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PERSONALIA

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Vladimir Evgen'evich Fortov (on his sixtieth birthday)

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Professor Vladimir Evgen'evich Fortov, Full Member of the Russian Academy of Sciences (RAS), an outstanding scientist who has made important contributions to progress in the physics of high energy densities and nonideal plasmas and to the physics and mechanics of shock and detonation waves, was born on 23 January 1946 in Noginsk, a town in the Moscow region. In 1962, he enrolled in the Department of Aerophysics and Space Research of the Moscow Physical-Technical Institute (MFTI, now Moscow Institute of Physics and Technology — MIPT) where he began his research work under the guidance of V M Ievlev, USSR AS Corresponding Member, while still an MFTI sophomore. Ahead of schedule Fortov defended his final year degree thesis devoted to solving the Fermi – Zel'dovich thermodynamic problem and after graduating *cum laude* became a postgraduate at the chair of physical mechanics. In 1971, he defended his thesis for Candidate of Physicomathematical Sciences that dealt with special aspects of the research into high-power shock waves and nonideal plasma, the research he had begun in his final year degree thesis.

After defending his candidate thesis, Academician Ya B Zel'dovich suggested that Academician N N Semenov invite Fortov to work in the Chernogolovka affiliate of the Institute of Chemical Physics (ICP) of the USSR Academy of Sciences; here Fortov was able to use the powerful experimental explosion equipment of the ICP affiliate for studying thermophysical properties of dense shock-compressed plasmas and the extreme states of matter. These results formed the basis of Fortov's thesis for Doctorate of Physicomathematical Sciences devoted to the dynamic physics of nonideal plasmas (1976). This was a time of commencement of his close cooperation with Lev Vladimirovich Al'tshuler who became Fortov's mentor and friend for many years to come.

In parallel with the plasma research, Fortov was actively studying thermomechanical, kinetic and strength characteristics of materials subjected to shock-wave loading. The emphasis was on searching for and studying novel mechanisms of deformation and destruction produced in materials at high rates of load application and raised levels of dynamic stress. Experience and abundant data accumulated when studying high-speed shock processes proved to be invaluable at the beginning of the 1980s when a team of scientists lead by Academician R Z Sagdeev joined the Vega International Space Program aimed at studying Halley's Comet. The Vega spacecraft crossed the dust cloud of the comet with a relative velocity of 80 km s^{-1}. In view of very high collision velocities, the requirements for the shielding were extremely demanding. The developed dust shield of the Vega probes, as well as a complex of dust-bombardment scientific instruments, functioned quite successfully. Another type of work on studying shock phenomena concerned defense programs in which

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Fortov, together with the Novosibirsk and Tomsk schools of mechanics, conducted experimental and theoretical investigations of protective properties of various armors and hitting elements, as well as obstacles and constructions concerned with special facilities, beginning in the mid-1980s.

Finding successful solutions to these problems was substantially facilitated by the active cooperation that Fortov established with the General Physics Institute (IOFAN) and the Institute for High Temperatures (IVTAN) of the USSR Academy of Sciences, headed by Academicians A M Prokhorov and A E Sheindlin, respectively. Experiments conducted at the IOFAN on the impact of pulsed laser beams striking targets made it possible to test models of the processes at pressures up to 10 Mbar that are typical of realistic collisions with high-speed micrometeors in space. Electrodynamic rail accelerators were built at IVTAN with a typical projectile mass of up to 1 g and with a throwing velocity up to 7.5 km s^{-1}.

In the 1980s, Fortov turned to the problem of conversion of explosion energy into electromagnetic radiant energy. A special facility was built at the ICP department and the first multimegawatt pulses of microwave radiation were generated there in 1987 by a magnetic explosion generator.

In 1986, Fortov initiated studies at the IVTAN into high-temperature thermal physics, designing and building of large-scale test benches for implementing high pulsed pressures and temperatures — explosion chambers for a mass of explosives up to 1000 kg, capacitor batteries for currents up to 10 MA, magnetic explosion generators for the megavolt range of voltages and power on the order of 10 GW. Used together with shock-wave pulsed-pressure generators of the RAS Institute of Problems of Chemical Physics, these test benches made it possible to conduct a wide range of fundamental and applications-oriented studies of properties of materials under extreme conditions. Wide-range equations of state were developed for more than 200 materials (both chemical elements and compounds) and were successfully used for modeling high-velocity collisions of solid bodies, action of intense laser and X-ray radiation, electron and ion beams striking solid targets, and so forth. To study the destruction caused by loads applied for nano- and subnanosecond intervals of time, laser and beam shock-wave generators were applied. The most important results obtained for brittle materials are connected with the discovery of failure waves generated under shock compression, which provide an example of nonlocal response of a material to loading. A spherical explosion chamber 13Ya3 was designed and installed at IVTAN — the largest in the world and having unique parameters. At the present moment, the Moscow Regional Joint-Use Explosion Center (TsKP) of the RAS is being created, based on this chamber and on a number of other facilities at the Institute of Thermal Physics of Extreme States (ITES) of the RAS Joint Institute for High Temperatures (OIVT).

"...Fortov is unique, in the sense of P W Bridgman, in having created an entirely new field of physics — the physics of dense plasmas", wrote the American scientist R N Keeler, who proposed Fortov's candidacy for the P W Bridgman Award, remarking that "...Fortov has been the first researcher in the high-pressure field since Bridgman to create an entirely new field for himself — the field of dense plasmas. No one had even come near reaching the states he began to achieve in a routine manner. With these new techniques, he was able to reach temperatures several eV, and 1 g cm^{-3}... Perhaps diamond anvil technology is comparable although this technology was the work of many."

Fortov's achievements in thermal physics and thermal mechanics of extremely high pressures and temperatures were rewarded by his election to Corresponding Member of the USSR Academy of Sciences in 1987, and as Full Member of the RAS in 1991.

At the beginning of the 1990s, Fortov, together with Academicians E P Velikhov and V P Smirnov, initiated a novel area of research at the 'Angara-5-1' facility, connected with the excitation of shock and heat waves in solid targets bombarded by an intense flux of soft X-ray radiation. Fortov also suggested a number of possible applications of electron beams and soft X-ray radiation for solving special problems.

Using large-scale electrophysical facilities allowed Fortov to expand research to the effects of electromagnetic radiation on electronic control systems and on actuating components. In collaboration with St.-Petersburg school of Nobel Prize Winner in Physics Academician Zh I Alferov and the school of Academician G A Mesyats, gigawatt emitters of harmonic oscillations in the centimeter wavelength range were designed, and new data were obtained on the stability of electronic devices exposed to external radiation.

From the late 1990s, Fortov began working on methods of generation of extreme states of matter and on studying them using high-power femto- and picosecond laser pulses. In 2002, a femtosecond terawatt infrared-range laser system was built at the TsKP 'Laser femtosecond facility' of the RAS ITES OIVT; the laser system was based on the chromium – forsterite active element. The TsKP is equipped with modern diagnostic tools and is actively involved in studying thermodynamic and kinetic properties of matter under extreme conditions.

Another part of Fortov's activities has been the study of plasma crystals and plasma liquids in dusty plasmas both in laboratory conditions and in the microgravity environment on-board the orbital Mir space station and the International Space Station. These largely pioneering studies are conducted in a wide range of temperatures and pressures — in glow discharge dc plasmas and in high-frequency low-pressure discharge at room and cryogenic temperatures, in plasmas excited by nuclear reactions and in plasmas induced by ultraviolet radiation, in beam plasmas, and in thermal plasmas at atmospheric pressure. The research initiated by the ITES also involved the Russian Federation State Research Center 'Physics and Energy Institute' (in the town of Obninsk) and the Troitsk Institute of Innovative and Thermonuclear Technologies, The Russian Research Centre 'Kurchatov Institute', The Rocket and Space Corporation 'Energiya', Rosaviakosmos, the Yu A Gagarin Center of Astronaut Training, the Flight Control Center, the German Space Agency, and the Max Planck Institute for Extraterrestrial Physics. The Plasma Crystal-3 experiment gives an example of extensive international cooperation.

Ever since the Vega project, space research has occupied an important place in Fortov's work. Computer codes that had been written earlier for simulating high-velocity collisions were adapted to dealing with problems of the asteroid collision threat and were used to analyze the collision of the Shoemaker – Levy comet with Jupiter. The data of subsequent observations conducted by many observatories around the world confirmed the theoretical predictions. Similar work was carried out in 2005 in connection with the project Deep Impact — a space experiment in which a high-velocity collision between a metal projectile and a cometary nucleus was observed for the first time.

Fortov has paid great attention to training new generations of scientists. He is Head of the Chair of High-Temperature Physics Processes at the MFTI. He has acted as science supervisor to eleven doctorate and more than 30 candidate theses.

Fortov and his colleagues have written and published 16 monographs and more than 300 original papers in leading journals both in this country and abroad. He received the International A P Karpinskii-Topfer Scientific Award for Physics and Chemistry (1997), the P W Bridgman Award for High Pressure Plasma Investigations and Achievements in High Pressure Physics and Chemistry (1999), the Max Planck Award for Physics (2002), The Hannes Alfven Prize of the European Physical Society (2003), the G E Duvall Prize (2005), and the Albert Einstein Gold Medal for Physics (2005); he has been elected a member of numerous foreign and international academies and universities, and chairs the UNESCO International Basic Sciences Programme.

Fortov was appointed to high academic and state positions in the years of collapse of the former USSR, particularly hard times for sciences in Russia, where he did everything possible to slow down the negative processes. Under his guidance, the Russian Foundation for Basic Research became the first ever Russian institution that adopted the procedures of independent expert assessment — a form quite new for science in Russia. In his capacities as Vice Prime Minister of the Government of the Russian Federation (namely Chairman of the RF State Committee for Science, Policies in Science and Technology, and Technologies, Minister of Science and Technologies of the Russian Federation, RAS Vice-President, and member of the RF Presidential Council on Science and High Technologies), V E Fortov has achieved much good for the preservation and advancement of science in this country. His numerous press interviews and articles in the media and his uncompromising high-principled attitude have greatly helped strengthen the position of Russian science and uphold its survival in times of radical change. He was able to implement several large-scale projects that were decisive for science as a whole. For instance, he actively participated in creating the MVS 1000M Supercomputer running at 1 TFlop per second.

Fortov was awarded the Russian 'Order of Merit for the Country' of Fourth Class (1996) and Third Class (1999), and The Order of the Red Banner of Labor (1986), as well as a number of medals. He received the USSR State Prize (1988) and the RF State Prize (1997), as well as Prizes of the RF Government (1997, 1999, 2002).

At the present time Fortov is the Academician-Secretary of the RAS Division of Energy Production, Machinery Construction, Mechanics and Control Processes, and a member of the RAS Presidium. He chairs a number of interdepartmental coordination councils and RAS science councils, is Editor-in-Chief of the *High Temperature Thermal Physics* journal and the member of the editorial boards of *Physics – Uspekhi* and a number of other scientific publications in this country and abroad.

On his 60th birthday, we wish Vladimir Evgen'evich Fortov many happy returns, good health, much happiness, and new achievements.

Zh I Alferov, A F Andreev, S I Anisimov,
A A Boyarchuk, V L Ginzburg, V E Zakharov,
V V Kostyuk, G A Mesyats, O N Favorskii,
L D Faddeev, K V Frolov, A E Sheindlin