.

1996

A system for modelling flight dynamics problems. Coauthor with OKUNEV, Yu. M., SADOVNICH II, V. A. and SAMSONOV, V. A. In *Mathematical Modelling. Vestn. MGU. Ser. Matematika, Mekhanika*, 1996, 6, 66–75.

Thermal processes in a gas-dynamics continuous casting mould. Coauthor with AFONINA, N. Ye., GROMOV, V. G. and LEVIN, V. A. In *Heat and Mass Exchange – MMF-96*. Vol. 11. *Heat and Mass Exchange in Chemical Engineering Devices*. A. V. Lykov ANK ITMO, Akad. Navuk Belarusi, Minsk, 1996, 241–244.

1997

Plane steady self-similar vortex flows of an ideal fluid (Keplerian motions). *Dokl. Ross. Akad. Nauk.* 1997, **352**, 3, 335–338.

Plane steady self-similar vortex flows of an ideal fluid. *Izv. Ross. Akad. Nauk. MZhG*, 1997, 4, 39–53.

On the 90th birthday of Leonid Ivanovich Sedov. *Izv. Ross. Akad. Nauk. MZgG*, 1997, 5, 3–8. See also *Proc. of the Steklov Inst. of Math.*, 1998, **223**, 1–5.

1998

The impact of electromagnetic energy addition to air near the flying body on its aerodynamic characteristics. In *Proceedings of 2nd Weakly Ionized Gases Workshop*. AIAA Publ., Norfolk, Virginia, 1998, 1–31.

A supersonic pulse detonation ramjet engine (SPDRE) and its method of functioning. Coauthor with ALEKSANDROV, V. G., VEDESHKIN, G. K., KRAIKO, A. N., OGORODNIKOV, D. A., REYENT, K. S. and SKIBIN, V. A. Russian Patent No. 2157909. Priority from 26.05.1999. Registered on 20.10.2000.

Some recent results in aerodynamic applications of flows with localized energy addition. AIAA paper 99-4819, 1998.

2000

A feature of the non-self-similar interaction of gas dynamic discontinuities. *Dokl. Ross. Akad. Nauk.* 2000, **372**, 2, 185–188.

Non-self-similar interaction of gas dynamic discontinuities. *Izv. VUZ Sev.-Kavkaz. Regiona. Yestestv. Nauki*, 2000, 3, 181–183.

2003

Aerodynamic applications of weakly ionized gases. Where are we? AIAA, Reno, Nevada, 2003 (in press).

Instability and the formation of regular structures during explosive throwing of plates. *Dokl. Ross. Akad. Nauk* (in press).

Translated by P.S.C.