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PERSONALIA

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In memory of Fedor Vasil'evich Bunkin

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An outstanding physicist and organizer of Soviet and Russian science, a brilliant representative of the Russian school of radio physics and quantum electronics, Academician Fedor Vasil'evich Bunkin, passed away on May 6, 2016 at the age of 87. The fundamental work of F V Bunkin helped to develop the ideas of this school in the new directions of laser physics, nonlinear optics and acoustics, remote sensing of the atmosphere and ocean, and condensed matter physics.

Fedor Vasil'evich was born on January 17, 1929 in the village of Aksin'ino (now the Khimki–Khovrino residential district of Moscow). Having finished a seven-year school and the road-transport technical school he passed in 1946 examinations as an external schoolboy, received matriculation and then entered the Heating Engineering Faculty of Moscow Power Engineering Institute. In 1947, he transferred to Moscow State University as a second-year student of the Physical and Technical Faculty (later transformed into the Moscow Institute of Physics and Technology (MIPT)). In 1952, he received the diploma of radio physics engineer and was accepted into the postgraduate course of the P N Lebedev Physical Institute of the USSR Academy of Sciences (FIAN).

While a student, Fedor Bunkin began his scientific work at the FIAN Laboratory of Oscillations. All his subsequent activity was connected with the A M Prokhorov Institute of General Physics of RAS (IOFAN), where scientific groups of a wide range of specializations were united around this legendary Laboratory.

F V Bunkin's scientific style, characterized by deep theoretical approaches in intimate and obligatory relation to experiment and applied aspects, was formed already at the early stage of his scientific activity (1949–1964). He thought that the high level of his theoretical and general physical background was due to the followers of the school of L I Mandelstam — M A Leontovich, S M Rytov, and G S Gorelik — who were then working at the Laboratory. Fedor Vasil'evich's work on statistical radio physics under the guidance of his teacher S M Rytov continued in the formulation of the theory of thermal radiation of anisotropic media and in the solution of general problems of the theory of fluctuations in nonlinear and nonequilibrium physical systems. Fedor Vasil'evich used the results of this work for the defense of his Candidate (1955) and then Doctoral (1964) theses.

In the mid-1960s, laser physics became a preemptive area of F V Bunkin's scientific interests. After that time, the many-year collaboration with A M Prokhorov, whom Fedor Vasil'evich thought of as his second teacher, ensued.

The first stage of his research work in this area was devoted to the formulation of the theory of the effects, induced by a strong optical field, of atomic ionization, molecular dissociation, cold electron emission, and bremsstrahlung. These classical studies carried out in co-authorship with A M Prokhorov and researchers at the Laboratory of Oscillations were almost immediately confirmed experimentally. The phenomena of laser discharge in the regime of cold combustion and low-threshold optical breakdown of gases near a solid surface were theoretically predicted and examined experimentally, and proposals were made on employing laser technology in the defense industry off-the-shelf. The most active period of F V Bunkin's studies on the interaction of laser radiation with substances is associated with the realization of these proposals in the substantial work on a defense order implemented in cooperation with the A A Raspletin Almaz design bureau. Fedor Vasil'evich's task was to provide, under the general guidance of A M Prokhorov, the theoretical groundwork of the studies of a large team of experimentalists.

Fedor Vasil'evich Bunkin
(17.01.1929 – 06.05.2016)

From the late 1970s, Fedor Vasil'evich sharply broadened the range of his scientific interests, turning, with the support of A M Prokhorov and A V Gaponov-Grekhov, to subjects (new to himself and IOFAN) that included laser and acoustic probing of the ocean and nonlinear ultrasonics. The path to these subjects was paved by the theoretical and experimental work by F V Bunkin and his colleagues engaged in laser excitation of sound in a liquid.

Expeditions studying the distant propagation of low-frequency sound in the Barents Sea were organized under

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his guidance. Experiments with stationary acoustic paths were conducted and interpreted there using new theoretical models. These experiments allowed measuring the effects of tidal streams and internal waves on the fluctuations of probing signals. In this and some other sea water areas, experiments on the radar and laser probing of the ocean surface layer from aircraft and ships were performed.

To develop work on solving the general problem of monitoring the large-scale Russian ocean shelf, F V Bunkin, together with the researchers of the IOFAN Wave Research Center (WRC), founded by him, formed a scientific-design subdivision of hydroacoustics by the end of the 1990s. This subdivision, headed by F V Bunkin and in wide cooperation with a number of production plants and research institutes, worked out the technical means for acoustic diagnostics of sea water areas and provided implementation of state defense orders. The evaluation of the fundamental and applied significance of the hydrophysical studies conducted at WRC was the decision of the RAS Presidium and the General Staff of the Navy, according to which WRC was entrusted with the scientific guidance and maintenance after 2000 of one of the basic areas of special work intended for the Russian Navy.

The use of nonlinear optical analogies resulted in the prediction and experimental discovery by F V Bunkin and his colleagues of new effects in physical acoustics. First and foremost, it was the parametric phase conjugation (PC) of ultrasonic beams. Studies of the wide range of experimental PC schemes and methods to develop magnetic materials ended in the creation of a unique ultrasonic PC apparatus with a giant amplification and with prospects of application in medicine. The theoretical and experimental studies of high-power ultrasound propagation in viscous liquids revealed new effects of wave packet self-compression supplemented with thermal ultrasonic 'self-bleaching'. The analysis of the physical mechanisms underlying these effects became the basis for working out new applications in high-contrast acoustoscopy and ultrasonic biomedical technologies.

From the mid-1970s, Fedor Vasil'evich actively developed new ideas of employing the methods of light impact on a substance in condensed matter physics. In pioneering work on these subjects, he formulated and justified the opto-thermodynamic approach to the problems of laser monitoring of the phase state of condensed media.

Within this range of ideas, F V Bunkin and his colleagues theoretically predicted and experimentally examined the effects of light-induced critical opalescence, the concentration self-action of light and light-induced spinodal decay in layering liquid solutions. The elaboration of the principles of selective laser monitoring of chemical reactions was the basis of the new scientific area, namely, laser thermochemistry, now being developed by many physical, chemical, and materials science laboratories. In the context of this trend, researchers at WRC continue investigations, whose prospects of technological applications are associated with the effect of ablation formation of metallic nanoparticles and surface nanostructures under controlled lasing.

Starting the mid-1990s, F V Bunkin's scientific interests were concentrated on the physics of water and water solutions.

His own approaches in this sphere appeared, on the one hand, in studies the opto-thermodynamics of solutions, lidar diagnostics of the impurity composition of sea water, and nonlinear spectroscopy in a wide wavelength range. The original complex of equipment designed at WRC for four-photon polarization spectroscopy with high sensitivity in a wide and previously unexplored frequency shift range made it possible to reveal the allowed many-peak spectrum of low-frequency excitations of molecules and molecular complexes of water and water solutions.

On the other hand, on the basis of his theoretical investigations of laser gas discharges, Fedor Vasil'evich began in those years to formulate the theory of light-induced breakdown of transparent liquids. Sequential allowance for the effects of ionic composition and the concentration of dissolved gas and thermodynamic parameters on their structure and phase state allowed him to construct a fundamental theory of polar liquids in contact with a gas atmosphere. F V Bunkin's theory predicted that in such liquids nanobubbles of dissolved gas, whose stability is provided by ion absorption on their surface, are produced. The bubble production proceeds as a first-order quasi-equilibrium phase transition, and their existence is maintained by the competitive kinetics of the effects of aggregation and spontaneous origination of nanobubbles. The conclusions of the theory were also confirmed by direct observations using interferential microscopy methods.

Fedor Vasil'evich paid great attention to the organization of scientific research. While a Deputy Director of IOFAN and Professor at MIPT in the 1980s and 1990s, he formed and trained a highly qualified group of researchers for the Wave Research Center at IOFAN, which he founded in 1998. In collaboration with French colleagues, he initiated on the basis of WRC the establishment of the European Laboratory of Nonlinear Magnetoacoustics of Condensed Media.

In 1977–1992, F V Bunkin headed the Scientific Council of RAS on Coherent and Nonlinear Optics. For many years, he was Vice Chairman of the Scientific Council of RAS on the Complex Problem 'Hydrophysics', working out the scientific strategy of the development of the Russian Navy, and a member of the Scientific Council of RAS on Investigations in the Field of Defense. For many years, F V Bunkin headed the editorial boards of the Russian review journal *Fizika*, the journal *Physics of Wave Phenomena* (founded by him), the physical series of the journal *Izvestiya RAN* (*Bulletin of the RAS. Physics*), and *Akusticheskii Zhurnal* (*Acoustical Journal*), and was member of some editorial boards of some other physical journals.

F V Bunkin's contribution to the solution of fundamental and applied problems of modern physics was highly estimated by the State and the scientific community. He was awarded the State Prizes of the USSR (1982) and Russian Federation (1999), he was elected a Corresponding Member of the USSR Academy of Sciences (1976) and a Full Member of RAS (1992), was awarded the Orders of the Red Banner of Labor (1979), Friendship of the People (1985), ''For Merit to the Fatherland'' of the 4th degree (2000), and the Medal of Honor (2004). F V Bunkin's foreign colleagues marked his scientific achievements by granting the titles of Honorary Doctor of the University of Szeged (Hungary) and Honorary Professor of the University of Valenciennes (France).

In addition to his authorship of more than 300 scientific papers and several monographs and one of the most frequently cited Russian physicists, Fedor Vasil'evich was also a wise tutor. Students and followers of the scientific school of laser physics, acoustics and hydrophysics founded by him continue the research work which he fostered in many Russian and foreign laboratories. Among them there are

independent supervisors of research teams and innovative organizations.

The death of Fedor Vasil'evich Bunkin was a great loss for his colleagues and disciples. The bright memory of this prominent Scientist and Teacher will remain in their lives and work. His contemporaries will remember his classical scientific results, his brilliant ideas, and his style of thorough research work and democratic scientific guidance. His long and productive life will remain in their memories.

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V I Konov, O N Krokhin, G A Lyakhov, G A Mesyats,
V V Osiko, P P Pashinin, O V Rudenko,
G A Shafeev, I A Shcherbakov