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In memory of Robert Arnol'dovich Suris

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Robert Arnol'dovich Suris — a remarkable man and an outstanding scientist, whose research work made a considerable contribution to modern physics of semiconductors, semiconductor nanostructures, and solid-state electronics — passed away on May 14, 2024.

Robert Arnol'dovich Suris was born on December 31, 1936 in Moscow. Having graduated with honors from the Department of Physics and Chemistry of the Moscow Institute of Steel and Alloys with a degree in metal physics in 1960, he began working at the Pulsar Research Institute (Moscow). In 1964, he was transferred to the F V Lukin Research Institute of Physical Problems (Zelenograd, Moscow), where he worked for 24 years, having risen from a junior researcher to the head of the department. At the invitation of Zhores Ivanovich Alferov, since 1988 he worked at the Ioffe Institute (PTI); until 2018 as a head of the Sector of Theoretical Bases of Microelectronics. From 1993–1997, he combined this position with that of director of the Division of Solid-State Electronics of PTI.

In 1964, R A Suris defended his candidate thesis, in 1974, obtained his doctorate, and in 1982, was conferred the rank of professor. He was elected as a corresponding member of RAS in the Division of Physical Science (DPS) in 1997, and as a full member in 2006. Robert Arnol'dovich was a laureate of the 2001 State Prize of the Russian Federation, the 2002 Research Prize of the Humboldt Foundation, and the 1998 International Rank Prize Foundation. He was awarded the Order of Friendship, the Medal of the Order For Merits Before the Fatherland, II degree, and the Medal For Labor Distinction. He was a holder of many other awards.

Throughout his life, R A Suris tirelessly devoted a great amount of effort and time to teaching and training new researchers. During 1974–1988, he taught at the Moscow Institute of Physics and Technology at the basic Department of microelectronics of the Faculty of Physical and Quantum Electronics. From 1989–2012, he was a professor and head of the Department of Solid-State Physics of the Faculty of Physics and Technology at St. Petersburg Polytechnical University. Beginning in 2012, he was a professor and Head of the Department of Condensed Matter Physics at the National Research Academic University, which later received the name of its founder Zh I Alferov. Among Robert Arnol'dovich's students are over 20 candidates and 7 doctors of sciences.

R A Suris took an active part in scientific publishing. He was member of the editorial boards of the journals *Uspekhi Fizicheskikh Nauk* (*Physics-Uspekhi*), *Zhurnal Tekhnicheskoi Fiziki* (*Technical Physics*), *Mikroelektronika* (*Russian Microelectronics*), and — from 2008 to 2023 — editor-in-chief of the journal *Fizika i Tekhnika Poluprovodnikov* (*Semiconductors*). He was an active member of the Bureau of the Physical Sciences Division of the Russian Academy of Sciences (RAS), a member of the RAS councils on the problems of Physics of Semiconductors and Condensed Matter Physics, a member of the Bureau of the Council Quantum Technologies, chair of the dissertation council at A F Ioffe PTI, and a member of the Presidium of the St. Petersburg Division of RAS. He devotedly served science in all its complexity. His wisdom, indisputable authority, benevolence, and dedication to the ideals of science were indispensable in solving the difficult political problems of science.

Robert Arnol'dovich Suris
(31.12.1936–14.05.2024)

In recent years, R A Suris was a permanent chair of scientific sessions of the Physical Sciences Division (PSD) RAS. He managed to breathe new life into these meetings. A distinctive feature of the scientific sessions of PSD RAS guided by Robert Arnol'dovich was the precise choice of an acute scientific problem and a speaker, the liveliness of discussions initiated, if not provoked, by the chair of the scientific session. His authority and personal charm made it

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possible to invite as speakers both rather eminent specialists and bright young scientists, which brought the sessions of PSD RAS closer in spirit to V L Ginzburg's famous seminars.

R A Suris was a chair or a member of program committees of many Russian and international conferences, including the Russian Semiconductor Physics Conference and the annual conference Nanostructures: Physics and Technology, organized by the A F Ioffe Physical-Technical Institute and the Academic University. He gave talks many times at Russian and international conferences as an invited speaker. Robert Arnol'dovich was a charismatic speaker and a brilliant storyteller. His scientific (and not only scientific) speeches, accompanied, owing to his unique memory and broad scientific erudition, by both remarkable historical excursions and examples from parallel fields of science, were always remembered by the audience for a long time.

He took an active part in international research projects, particularly with colleagues from the University of Wurzburg and Technical Universities of Munich and Dortmund, leaving everywhere an indelible trace of the atmosphere of creative exploration and scientific excitement.

R A Suris's scientific activity was unusually rich. When a student, he submitted exams on the theoretical minimum to Landau and his students. This largely determined the breadth of his scientific horizon and interests: from fundamental problems of statistical physics and the theory of phase transitions to the theoretical bases of operation of semiconductor devices. R A Suris is widely known in Russia and abroad for his outstanding results in the field of solid state and semiconductor theory, semiconductor nanostructures, nano- and optoelectronics, the theory of solid-state devices, and microelectron technology. He was the author of over 300 scientific publications, widely cited in international scientific literature. RA Suris put forward a number of fundamental ideas that played a key role in semiconductor physics and in solid-state electronics. He was one of the pioneers in the theory of nano-heterostructures and devices based on them. The investigation of new phenomena predicted by him often became an independent branch of research. The results obtained by R A Suris were a stimulus for many experimental studies and technical designs. The ideas that he put forward underlay the development of new types of semiconductor lasers.

In 1971, he published (together with R F Kazarinov, who worked then at Ioffe PTI) a paper on the optical properties of special semiconductor periodic heterostructures, superlattices, predicting the possibility of laser generation in such a system. The work became famous and fostered the nomination of its authors for the Nobel Prize. This field of research and technology is now called quantum-cascade lasers. In 1994, such a quantum-cascade laser was successfully realized at Bell labs (USA). Cascade lasers operating in the infrared to terahertz ranges have many applications, including in medicine and ecology, monitoring of technological processes, security systems, and communication. For the invention of the cascade laser, R A Suris, together with colleagues from Bell labs (F Capasso, J Faist, and R Kazarinov), received the 1998 International Rank Prize for optoelectronics.

In 2000, Robert Arnol'dovich successfully developed the theory of semiconductor nanostructures with quantum-dot superlattices. Among the numerous brilliant results, one should note the idea of their use for generating weakly damped terahertz-range Bloch oscillations, based on a strong suppression of electron scattering in such systems, predicted by him. This provides new prospects of a sharp decrease in threshold currents of cascade lasers and a considerable increase in their temperature stability.

In 1972, R A Suris, together with R F Kazarinov, put forward an idea and developed the theory of the distributed feedback heterolaser — a key element of fiber-optic communication systems. In the 1990s, R A Suris, together with L V Asryan, formulated the theory of semiconductor injection lasers of a new generation — quantum dot lasers obtained by self-organization in the course of epithelial growth. This research was included in the series of studies that received the 2001 State Prize of the Russian Federation.

He formulated the theory of near-surface states in semiconductor heterostructures and developed it, together with V A Gergel, for metal–oxide–semiconductor (MOS) structures underlying silicon microelectronics. The term 'Gergel–Suris pools' for spatial fluctuations of charge carrier concentration in MOS structures came into lasting use among contemporary physicists.

R A Suris predicted and developed (together with B I Fuks) the theory of a previously unknown type of waves in charge carrier plasma in semiconductors — trap charge exchange waves. Such waves determine the dynamic properties of infrared-range impurity photodetectors and photorefractive media. He was at the head of the team that obtained important results in flicker-noise physics in epitaxial films of high-temperature semiconductors.

Specialists in microelectronic technology knew well Suris's results on the diffraction theory of image formation in the process of photolithography, which made it possible to overcome the then element size limits. Very popular was his book, *Optical Principles of Contact Photolithography*, written in 1982 together with G N Berezin and A V Nikitin. R A Suris also developed other important fields of physics and technology of condensed media, including the theory of epitaxial growth of heterostructures and the theory of fullerenes.

Together with his students and colleagues, Robert Arnol'dovich developed the theory of many-particle electron-hole complexes in nanostructures. The idea of the key role of correlation between a photoexcited trion and a hole in the Fermi sea of free charge carriers in doped quantum wells, suggested by R A Suris in 2001, was much before its time and was rediscovered again by foreign scientists examining correlated atomic systems. The term 'Suris tetron' denotes such a state, which has become very significant in the now rapidly developing physics of extremely two-dimensional semiconductors.

In recent years, R A Suris returned to the development of the theory of collective effects in exciton systems. As far back as the 1970s, he put forward (together with R F Kazarinov and V A Gergel) a number of important predictions concerning the optical properties of Bose–Einstein condensates of excitons in bulk semiconductors and the role of disorder in such systems. R A Suris proposed a model of crystallization of dipolar excitons in structures with quantum wells — the effect discovered in the studies of experimenters M Stern, V Umansky, and I Bar-Joseph from the Weizmann Institute in Israel. Until his last days, he worked actively on the theory of transport effects in exciton systems and the influence of disorder on elementary excitations in condensate of two-dimensional excitons. R A Suris's active interest was

also attracted by the fundamental problems of astrophysics and particle physics, and here he suggested original and important ideas for detection, which will find implementation in next-generation gamma-ray observatories.

R A Suris's activity was not limited only to his work. Back in the days, he was an almost professional diver and was fond of fishing and traveling. He was an enthusiastic automobilist who drove his Zhiguli around almost the entire Soviet Union. In his busy work schedule, Robert Arnol'dovich always found time for his family, caring for his wife Irina Mikhailovna, who was always nearby. His granddaughters adored him.

We will remember Robert Arnol'dovich forever as a great scientist with an unusually lively mind and broad erudition, a wise teacher and mentor, a caring colleague and a reliable friend, a man of deep decency, boundless goodwill, and exceptional fascination.

E B Aleksandrov, A G Zabrodskii, S V Ivanov,
E L Ivchenko, V V Kveder, Z F Krasil'nik,
G Ya Krasnikov, A G Litvak, O V Rudenko,
A I Rudskoi, M V Sadovskii, A V Chaplik