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PERSONALIA

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In memory of Vladimir Evgen'evich Fortov

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Academician Vladimir Evgen'evich Fortov was a world renowned scientist and laureate of many prestigious prizes and honorary titles. He made a major contribution to the physics of extreme states of matter and high energy densities, nonideal plasmas, shock and detonation waves, thermophysics, chemical physics, space research, and electric power, as well as several other realms of physics and technology (including defense programs).

Fortov was president of the Russian Academy of Sciences (RAS) from 2013 to 2017, a full commander of the Order for Services to the Fatherland, a courageous citizen, and a man with an open heart. January 23, 2021 would have been his 75th birthday.

It was not to be. Vladimir Evgen'evich passed away on November 29, 2020. His mighty body, strong by nature, could not cope with consequences of COVID. And it seemed to all those who knew Vladimir Evgen'evich that no obstacle existed in the world that he could not surmount.

Fortov was born in the town of Noginsk, Moscow Region less than a year after the victory in the Great Patriotic War into the family of air force engineer-lieutenant colonel Evgenii Viktorovich and school teacher Galina Ivanovna Fortov. Inspired by heroic feats of their parents' generation, children in those times aspired to grandiose deeds. Vladimir's childhood and school years were spent near a military airfield (because of his father's profession), which could not but have influenced the course of his life. In 1962, on finishing school at age 16, he enrolled in the Department of Aerophysics and Space Research of the Moscow Institute of Physics and Technology (MIPT), where stars of Russian science were teaching and whom Vladimir Evgen'evich always remembered with deep respect and gratitude. While still a second-year student, Vladimir began his research work in the primary department of the Scientific Research Institute of Thermal Processes (now the M V Keldysh State Research Center) under the supervision of V M Ievlev, a corresponding member of the USSR Academy of Sciences. In 1968, V E Fortov graduated from the institute with distinction in Thermodynamics and Aerodynamics and became a post-graduate student at the MIPT Department of Physical mechanics. In 1971, he defended his candidate thesis, entitled "Thermophysics of Nuclear Rocket Engines", ahead of schedule, and was to be sent to work in the far east.

However, a fortuitous meeting with academician Ya B Zel'dovich, who had listened closely to V E Fortov's talk at a conference, radically changed the life of the young scientist: Yakov Borisovich put in a good word about him to the Nobel Prize winner N N Semenov. And so, in 1971, with Ya B Zel'dovich's magic touch, Fortov began working in the Chernogolovka Branch of the Institute of Chemical Physics of the USSR Academy of Sciences. There, he engaged in investigations in the field of nonideal plasma physics and extreme states of matter. The results underlay his doctoral thesis, "Nonideal Plasma Investigations Using Dynamic Methods," which he defended in 1976, only five years after he started his research. This subject remained at the center of Fortov's attention his whole life.

Vladimir Evgen'evich Fortov
(23.01.1946 – 29.11.2020)

V E Fortov was deeply involved in studies of the mechanics of deformation and damage to materials at high pressures and temperatures, as well as at high deformation rates. Beginning in the 1980s, he supervised experimental and theoretical research into the mechanical properties of materials and damaging elements, barriers, and structures of special hardware.

When in the early 1980s a team of scientists headed by academician R Z Sagdeev started implementing the Vega International Space Program aimed at studying Halley's comet, Fortov's experience, gained in the investigation of high-speed impact, came to be in great demand. The protection of the Vega spacecraft from meteorites and a system of dust impact analyzers successfully fulfilled their task, and the computer codes used then were later adapted for studying the problem of asteroid hazards. So, in early 1994, the team

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headed by Fortov made a detailed prediction of possible observable consequences of an extraordinary space event: the collision of the Shoemaker–Levy comet with Jupiter in July 1994. The data of subsequent observations carried out by many observatories around the world confirmed the high accuracy of these predictions. Analogous work was performed in 2005 in connection with the Deep Impact Project, a space experiment in which pioneering observations were made of a high-velocity collision of a metal striker with the nucleus of the 9P/Tempel comet.

For many years, Fortov actively cooperated with the General Physics Institute (GPI) and the Institute for High Temperatures (IHT) of the USSR Academy of Sciences, which were then headed by Academicians A M Prokhorov and A E Sheindlin. Experiments on the pulsed laser irradiation of targets, which were performed at GPI, permitted verifying computational and physical models at megabar pressures typical of hypersonic collisions with high-velocity meteorites. To this end, railotron electrodynamic accelerators and explosion generators of high-power shock waves were made at IHT.

On V E Fortov's initiative, research in the area of high-temperature thermophysics was launched at IHT beginning in 1986. Large-scale experimental facilities were constructed to produce high-pulsed pressures and temperatures; the 13Ya3 spherical explosion chamber was built, which was the world's largest and a unique technical structure. High-power shock-wave generators and experimental techniques of studying the physical properties of matter under extreme conditions elaborated with the use of explosions, as well as lasers and relativistic electron and ion beams, permitted constructing wide-range semiempirical equations of state for a large number of chemical elements and structural materials employed in the design of new technical equipment. These series of investigations continued successfully at the Joint Institute for High Temperatures (JIHT) of RAS, which Fortov headed in 2007.

Fortov proposed that electron and ion beams, as well as soft X-ray radiation, be used to solve special problems. At the Division of the Institute of Chemical Physics (ICP), a facility was constructed where explosion magnetic generators were employed in 1987 to produce the first multimegawatt microwave radiation pulses. In cooperation with the St. Petersburg school of Nobel Laureate academician Zh I Alferov and the school of academician G A Mesyats, gigawatt sources of harmonic centimeter radiation were made, new data were obtained concerning the resistance of electronics to high-power electromagnetic radiation, and extensive work was carried out in special-purpose research areas, including those related to the development of next-generation rocket and defense technologies and antiterrorist equipment.

V E Fortov's research work promoted the creation of specimens of nuclear missile armaments of the 21st century to guarantee the defense capacity of our country and retention of the geopolitical role of Russia as one of the leaders determining world politics in the coming decades.

Another impressive line of V E Fortov's research was highly nonideal dust plasma. He supervised a series of pioneering experimental investigations into the structural and dynamic properties of plasma-dust crystals and liquids over a broad temperature and pressure range. For the first time, plasma crystals and liquids were obtained in a glow discharge, thermal plasmas, UV-radiation plasma, and radioactive and cryogenic plasmas; a series of impressive 'plasma crystal' experiments examining plasma crystallization were performed aboard the Mir space station and the International Space Station.

Vladimir Evgen'evich took an active part in extreme expeditions. In May 2005, Fortov participated in a cruise aboard the Volk atomic submarine; in 2007, he participated in the High-Latitude Arctic Deep-Sea Expedition to the North Pole; in 2008 (in the framework of the International Polar Year Program), he took part in the International Antarctic Expedition to the South Pole and the Pole of Relative Inaccessibility; in 2010, he descended to the depths of Lake Baikal and Lake Leman (Switzerland); and in 2014, he visited the Vostok Polar Station in the Antarctic. Fortov was a prize winner of the USSR championship in yachting, rounding Cape Horn and the Cape of Good Hope on a yacht and crossing the Atlantic Ocean on a sailing yacht. He was keen on alpine skiing, tennis, piloting, chess, and mountaineering.

Both the scientific and life experience of Vladimir Evgen'evich in extreme situations was in demand in examining the causes and consequences of anthropogenic catastrophes. In 1988, Fortov visited the Chernobyl nuclear power plant as a member of a workgroup of the USSR Academy of Sciences formed to estimate the impact of the accident. In 2009, he was a member of the committee appointed to investigate the disaster at the Sayano-Shushenskaya hydropower plant.

Vladimir Evgen'evich did scientific-organizational work and was engaged in public activity for many years. V E Fortov's promotion to senior academic and public positions came during the hard years for Russian science, which followed the disintegration of the USSR. V E Fortov made all possible (and impossible) efforts to slow down negative processes. In 1993, he was appointed the First Chair of the Russian Foundation for Basic Research (RFBR). Worked out at the Foundation was the first Russian grant system based on independent expertise. According to a pointed remark of one of the grant winners, "in the 'evil' 1990s, these RFBR grants were like social cards for bread in the Leningrad blockade for quite unadapted scientists thrown into market relations." These grants helped to retain scientific schools and to support Russian scientists. While the Chair of RFBR, he increased its financing threefold. These steps were quite timely and necessary for Russian science. Many people remember them with gratitude.

From 1996 to 1998, Fortov was Deputy Chair of the Russian Government, Chair of the State Committee on Science and Technology, and Minister of Science and Technology of Russia. Adopted during this period were the Law on Science and Scientific-Technical Policy of the RF, the Strategy of Science and Technology Development of the RF, and several other state documents aimed at protecting and maintaining the scientific-technical network of the country. The key points of these documents (a 4% budget allocation for science from GDP, the status of the Academy of Sciences, the property of scientific institutions, a land tax, equipment, support for state science centers, etc.) played a stabilizing role for domestic science. During V E Fortov's work in the government, the financing of science was increased 1.8 times and the financing of the RAS 2.2 times, with a 17% to 23% increase in the proportion of the RAS in the science budget of the country.

Together with academicians A V Gaponov-Grekhov, V E Zakharov, and V P Skulachev, Fortov proposed and implemented a special program for the Support of Scientific

Schools and Prominent Scientists in Russia. Many thousands of scientists in the country received material support. International scientific and technical cooperation broadened, and the exchange of scientific instruments and equipment was simplified by abolishing taxes and customs duties.

In 1987, V E Fortov was elected corresponding member of the USSR Academy of Sciences, and in 1991 full member of RAS. From 1996 to 2001, he was RAS vice-president.

From 2001 through 2013, and from 2017 to the end of his life, V E Fortov was academician-secretary of the Division of Power Engineering, Machine Building, Mechanics, and Control Processes of the RAS.

The Russian Academy of Sciences took an active part in developing and adopting the energy strategy of Russia, signing a large-scale agreement concerning collaboration in science and technology in the field of the traditional and future energy industry of the country. Prepared and signed was an agreement in cooperation between Rosatom and RAS in a wide spectrum of fundamental and applied work, with a view to foster the accelerated development of nuclear energy in Russia.

Fortov was elected a full member of the European Academy of Sciences (1998), the Max Planck Research Society (Germany, 2000), the Royal Academy of Engineers of Great Britain (2003), the Royal Academy of Engineers of Sweden (2004), the Norwegian Scientific Academy for Polar Research (2009), the Royal Academy of Engineering of Spain (2013), the European Academy of Sciences and Arts (2014), and the European Foundation for the Support of Innovation; a foreign associate of the National Academy of Engineering of USA (2002), the Georgian National Academy of Sciences (2002), the National Academy of Sciences of USA (2014), the National Academy of Sciences of the Republic of Kazakhstan (2015); an honorary member of the American Physical Society, USA (2001) and the Russian Academy of Missile and Artillery Sciences (2016); and an honorary doctor and professor of many universities around the world.

Fortov's high international authority facilitated the development of large-scale international projects, such as the construction of the Facility for Antiproton and Ion Research (FAIR) — a new international research center, the largest in the world, being constructed in Darmstadt (Germany). Alas, the project will be completed without Vladimir Evgen'evich.

V E Fortov devoted considerable attention to work at the Department of Physics of High-Temperature Processes of his native MIPT. He was a supervisor of 14 doctoral and more than 40 candidate's theses, and 8 of his pupils were elected members of the RAS. In 2010, in recognition of their pedagogical merits, Fortov and his colleagues were awarded the RF Government Prize in the field of education.

V E Fortov and his colleagues issued more than 30 monographs and over 800 original papers in leading foreign and Russian journals. In the journal *Uspekhi Fizicheskikh Nauk* (*UFN*) (*Physics–Uspekhi*) alone, Vladimir Evgen'evich published over 28 extensive reviews that annually bring about a hundred UFN citations.

V E Fortov was deputy chair of the Council on Science and Education under the RF President, the chair of several interdepartmental coordination councils and scientific councils of the RAS, and a member of the Research Advisory Board under the UN General Secretary and several other domestic and foreign councils and committees. Fortov was editor-in-chief of five Russian journals and a member of editorial boards of several foreign and domestic publications.

For his scientific and organizational activities, V E Fortov was decorated with many international and Russian awards and prizes. A mere list of them would take more than one page.

In May 2013, on the eave of the beginning of a hard period for the Russian scientific community, Vladimir Evgen'evich Fortov was elected president of the Russian Academy of Sciences. In this office, he had to solve the grave problems of upholding the survival of Russian science in the course of radical painful transformations and to strive to heighten the role and authority of RAS under new conditions. His numerous papers and addresses in the mass media and a highly principled stand facilitated a successful navigation of the academy's ship and the whole scientific community through storms and reefs in this dramatic period in the history of Russian science.

A brilliant scientist, an outstanding leader, a talented pedagogue, a man of highest moral principles and personal courage, Vladimir Evgen'evich Fortov was and will always be for us an example of whole-hearted service to science. He will remain in our memory forever in his scientific heritage, in his pupils, and in his attitude to work and science. In his endeavor to state and solve impossible problems, he will remain in Russian science as a scientist who would not only develop new fields and solve important problems, but also as a statesman to whose lot fell the hardest years of managing the Russian Academy of Sciences.

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G A Mesyats, L P Pitaevskii, V A Rubakov,
O V Rudenko, G N Rykovanov, A M Sergeev,
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