P N LEBEDEV PHYSICAL INSTITUTE — 75 YEARS

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P N Lebedev Physical Institute RAS: past, present, and future

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Contents

Abstract. **This paper reviews the history of the P N Lebedev Physical Institute of the Russian Academy of Sciences (FIAN in *Russ. abbr*.). Major achievements of FIAN scientists are discussed, current activities are described, and future prospects are outlined.**

1. Introduction. The Physical Cabinet

The P N Lebedev Physical Institute (FIAN) is Russia's oldest research center, the same age as the Russian Academy of Sciences (RAS); physics received full status as an independent science in Russia when the Academy was founded. For the entire 18th century, the Chair of Physics of the Academy was the only center of progress in physics in Russia. The Chair possessed a well-equipped Physical Cabinet to which all important experimental studies that were being conducted at the Academy at the time are related. The Physical Cabinet was also used to organize, under the auspices of the Academy, the first physics courses in Russia. The year 1724 (the year the Academy was founded) is officially regarded as the year of the foundation of the Physical Cabinet, while in fact its history began even earlier. The material basis of the Cabinet was the collection of various physical instruments, machines, and tools gathered in the Kunstkamera by the time it opened in Saint Petersburg in 1714; the exhibits were searched for and acquired on the instructions of Czar Peter I after his trip to Europe. Some instruments fabricated by Russian artisans also found their way into the Kunstkamera [1].

The following directors managed the Physical Cabinet (subsequently the Physical Laboratory and the Physical and Mathematical Institute) for nearly two centuries:

The building of the Kunstkamera (Saint Petersburg) created by Peter the Great in 1714, where the Physical Cabinet of the Petersburg Academy of Sciences was situated in 1724–1828.

The main building of the Academy of Sciences in Saint Petersburg. Its right wing housed the Physical Cabinet, then the Physical Laboratory, and even later the Physical Institute of the Academy of Sciences from 1828 to 1934.

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Bulfinger Georg Bernhard
(1726–1730)

Euler Leonhard
(1731–1733)

Kraft Georg Wolfgang
(1733–1744)

Richmann Georg Wilhelm
(1744–1753)

Parrot Georg Friedrich
(1828–1840)

Lenz Heinrich Friedrich Emil
(1840–1865)

von Jacobi Moritz Hermann (Boris Semenovich)
(1865–1874)

Wild Genrikh Ivanovich
(1874–1893)

Golitsyn Boris Borisovich
(1894–1916)

Lazarev Petr Petrovich
(1917–1921)

Steklov Vladimir Andreevich
(1921–1926)

Ioffe Abram Fedorovich
(1926–1928)

Directors of the Physical Cabinet of the Petersburg Academy of Sciences (1724–1912), Physical Laboratory of the Imperial Academy of Sciences (1912–1921), and Physical and Mathematical Institute of the Russian Academy of Sciences (1921–1934). Given in parentheses are the years of directorship of the Physical Cabinet (Physical Laboratory, Physical and Mathematical Institute of the Academy of Sciences).

1726–1730 Bulfinger Georg Bernhard,
1731–1733 Euler Leonhard,
1733–1744 Kraft Georg Wolfgang,
1744–1753 Richmann Georg Wilhelm,
1756–1771 Aepinus Franz Ulrich Theodor,
1771–1810 Kraft Wolfgang Ludvig,
1810–1828 Petrov Vasilii Vladimirovich,
1828–1840 Parrot Georg Friedrich,
1840–1865 Lenz Heinrich Friedrich Emil,
1865–1874 von Jacobi Moritz Hermann (Boris Semenovich),
1874–1893 Wild Genrikh Ivanovich,
1894–1916 Golitsyn Boris Borisovich,
1917–1921 Lazarev Petr Petrovich,
1921–1926 Steklov Vladimir Andreevich,
1926–1928 Ioffe Abram Fedorovich,
1928–1932 Krylov Aleksei Nikolaevich.

The Physical Cabinet was not always functioning and expanding smoothly. Years of growth (under Bulfinger, Kraft

Sr., Richmann, Parrot, Lenz, Jacobi, Wild, Golitsyn) were followed by years of decline (under Aepinus and Kraft Jr., and to some extent under Petrov) and again by new climbs. Whatever happened, the Physical Cabinet always remained the backbone that determined the progress of academic physics in Russia.

G F Parrot is remembered for his great contribution to the development of the Physical Cabinet. Having taken it over after V V Petrov, he carried out its vigorous reorganization and in 1828 succeeded in moving the Cabinet from the Kunstkamera to the main building of the Academy, where the Physical Cabinet, the Physical Laboratory that grew out of it, and then the Institute lived until the Academy moved to Moscow in 1934.

At the end of the 18th century to the beginning of the 19th century, with ever increasing attention physicists turned to electric phenomena, so it is no surprise that we find among the directors of the Physical Cabinet the names of scientists who are part of the history of the study of electricity: V V Petrov (electric arc), H F E Lenz (the Joule–Lenz law), M H Jacobi (galvanoplastics).

In 1894, the directorship of the Physical Cabinet passed to Academician B B Golitsyn, who in 1912 converted the Physical Cabinet into the Physical Laboratory, which existed until 1921. B B Golitsyn is the founder of Russian seismology, and developed the theory and design of seismological instruments. It was his achievement that seismology became an exact science. Golitsyn also worked on optics, molecular physics, and spectroscopy. He was the first to introduce the concept of temperature of thermal radiation (in 1893), verified experimentally the Doppler effect for light, studied the critical state of matter, and conducted a number of spectroscopic studies.

The period that followed the revolution of 1917 was not among the happiest for the Physical Laboratory of the Academy led by Academician P P Lazarev; in 1921, it merged with the Mathematical Cabinet of the Academy and formed the joint Physical and Mathematical Institute. The post of director was conferred on a well-known mathematician, Academician V A Steklov. The Institute consisted of three departments: Physics, Mathematics, and Seismology. The last two departments functioned quite successfully, but the Department of Physics, with its small staff and insufficient equipment, had to virtually stop physical experiments. In 1928, the Department of Seismology, the largest department of the three, separated into an independent institute, and the remaining two formed the Physical and Mathematical Institute under the directorship of Academician A N Krylov.

In 1932, the directorship of the Department of Physics passed to Academician S I Vavilov, a student of Academician P P Lazarev. The Department began to study the properties of just discovered neutrons, light emission from liquids exposed to ionizing radiation, the problem of coloring of crystals, the microstructure of liquids, electric breakdown in gases, and catalysts of chemical reactions. This was the period when the Institute added to its staff such brilliant physicists as G A Gamow, L V Mysovsky, N A Dobrotin, I M Frank, P A Cherenkov, L V Groshev, B M Vul, and some others. New equipment was acquired, and scientific seminars were

Academician Aleksei Nikolaevich Krylov (left), Director of the Physical and Mathematical Institute (FMI in *Russ. abbr.*) of the Academy of Sciences, 1928–1932, and Sergei Ivanovich Vavilov, Director of the Department of Physics of FMI after 1932, later the first Director of FIAN.

Petr Petrovich Lazarev (left) and Petr Nikolaevich Lebedev. It was precisely for P N Lebedev that the building for the Physical Institute of the Moscow Science Institute was erected on Miussy Square in 1912 (funded by voluntary donations); the last institute was created by the Kh S Ledentsov Society for the Promotion of Success of Experimental Sciences and Their Practical Applications (the society was officially opened on 24 February 1909) [2].

The building of FIAN in the Miussy district [3].

started. The Department was rapidly mastering the new physics and growing by leaps and bounds into the new efficient phase of its existence. It was during these years that an outstanding discovery was made of a phenomenon which became known as Vavilov–Cherenkov radiation. Its theoretical explanation was soon found by the future Academicians I E Tamm and I M Frank. The discovery was later awarded the Nobel Prize in Physics 1958.

The day of 28 April 1934 is regarded as the official date of the creation of the Physical Institute of the USSR Academy of Sciences (AS) when the general session of the USSR Academy of Sciences passed a resolution on splitting the Physical and Mathematical Institute into two: the Physical Institute and the Mathematical Institute. Soon, in summer 1934 both institutes were ordered by a decree of the USSR Government to move together with the Academy of Sciences to Moscow, and occupied the building on 3rd Miusskaya St., which had already been built in 1912 using donations for the laboratory headed by Petr Nikolaevich Lebedev. On 18 December 1934, the Physical Institute was named after P N Lebedev.

This completed more than 200 years of the evolution of a small section of the Kunstkamera, and the transformation of the Department of Physics of the Physical and Mathematical Institute of the Academy of Sciences to the Physical Institute that was begun by A N Krylov and completed by S I Vavilov. This event also symbolized the merger of the old Petersburg-style academic physics with the younger university physics of Moscow. It is proper also to mention here the friendship between B B Golitsyn and P N Lebedev, which began in their student days at Strasbourg University and continued until P N Lebedev's death. The new Physical Institute merged the traditions of the B B Golitsyn and P N Lebedev scientific schools. Academician S I Vavilov, a student of P P Lazarev (P N Lebedev's assistant and his closest co-worker), became head of the Institute. S I Vavilov can thus be regarded as P N Lebedev's "grandson-in-science".

When looking for co-workers, S I Vavilov invariably tried to find the most talented researchers; this created the right atmosphere for nurturing strong scientific schools in the future. Academician A N Krylov's joke is remembered in this connection: he had said that Sergei Ivanovich had been trying to invite to the Institute only colleagues who were stronger than himself.

S I Vavilov, P N Lebedev's "grandson-in-science", in the FIAN director's office, with P N Lebedev's instruments displayed there.

2. FIAN: the Soviet period

It was in fact in this period that the new history of the Physical Institute of the Academy of Sciences began; the Institute became known by its Russian abbreviation FIAN [1, 4]. Even though S I Vavilov specialized in physical optics, his span of interests was much wider. Thus, he recognized the importance of the physics of the atomic nucleus that was rapidly developing at the time, and clearly understood the need for supporting the "new physics" that had been born at the beginning of the 20th century — the theory of relativity and quantum mechanics. He also had no doubt that theory is as important to modern physics as experiment, and that these two parts of the physical science are inseparable.

S I Vavilov aimed to create a "polyphysical" institute which would combine the main avenues of modern physics dictated by the logic of the progress of science, and at the same time have a first-rate specialist heading each discipline. He discussed the future structure of the Physical Institute with his colleagues, first of all with L I Mandelstam, who taught at Moscow State University (MGU) and who was one of the first whom Vavilov invited to work at the Institute. S I Vavilov knew Moscow university physicists very well because he himself had long taught there as associate professor, and full professor and then held the Chair of General Physics.

In autumn 1934, the following appeared at FIAN: the Laboratory of the Atomic Nucleus headed by D V Skobeltsyn, which consisted of V I Veksler, S N Vernov, L V Groshev, N A Dobrotin, I M Frank, P A Cherenkov, and others; the Laboratory of the Physics of Oscillations headed by N D Papaleksi (A A Andronov, B A Vvedenskii, G S Gorelik, S M Rytov, P A Ryazin, E Ya Shchegolev, and others; the Laboratory of Physical Optics under G S Landsberg; the Laboratory of Luminescence under S I Vavilov (V V Antonov-Romanovskii, V L Levshin, M A Konstantinova, L A Tumerman, and others); the Laboratory of Spectral Analysis headed by S L Mandelshtam; the Laboratory of the Physics of Dielectrics headed by B M Vul; the Laboratory of Theoretical Physics headed by I E Tamm (D I Blokhintsev, V L Ginzburg, M A Markov, K V Nikolskii, E L Feinberg, V A Fock, and others), and the Laboratory of Acoustics headed by A A Andreev (S N Rzhevkin, L D Rozenberg, Yu M Sukharevskii, and others). In the pre-war years FIAN annually sent research parties to Elbrus mountain to observe cosmic rays and certain phenomena in atmospheric optics.

In July 1941, at the start of the Great Patriotic War, the Physical Institute moved from Moscow to Kazan and remained in the buildings of Kazan State University until the return in autumn 1943. Practically the entire work of the Institute dealt with the needs of the military. The Laboratory of Luminescence developed and brought to the industrial application stage luminescent compounds for aircraft dashboards and infrared binoculars for nighttime vision. The Laboratory of the Atomic Nucleus offered to the military equipment industry roentgenoscopic instruments for monitoring the valves of aircraft engines and gamma-ray thickness gauges for checking the quality of cannon barrels. The Laboratory of Dielectrics developed recipes for high-strength thermally stable ceramics for radio capacitors and transferred this technology to industry. The discovered new methods of metal coating of paper were also used by the industry to manufacture paper capacitors. FIAN's acoustics experts worked on the Black and Baltic seas disabling German contactless acoustic mines (by acoustic trawling and remote-

S I Vavilov with a group of students (1934). Sitting (left to right): V V Antonov–Romanovskii, S I Drabkina, S I Vavilov, A G Morozova, A K Timiryazev, (?). Standing (left to right): I M Frank, D I Blokhintsev, I P Tsyrg, M A Markov, L N Katsaurov, M M Melankholin, (?), (?).

A group of FIAN's scientists (1945). *1* — V L Ginzburg, *2* — F S Baryshanskaya, *3* — I M Frank, *4* — L L Benguerel, *5* — G S Landsberg, *6* — S L Mandelshtam, *7* — S Z Belenkii, *8* — K I Alekseeva, *9* — N S Ivanova, *10* — G P Motulevich, *11* — I L Fabelinskii, *12* — P A Cherenkov, *13* — P A Bazhulin, *14* — Z I Katsaurova, *15* — V I Malyshev, *16* — B L Belousov, *17* — I Veshneva-Bell, *18* — L N Bell, *19* — R I Sapegina, *20* — Trefan, *21* — A A Cherepnev, *22* — N A Dobrotin, *23* — ?, *24* — A A Shubin, *25* — E L Feinberg, *26* — Kh E Sterin, *27* — M A Markov, *28* — M N Alentsev, *29* — M V Danilova, *30* — T Globina.

control detonation of acoustic mines). FIAN's physics theoreticians developed an electrodynamic theory of layered magnetic antenna cores and the theory of propagation of radio waves along the real surface of Earth, which made it possible to execute high-precision location of ground and above-water objects. Methods of direction-finding for submarine hunting were radically improved. Oscillation specialists designed new types of highly sensitive aircraft antennas. The Laboratory of Optics passed on to metallurgical, aircraft, and tank plants new express techniques and portable instruments for the spectral analysis of the composition of steels and alloys. Furthermore, methods of testing the quality of gasolines based on Raman scattering of light were developed and transferred to industrial plants. Hospitals received a new stereoscopic device for analyzing X-ray images.

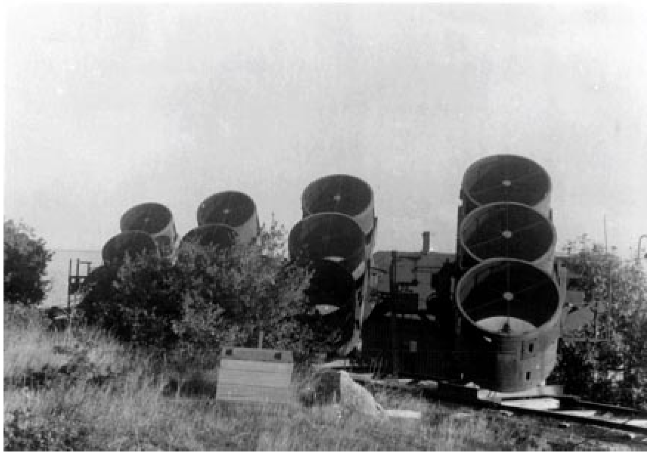
The return of FIAN to Moscow in the autumn of 1943 signaled also a return from military-oriented tasks to nonmilitary fundamental research. The theoretical seminar chaired by I E Tamm resumed its regular sessions. In 1944, V I Veksler suggested, and E L Feinberg provided the theoretical foundation for, the principle of phase stability of accelerated relativistic charged particles, which made possible the creation of modern high-energy accelerators. In that period, particle acceleration became FIAN's main 'growth point'. Electron synchrotrons with energies of 30 MeV (1947) and then 250 MeV (1949) were launched one after another, and then a proton accelerator of 180 MeV (1953), which served as a model for the future Dubna 10-GeV synchrophasotron and was somewhat later (1959) transformed into a 680-MeV electron synchrotron, was established. After this, intense studies were undertaken into photonuclear and photomeson processes.

Experiments with cosmic rays, which at the time were the only source of very-high-energy particles, were also being continued. The importance of such studies became greater in view of the Soviet Atomic Project. The first expedition to the Pamir Mountains under the leadership of V I Veksler was organized while the war still raged on, in 1944. In 1946–1947, FIAN's high-altitude research station was erected in the Pamirs to study cosmic rays. This work brought outstanding results: the discovery of the nuclear cascade process produced by primary cosmic particles in Earth's atmosphere. In 1946, the Dolgoprudnaya Research Station was also founded near Moscow under S N Vernov's supervision, for high-altitude monitoring of cosmic rays. On S I Vavilov's initiative, A I Alikhanyan's laboratory, which studied the composition and spectra of cosmic rays at the high-altitude Aragats station in the mountains in Armenia, was transferred from the Institute for Physical Problems to FIAN, since Vavilov wanted to concentrate all cosmic ray studies in a single organization.

In 1946, FIAN's theorists V L Ginzburg and I M Frank discovered 'at the tip of the pen' so-called transition radiation of charged particles moving across an interface between two dissimilar media. The predicted transition radiation was experimentally detected by A E Chudakov in 1955. Later on, this phenomenon was actively studied at FIAN's Laboratory of Elementary Particles with a view to creating a detector based on this effect for high-energy physics research.

At the beginning of the 1950s, the physics theoreticians I E Tamm, A D Sakharov, V L Ginzburg, V I Ritus, and Yu A Romanov played a very important role in creating a nuclear shield for the country — its thermonuclear weapons [5].

Accelerator S-60.



Photograph of Cherenkov detectors in Crimea. In 1960, for the first time in the world the Laboratory of Cosmic Rays led by A E Chudakov created at FIAN's Crimea research station a facility for searching for local sources of gamma quanta in primary cosmic radiation (PCR) using a novel technique. The technique consisted in recording flashes of Cherenkov radiation produced in the atmosphere by electrons of extensive air showers (EASs), when the interaction of an EAS with atomic nuclei in air generates a colossal flux of secondary particles. These flashes could be recorded against the background of night airglow in cloudless and moonless nights by virtue of the short time span of simultaneous emission of radiation from the EAS particles. The facility consisted of 12 parabolic mirrors 155 cm in diameter mounted on a common rotating platform and functioned until 1963 (A E Chudakov, A L Dadykin, V I Zatsepin, N M Nesterova, E I Tukish, V I Yakovlev, and others).

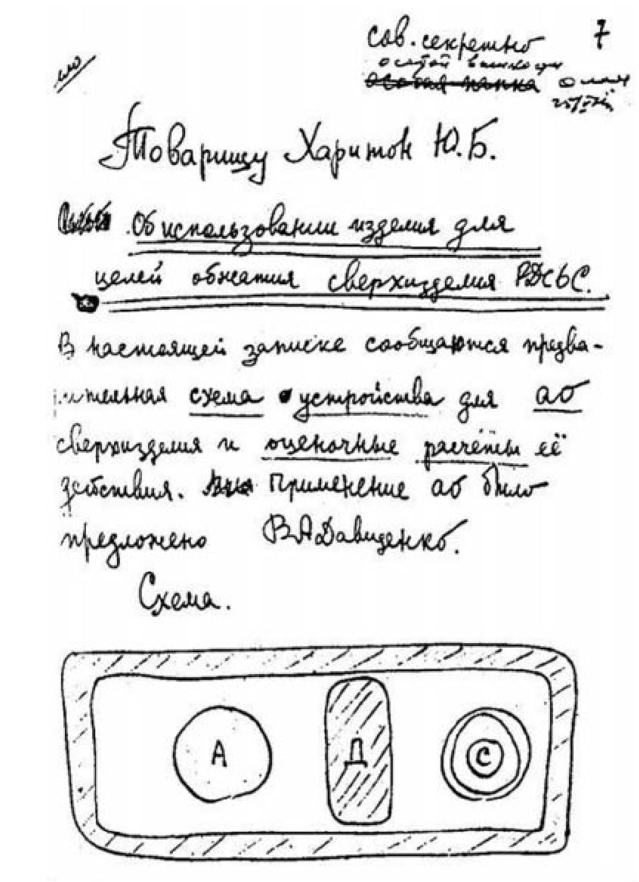
In 1951, FIAN moved to a new building — 53 Lenin Avenue, which it is still occupying as of the moment of writing this article.

FIAN is fully justified in taking pride in the achievements of its scientists awarded Nobel Prizes (I E Tamm, P A Cherenkov, I M Frank, N G Basov, A M Prokhorov, A D Sakharov, V L Ginzburg).

FIAN's scientists have made exceptional contributions to practically every field of modern physics. Many important results and discoveries are inseparable from the names of scientists who worked or are working at the Institute:

— Raman scattering; Mandelstam–Brillouin scattering; Vavilov's law; the Levshin–Perrin formula; Tamm levels; the Hartree–Fock method; the Vavilov–Cherenkov effect; the principle of phase stability; the Franz–Keldysh effect; the Ginzburg–Landau equation, and the Keldysh diagram technique;

I E Tamm (left) – head of FIAN's group of physics theoreticians (formed in June 1948 by the USSR Council of Ministers Resolution No. 1990–774 to investigate the feasibility of developing the hydrogen bomb [5]) and I V Kurchatov, the scientific leader of the Soviet Atomic Project.



Сов. секретно 7

Товарищу Харитон Ю.Б.

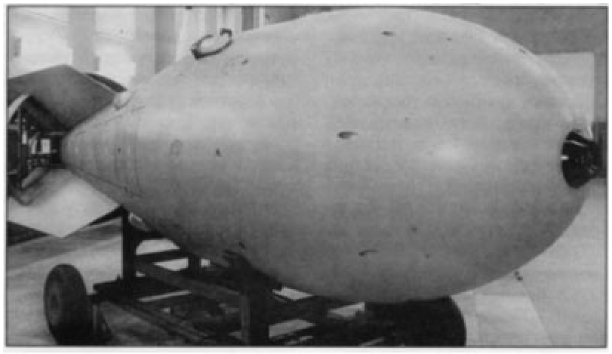
Об использовании изделия для целей обжатия сверхизделия РДС6С.

В настоящей записке сообщаются предварительная схема устройства для АО сверхизделия и оценочные расчёты её действия. Применение АО было предложено В.А.Давиденко.

Схема.

А Д С

The title page of A D Sakharov's memorandum to senior work supervisor Yu B Khariton (a schematic of the idea of preliminary compression of the 'sloika' ('layered cake') by an auxiliary atomic explosion).



The first Soviet nuclear charge with thermonuclear enhancement, RDS–6, tested on 12 August 1953 at the Semipalatinsk site, shaped as a bomb ready for application as weapon [6]

— explanation of the baryon asymmetry of the Universe; muonic catalysis of nuclear reactions; the exchange nature of nuclear forces; the concept of supersymmetry; the functional formulation of quantum field theory and quantum statistics; universal methods of quantization of gauge theories; the theory of higher-spin gauge fields; the sigma-model approach to describing low-energy string dynamics; quantization of superstrings in curved spacetime; the quasinuclear model of heavy meson resonances; the kinetic plasma theory; the theory of runaway electrons; the flow theory of rarefied plasma around bodies; the propagation theory of radio waves along Earth's surface; the propagation theory of radio waves in plasmas; nonlinear modification of the ionosphere exposed to high-intensity radio waves; the parametric resonance in plasma; the nonlinear theory of mirror instability of magnetized plasma with pressure anisotropy; the theory of dissipation mechanisms of turbulence in sea waves; the theory of extremal waves ('killer waves') on water;

— fundamentals of thermonuclear weapon and controlled thermonuclear fusion; the idea of ionization compression of light matter by heavy matter at high temperatures; the tokamak idea; the principle of inertial (laser-driven) thermonuclear fusion; the concept of a hybrid nuclear reactor; neutron physics research;

— formulation of a new principle of generation of electromagnetic waves; the creation of masers and lasers; the development of the basic principles of laser physics; fundamental and applications-oriented work in laser fields for civil and military applications (semiconductor lasers: injection lasers and lasers with electron and optical pumping; chemical and excimer lasers, high-pressure gas lasers with electrical discharge excitation, photodissociation lasers pumped by the emission of open electric discharges and shock waves; laser frequency standards; cathode-ray tubes with laser screens; laser-driven systems for spherical compression and heating of plasmas; laser location of the Moon; laser applications to probing the atmosphere and to monitoring the ozone layer in the upper atmosphere; implementation of a new class of spiral laser beams; development of the photochemical technique for the excitation of active gaseous media; creation of a new class of molecular lasers covering the near-infrared, visible, and ultraviolet ranges of the spectrum; development of various optical methods and devices for formatting, storing, and processing information, including efficient holographic elements, controllable optical transparencies and image converters with record-high sensitivity and spatial resolution);

— stimulated Raman scattering of light; stimulated scattering of the Rayleigh line wing; self-focusing of light beams in a nonlinear medium; the effect of optical wave front reversal; the method of intracavity resonance spectroscopy; the physical foundations of spectral analysis; studies in metal optics;

— phenomenological theory of ferroelectric phenomena, superconductivity and superfluidity of liquid helium; the theory of crystal optics effects taking into account spatial dispersion; the theory of tunneling effects in solids taking into account inelastic processes; the theory of multiphoton ionization of atoms and solids in high-intensity electromagnetic waves; the concept of superlattices;

— the discovery of the ferroelectric properties of barium titanate; collisional ionization of impurities in germanium; metal–insulator transition in two-dimensional hole layers on the germanium surface; predicting, identifying, and studying the condensation of excitons and the properties of an electron–hole liquid in semiconductors; the creation of diffused transistors and diamond-based detectors of nuclear radiation; the development and creation of ultrafast nanoelectronic devices based on tunneling resonance heterostructures; the emergence of the spatially inhomogeneous state in superconductors exposed to optical pumping and tunneling injection;

— development of the principles of relativistic microwave electronics and the creation of new types of ultrapower microwave devices;

— design and launching of electron synchrotrons, a ring phasotron, and high-current electron accelerators; creation of the X-pinch — a superbright source of soft X-ray radiation; the detection of polarization of elementary particles;

— the prediction and detection of transition radiation; priority studies of cosmic rays using the Wilson chamber in a magnetic field; the principle of recording nuclear particles — the bubble chamber; the discovery of Earth's radiation belts; the discovery and study of nuclear cascade processes in extensive air showers; the theory of 'cut-off' of the spectrum of cosmic rays due to interaction with universal background; the study of cosmic rays at high-altitude research stations, and using balloons and space apparatuses; the study of the spatial and temporal distributions of charged particle fluxes in the Earth atmosphere; the study of modulation of fluxes of galactic cosmic rays by solar activity; the discovery of the effects of inversion of the solar magnetic field in cosmic rays; the study of intrusion of high-energy solar protons and magnetospheric electrons into the Earth atmosphere;

— infrared spectrometry of radiation emitted by Earth, by its upper atmosphere and by cosmic bodies; research into X-ray astronomy of the Sun; the discovery of solar radio emission in the meter wave range; the theory of solar flares; the discovery of the solar supercorona; the discovery of interstellar wind caused by the motion of the Solar System relative to the interstellar medium; the determination of temperature and pressure on the surface of the planet Venus; the detection of radio lines from highly excited atoms of the interstellar medium; the discovery of giant radio pulses from pulsars; the creation of very long baseline radiointerferometers; the development of the electrodynamics of pulsar magnetospheres; the proposal and implementation of the pulsar timescale; the prediction of the position of cosmic microwave background in the millimeter and centimeter wave ranges; the quantitative theory of growth of supermassive black holes; the theory of formation of galaxies and other structures in the Universe as a result of the gravitational instability of cold matter; the discovery of the effect of spontaneous generation of density inhomogeneities in the early Universe; the creation of the theory of the inflation Universe.

The intense expansion of research conducted at FIAN has resulted in a number of research fields splitting off and forming independent research institutions:

— Institute of Colloids and Electrochemistry (P A Rebinder, 1937);

— Research Institute of Nuclear Physics, MGU (D V Skobeltsyn, 1946);

— Radioengineering Laboratory of the USSR AS (A L Mints, 1946), renamed Radioengineering Institute of the USSR AS in 1957;

— Obninsk Scientific Research Laboratory (D I Blokhintsev, 1947), transformed into Institute for Physics and Power Engineering in 1950;

— Laboratory of High Energies of the Joint Institute for Nuclear Research (Dubna; V I Veksler, 1956);

— Acoustics Institute of the USSR AS (L M Brekhovskikh, 1953);

— Laboratory of Neutron Physics of the Joint Institute for Nuclear Research (Dubna; I M Frank, 1957);

— Institute of Semiconductors of the Siberian Branch of the USSR AS (A V Rzhanov, 1962);

— Institute of Spectroscopy of the USSR AS (S L Mandelshtam, 1968);

— Institute for Nuclear Research of the USSR AS (A N Tavkhelidze, 1970);

— Institute of General Physics of the USSR AS (A M Prokhorov, 1982).

The Soviet period in the life of FIAN, lasting almost 58 years, was undoubtedly the most brilliant in the history of the Institute. It was awarded two State Orders. During these years the Institute included on its staff

- 6 Nobel Prize Laureates,
- 11 Heros of Socialist Labor, one of them a three-times laureate (A D Sakharov) and two have had the title conferred on them twice (A M Prokhorov and N G Basov),
- 29 Lenin Prize winners,
- 156 winners of the USSR State Prize,
- 46 winners of various international awards,
- 35 laureates of the Lenin Young Communist League Prize,
- 46 scientists who received eponymous awards and gold medals from the USSR Academy of Sciences.

This was the period when FIAN became the outstanding research body now well known all over the world of science.

3. FIAN: the post-Soviet period

The demise of the Soviet Union hurt Russian science very much. Funding dropped to a small fraction of the earlier level, the salaries of researchers took a nosedive, new equipment and instruments ceased to arrive, industrial science petered out, and the young generation lost all interest in science. Many scientists left research or went abroad. The number of scientists at the Institute shrank by a factor of more than two. Life was especially hard at the beginning of the 1990s and after the financial default of 1998.

However, despite these misfortunes, FIAN survived and, more than that, it continued to progress. FIAN's successes rest on the foundation of the traditionally strong scientific schools which grew within the Institute and evolved together with it. The broad range of research fields that had formed as the Institute expanded and covered practically all fields of physics now dictated the current structure of FIAN consisting of six research divisions.

The high international prestige of the Institute and its international links played an enormous role at this stage: in these difficult years FIAN's scientists were able to conduct joint research projects with colleagues abroad.

The numerical strength of FIAN at the current moment is about 1600, of which about 800 are research workers, including 22 members of the Russian Academy of Sciences and about 200 DSc and 400 CandSc scientists. The Institute has affiliates in Samara, Protvino, and Almaty, a technopark in Troitsk, radioastronomical observatories in Pushchino and Kalyazin, and a laboratory in Dolgoprudnyi.

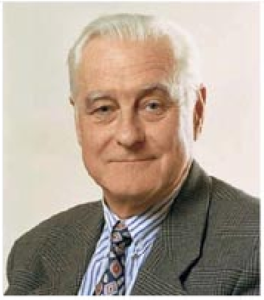
FIAN's scientists annually publish about 20 monographs and approximately 1500 research papers in journals in this

Vavilov Sergei Ivanovich
(1934–1951)

Skobeltsyn Dmitrii Vladimirovich
(1951–1972)

Basov Nikolai Gennadievich
(1973–1988)

Keldysh Leonid Veniaminovich
(1989–1994)



Krokhin Oleg Nikolaevich
(1994–2004)

Mesyats Gennadii Andreevich
(since 2004)

FIAN Directors after 1934 (given in parentheses are the years when they led FIAN).

country and abroad, and deliver talks at conferences. The Institute concentrates its activities along the following avenues of research.

(1) Theoretical physics, including quantum field theory, quantum statistics and the theory of fundamental interactions, nonlinear physics; high-energy physics, elementary particle physics, nuclear physics; biophysics.

(2) The physics of charged-particle accelerators; pulsed high-power electronics; physical electronics.

(3) Classical and quantum optics, luminescence, scattering of light; spectroscopy of atoms, molecules, condensed media, gases and plasma; X-ray optics.

(4) Quantum radiophysics; interaction between laser radiation and matter; nonlinear optics; laser metrology; information technologies.

(5) Plasma physics; controlled thermonuclear fusion; laser thermonuclear fusion.

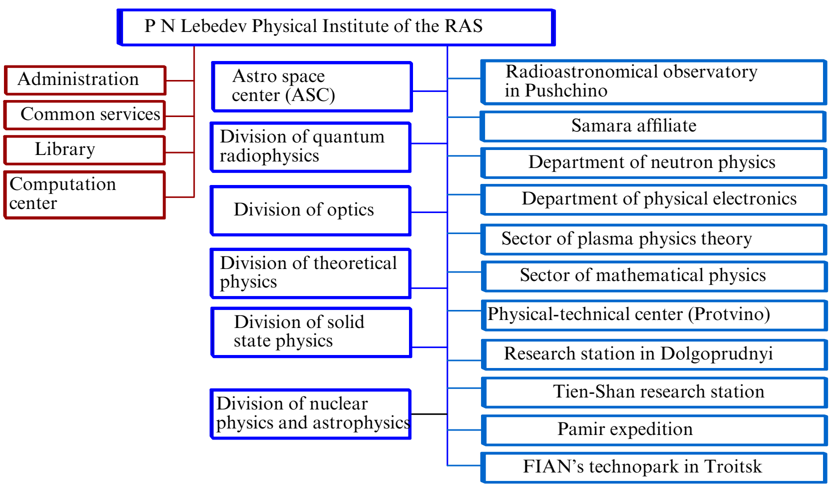
(6) Solid state physics; semiconductors; mesoscopics; solid-state nanostructures; nanotechnologies; optoelectronics; superconductivity.

(7) Astrophysics, all-wavelengths astronomy, cosmic rays, cosmology (ground- and space-based, experimental and theoretical studies); physics of the Sun, atmosphere, ionosphere, and terrestrial and planetary magnetospheres; planetary and applied astronomy.

(8) Experimental techniques, novel physical methods in research areas, technology, engineering, medical sciences, and ecology.

Among FIAN's research divisions (they are mostly well defined for the fields of research), one is different — the

STRUCTURE OF THE INSTITUTE

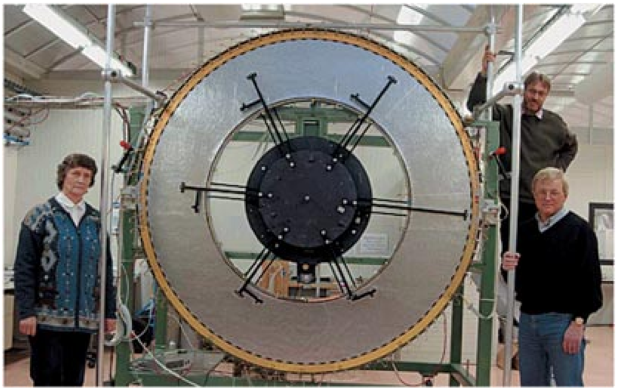


Division of Theoretical Physics, whose scientists work in practically every field of physics. One can state without hesitation that at the moment this is the best theoretical physics department in Russia.

Academician V L Ginzburg — FIAN's veteran and Nobel Prize Laureate — predicted in his papers the existence of thermoelectric phenomena in superconductors, developed a phenomenological theory of ferroelectric phenomena, created a phenomenological theory of superconductivity and superfluidity of liquid helium, developed the theory of crystal optic effects taking into account spatial dispersion, established the applicability criterion for the theory of Landau second-order phase transitions, pointed out the possibility of occurring high-temperature superconductivity in layered systems via the electron–exciton interaction, and developed the theory of radio wave propagation in plasmas. This is far from being a complete list of outstanding results obtained in quite different fields of physics — by one scientist.

Researchers of the Division of Theoretical Physics have successfully worked for a long time on the fundamental aspects of quantum field theory and the theory of superstrings (a promising area of theoretical physics whose goal is to develop a unified theory of fundamental interactions). For instance, a functional formulation of quantum field theory and quantum statistics was devised within this framework (E S Fradkin). The fundamental idea of supersymmetry was suggested (Golfand, Likhtman); the theory of quantum electrodynamics in high-intensity external fields was developed (Nikishov, Ritus); universal methods for quantization of gauge theories were constructed (Batalin, Vilkovyskii, Tyutin, Fradkin); a sigma-model approach to describing low-energy string dynamics was described (Fradkin, Tseitlin), and the theory of higher-spin gauge fields was developed (Fradkin, Vasiliev). One of the important achievements of recent years in string theory was the work by P P Metsaev, "IIB Green–Schwarz superstring in the plane wave Ramond–Ramond background". He was able to construct the first example of a quantum superstring in curved spacetime in the presence of Ramond–Ramond fields. The quantization of superstrings in Ramond fields is of principal importance for implementing the program of string description of nonperturbative dynamics of gauge fields, which may lead to an alternative method of describing the properties of hadrons. Since 2003, Metsaev's paper has been cited more than 500 times.

Academician L V Keldysh published a series of fundamental papers on interband elastic and inelastic tunneling of charge carriers in semiconductors, which immediately made him known to the world scientific community. He was the first to suggest spatially periodic fields for fashioning artificial spectra in crystals caused by additional Bragg reflections produced by such fields. This idea was subsequently implemented in the creation of artificial superlattices. L V Keldysh developed a special diagram technique for the description of the states and kinetics of strongly nonequilibrium quantum systems. He was able to build the theory of the metal–insulator phase transition arising in semiconductors and semimetals owing to exciton instability. A completely new phenomenon of exciton condensation into mobile droplets of quantum electron–hole liquid was predicted and described; it was later experimentally revealed. The theory of multiphoton ionization of atoms in the field of a high-intensity electromagnetic wave that L V Keldysh developed proved very important for laser physics.



FIAN's group leader A P Shmeleva with colleagues at one of the end moduli of the transition radiation detector in a CERN laboratory during technical tests.

Academician G A Mesyats with visiting Russian scientists at the building site of the accelerator complex of the Large Hadron Collider (LHC) in Geneva (2006).

I wish to mention here a number of outstanding results achieved in plasma theory by Academician A V Gurevich and his team. They developed the theory of rarefied plasma flow around bodies; a kinetic plasma theory; a theory of nonlinear modification of the ionosphere subjected to high-intensity radio waves; a theory of dissipationless shock waves in dispersing media and the theory of soliton turbulence; developed the electrodynamics of pulsar magnetosphere; the theory of formation of galaxies and other structures in the Universe as a result of the evolution of the nonlinear stage of gravitational instability in dissipationless self-gravitating cold matter; a quantitative theory of growth of supermassive black holes; the theory of runaway electrons in plasma and described a mechanism of electric breakdown in gases created by such electrons, and suggested the idea of linkage between the lightning discharge and the transmission of cosmic rays.

Extreme waves ('killer waves') on the surface of the ocean which exceed the root-mean-square height of waves by a factor of 2 or more are very dangerous both for ships and for stationary structures, such as oil platforms. Academician V E Zakharov developed a theory of generation of extreme waves based on the numerical solution of exact hydrodynamical equations. It was shown that extreme waves are a result of the emergence of modulation instability of stationary travelling 'Stokes waves' which split into envelope solitons and produce 'soliton turbulence'. These inelastically interacting solitons merge with a certain degree of probability and form infrequent solitons of high intensity which transform into extreme waves. The time of this process is measured in tens of inverse instability increments.

FIAN's experimentalists also carry out successful research.

In 2001–2005, a series of research projects were carried out in the laboratory of the solar X-ray astronomy of FIAN's Division of Optics for studying active processes on the Sun. The work was conducted using a unique set of instruments developed in the laboratory and mounted aboard the satellite KORONAS–F which orbited Earth from 31 July 2001 to December 2005. More than a million images of the Sun in a number of wavelength ranges were obtained. The size of the electronic archive (the data obtained and processed during the 4.5 years of flight) came to about 1 TB. This work, which has recently received a first prize at a contest between research projects of the Institute, was rewarded with the RF Government Premium in 2008. To continue solar studies, a new satellite, KORONAS–Foton, carrying FIAN-made Tesis apparatus was launched in February 2009 and is functioning successfully.

FIAN carried out a large amount of experimental work at CERN on the Large Hadron Collider (LHC). One of the two largest experiments on the LHC aimed at the study of fundamental properties of matter at superhigh energies is ATLAS. The main tasks of the experiment are to search for the Higgs boson that gives masses to elementary particles, a search for supersymmetry particles, a study of the possibility of occurring additional dimensions, and improvement in the knowledge of the Standard Model parameters. FIAN, in collaboration with other Russian and foreign research teams, created the track detector of transition radiation, which incorporates 370,000 data channels transmitting the parameters of particles created in proton–proton collisions.

The Shalon mirror gamma telescope of FIAN's Tien Shan high-altitude research station was used to observe galactic and metagalactic sources. A detailed analysis of the directions of arrival of gamma showers revealed a new source of gamma rays whose coordinates coincide with those of the new supernova SN 2006gy that flared outside our Galaxy.

A study of a two-dimensional strongly interacting electron system on the surface of silicon (Si) at the Division of Solid State Physics (headed by Academician Yu V Kopaev), in which conductivity and interelectron interaction were varied by a magnetic field, demonstrated agreement of experimental results with the theory predicting a metal–insulator quantum phase transition. These results change drastically the entrenched notion that a metallic state cannot in principle be the ground state of two-dimensional systems.

Researchers at the Division of Solid State Physics also predicted a new type of electron ordering, characterized by toroidal moment. An important feature of such a state observed in crystals and heterostructures is the anomalously strong magnetoelectric effect.

Solid state physicists demonstrated that the mutual influence of dielectric and superconducting correlations, which results in a periodic distribution of superfluid density and an increased temperature of the superconducting transition, was the decisive factor in the search for high-temperature superconductors and in the interpretation of their properties.

Fundamental research at the Institute is traditionally closely tied to applications-oriented projects. Many fundamental studies are brought to the stage of practical products, while still maintaining a reasonably balanced combination of applications-oriented work and fundamental research. One consequence of this is innovations activities. This promises a large number of results that would be snapped up by industry. Here are several examples.

The work of two researchers of FIAN's Samara affiliate, M V Zagidullin and V D Nikolaev, "Development and investigation of the functioning of chemical gas generators of singlet oxygen and supersonic oxygen–iodine high-pressure lasers" was rewarded with the 2008 Science and Technology premium of the RF Government. The authors proposed a number of highly original designs of gas generators of singlet oxygen and developed a scientific foundation for designing high-power chemical oxygen lasers; they showed for the first time the feasibility of generating a high-pressure oxygen flow (of several dozen mm Hg) carrying a large fraction of singlet oxygen; they established the conditions for producing such flows and for the first time demonstrated experimentally a highly efficient generation of emission in a high-pressure supersonic oxygen–iodine laser; a significant contribution has been made to developing the theory of optical saturation of amplification in the lasing medium of the oxygen–iodine laser, to creating methods of formation of high-pressure active media which make it possible to increase considerably the restored pressure at the exit cone and facilitate the exhaust of the gas into the atmosphere. This new type of gas generator is now being used in practically every laboratory the world over. The results of research and development helped build a number of powerful facilities in Russia for various applications.

New engineering solutions found at FIAN's Physical Engineering Center headed by RAS Corresponding Member V E Balakin served to develop an inexpensive economical and compact proton accelerator for irradiation therapy of oncological diseases. By its characteristics, this facility far exceeds any equipment existing or being designed in any country. The factors of principal importance are its low energy consumption, small overall size, and low capital investment needed for building a radiation-shielded room, which makes it possible to produce a large number of them and mount them in practically any regional health center that has an oncological division. This facility is now regarded as a replacement for electron accelerators widely used in oncology throughout the world and currently imported into this country. At the time of writing, a FIAN facility is being installed at the Massachusetts Institute of Technology in the US.

In collaboration with the Institute of Electrophysics of the Ural Branch of the RAS, FIAN developed and built compact generators of high-voltage picosecond pulses at voltages up to 10^6 V, with a view to solving a number of fundamental and applied problems. It was shown that a relativistic electron beam lasting for tens of picoseconds and with a charge of up to one nano-Coulomb can be generated at the cathode in the atmospheric two-electrode gap with a nonuniform field. Such generators make it possible to form accelerated electron beams in a vacuum, and to generate microwave, X-ray, and laser radiation.

The Division of Quantum Radiophysics elaborated the principles of creating a three-dimensional display using a novel electrooptical data carrier formed of nanostructured polymer–liquid crystal composite layers with a smectic type ferroelectric liquid crystal; its response time is several times shorter than that of existing materials. An optical beam of a semiconductor laser has been proposed as a data carrier. An operative pilot version of a monochromatic 3D display has been built. The 3D display could be most effective in aircraft and cosmic navigation and in medical fields, such as computer-assisted tomography, visualization of data in biology, geophysics and seismic prospecting, modeling of three-dimensional fields, stresses and structures, design, 3D graphics, computer games, advertising and so forth.

The X-pinch as a source of radiation was applied to forming X-ray images of weakly absorbing biological objects using phase contrast methods. The first experiments have been carried out on the radiography of objects using the short-wavelength range of the spectrum (with wavelengths shorter than 1 Å).

Femtosecond solid-state lasers were developed and are used in various research laboratories in Russia and abroad.

A new class of laser beams — so-called spiral beams — have been realized in the Samara affiliate of FIAN. The properties of such beams make it possible to create a prescribed microdistribution of intensity and angular momentum in the region of focusing and therefore open a principally new option for contactless manipulation of microscopic objects in electronics and microbiology.

FIAN scientists created for the first time a femtosecond optical clock stable to within 1×10^{-14}; it is based on a compact methane optical standard and femtosecond synthesizer of optical frequencies. The phase noise level of the output microwave signal of the optical clock is lower than in the best quartz generators by 2 to 3 orders of magnitude. A compact femtosecond optical clock was realized in 2008 and the advantage of the created system in short-term stability of frequency in comparison with the industrial H-maser has been demonstrated.

The polyphysical character of the Institute, set by S I Vavilov, makes it essentially easier to achieve success at the intersection of several lines of inquiry.

Academician A V Gurevich, together with the staff of the Division of Nuclear Physics and Astrophysics and the Division of Theoretical Physics, created GROZA (Russian for thunderstorm) experimental complex at the Tien Shan high-altitude research station of FIAN to study pulsed radio emission during atmospheric storms and the interconnection between lightning phenomena and extensive air showers (EASs). During a storm, the detectors of the station are right inside the thundercloud. The instruments of GROZA continuously monitor EAS events and also record radio and gamma emissions in a wide frequency range. Short-duration (about 1 ms long) intensity bursts of soft gamma radiation were recorded for the first time in a terrestrial environment inside a thundercloud. The bursts arise hundreds of microseconds before the lightning discharge. They were shown to correlate with extensive air showers of cosmic rays.

The scientific goal of the RAMBAS (Radiation Mechanism of Biomolecular Asymmetry) program carried out by specialists in nuclear physics, theoretical physics, and optics collaborating with scientists in Japan and China is to study the physical and astrophysical aspects of one of the most important fundamental problems in science — the problem of the origin of life or, more precisely, the key issue in this problem, the origin of biological homochirality (or mirror asymmetry of the biosphere). The main focus of experimentalists is to test the hypothesis that biological homochirality is linked to parity violation in weak interactions. For the mechanism which could implement this linkage they suggested an asymmetric radiolysis of pre-biological molecules by longitudinally polarized electrons that are produced in the beta-decays (the so-called 'radiation mechanism'). As a result of the research pursued in the framework of the RAMBAS program, reliable evidence has been gathered in favor of the important role played by irradiation by relativistic charged particles in the synthesis of the most important bio-organic compounds and origination (in response to irradiation by polarized particles) of the chiral asymmetry of bio-organic matter. This last conclusion may prove to be of greatest importance for solving the problem of the origin of life and the emergence of chiral asymmetry, both in terrestrial and extraterrestrial scenarios of the birth of life.

The success of research at the Institute is determined to a large extent by how adequate the experimental equipment base is. For instance, a completely automatized measurement

Vitaly Lazarevich Ginzburg's famous seminar at FIAN (1700 sessions of the seminar took place between 1956 and 2001). Upper photo: seminar chairman V L Ginzburg; lower photos: participants in the seminar in FIAN's assembly hall.

complex (PAVIKOM) has been developed at FIAN for processing the data recorded by emulsion and solid-state track detectors. PAVIKOM, which has no analogs in Russia, has been officially accredited to be part of one of the largest and most significant international OPERA experiments oriented at obtaining reliable quantitative results on neutrino oscillations.

The Pushchino radioastronomical observatory (PRAO) at FIAN ASC is one of the largest radioastronomical observatories in the world. The observatory has three large radio telescopes, the RT–22, DKR–1000, and BSA, all included on the list of unique benches and facilities in Russia. The areas of research at FIAN ASC PRAO are as follows: the physics of pulsars; pulsar radio astrometry; the physics of the interstellar medium, interstellar plasma, and solar wind; galactic and extragalactic astronomy; the spectral radio astronomy; the search for radio emission caused by particles with record-high energies, and the Radioastron space project.

Two large space projects are being developed at FIAN ASC in the framework of the enacted Federal Space Research Program, under the guidance of Academician N S Kardashev: Radioastron and Millimetron. The main scientific goal of the Radioastron mission is to study astronomical objects of various types with an unprecedented resolution down to millionth fractions of a second of arc. This resolution will make it possible to study active galactic nuclei (AGNs) in the vicinity of the expected localization of supermassive black holes; dark matter and dark energy manifestations derived from how the parameters of AGNs depend on the red shift and from observing them through gravitational lenses; the structure and dynamics of star-formation regions in our Galaxy and in AGNs using maser and megamaser emissions; neutron stars and black holes in our Galaxy, and the structure and distribution of interstellar and interplanetary plasma revealed in fluctuations of the visibility function of pulsars. Project Millimetron further expands cosmic radio astronomy into the realm of shorter wavelengths.

The scientists of the Institute are able to use in their work technologies that are the latest word in the field of research support: a cluster of GRID, the world-wide system of data processing, has been created at FIAN. FIAN's GRID resource center is integrated operationally and functionally into the Russian segment of the global GRID infrastructure. The computational resources of a node of the GRID complex will be used to process experimental data gathered at the LHC and in a number of space experiments.

No evaluation of the contribution of FIAN and its scientists to physics would be complete without mentioning such a truly momentous phenomenon as V L Ginzburg's seminar which met weekly at FIAN from 1956 to 2001 and was undoubtedly well known to every physicist in this country. It was not only people from Moscow physics centers who spoke at this seminar: speakers and listeners included physicists and astrophysicists from many (perhaps all) significant research centers in Russia, the former Soviet republics, and nearby and remote countries in the West and in the East.

Physicists — those striving for the leader's role, those described as "ordinary working folk" (by the way, that was how V L Ginzburg classified himself), and students and postgraduates just starting their careers in science — were strongly attracted to it by the obvious uniqueness of the seminar, by the wide range of topical problems discussed during the sessions, by the high scientific level, and by the invariably affable attitude of the leader of the seminar toward every participant [7].

Reading hall of FIAN's library.

The library at FIAN is one of the best libraries of the Russian Academy of Sciences. By January 2009, the library held 462,508 books, journals, etc., of which 210,813 are in foreign languages; it is one of the largest collections of literature in physics and related sciences in the country. FIAN's library stores unique publications from the 17th to 19th centuries, books from personal collections with the autographs of famous scientists, publications of classics of science in their lifetime, and handwritten material. FIAN's library makes its literature accessible to everyone from the staff of the RAS and from educational institutions, as well as non-Academy research institutes and organizations.

In post-Soviet time FIAN's scientists have received

- one Nobel Prize (V L Ginzburg),
- 15 international science prizes and awards,
- 33 Russian state and civic premiums, and
- 31 eponymous prizes and RAS medals.

4. What do we strive for?

At the moment it is difficult to outline a long-term program of FIAN's future phases as the country is in economic crisis. However, we are able to name the main segments of our trajectory and what we hope to achieve in the near future.

First, personnel policies. This must be a combination of, on the one hand, caring consideration for the older generation of scientists which helped make FIAN the largest research center in the world, and, on the other hand, paying unfailing attention to attracting young scientists, postgraduates, and undergraduate students to FIAN.

In 2008, FIAN had 105 postgraduates, which was 27% of the total number of postgraduates at the RAS Physical Sciences Division. This is three times the number of postgraduates five years ago. To coordinate relations with undergraduate students and postgraduates, the Teaching & Research Complex (TRC) headed by a deputy director of the Institute has been set up. FIAN is linked in one form or another with many higher educational establishments in Moscow and other regions (with 25 chairs and TRCs). FIAN, together with universities having their own physics departments or technical universities formed on the basis of educational institutes concentrating on physics, created Teaching & Research and Research & Education centers to coordinate clusters of such organizations. Direct links at the chair level are maintained with other universities in physics and related fields. The Institute works on supporting the younger generation financially and helps to solve accommodation problems.

The number of successfully defended theses is growing, and this fact reflects objectively the significance and importance of the obtained results of research (21 CandSc and DSc viva voces in 2008).

We would like to have many of those who defend their theses continue working at FIAN, but we face the gigantic problem of the absence of apartments for young scientists. It will be difficult to sustain FIAN's development if this problem is not resolved. It can be solved only in the framework of the RAS and the country as a whole. Federal funding is required to start building houses on the land belonging to the Academy. At the moment we are only solving local problems: hostels, leases, mortgages, and the money we get from the RAS Managing Department. The Uspekhi Fiziki (Advancing Physics) Fund (known as the Ginzburg Fund) that had been created on the initiative of Vitaly Lazarevich was a great help.

FIAN's personnel policies also foresee invitations of successful scientists from other institutions, namely CandSc and DSc scientists and members of the RAS. In this way, FIAN added two full members and four corresponding members of the RAS and more than ten DSc researchers to its staff. Furthermore, one new full member and four corresponding members were elected at the last two elections to the Russian Academy of Sciences from the staff of FIAN. Inviting scientists from Russia and other countries for temporary work may also be very helpful; the Institute has adequate conditions for this.

We need to make better use of the polyphysical nature of the Institute in carrying out joint intrainstitute projects. This form of work has been expanding recently. Thus, the Laboratory of Problems of New Accelerators of the FIAN Division of Nuclear Physics and Astrophysics, in collaboration with the Sector of Interaction of Radiowaves and Plasmas of the Division of Theoretical Physics and the Laboratory of Vacuum and Plasma Electronics of the Department of Physical Electronics works on observing runaway electrons in long sparks. In collaboration with the laboratories of the Division of Quantum Radiophysics, the Department of Physical Electronics developed a hybrid femtosecond multiterawatt UV laser; the Laboratory of Semiconductor Lasers with Electron Pumping of the Division of Quantum Radiophysics is investigating, in collaboration with the Laboratory of Pulsed Processes of the Department of Physical Electronics, the feasibilities of high-power picosecond electronics for developing new semiconductor lasers. This trend is expected to expand further.

Another problem we need to solve is equipment renewal and upgrading. In recent years built-in and physical obsolescence was setting in and no new equipment was installed. The Institute is to receive in the next 3 to 4 years new equipment for an amount of money exceeding the sum obtained in the last 15 years. Organizations funding this are the Agency for Science and Innovation, the Ministry of Economic Development, the RAS, RosNanoTech, and military industrial organizations (VPK in *Russ. abbr*.). It is very important at the moment to prepare conditions for installing this equipment in laboratories, which requires a considerable amount of money.

A lot of attention will be devoted to expanding new avenues of research. The Center of High-Temperature Superconductivity and Superconducting Nanostructures is being organized at FIAN on the initiative of Academician V L Ginzburg; its equipment will be the best that technology can offer. A large-scale investment project is being implemented to house the center — it will add 6.5 thousand sq. m. of laboratory area to the experimental base of FIAN. The Center will use every existing technology of fabrication of superconducting nanostructures and a modern complex of analytical equipment.

We will expand our innovative activities. In 2008, work began on creating FIAN's Troitsk Technopark for the development of projects in high technologies. The topics planned for work at the Technopark are based mostly on FIAN's research results and cover scientific instrumentation design, nanoelectronics, optoelectronics, laser technology, including development and fabrication of components and semifinished products, materials science, and the creation of new materials. This is where the first project of the Rosnano Corp. in aspherical optics will be developed. Many stages need to be completed before the Troitsk Technopark is turned into one of the best innovative structures in the RAS.

FIAN's success was built on the foundation of traditionally strong scientific schools that emerged and grew stronger during the 75 years of the history of the Institute. The area of fundamental research of the Institute covers practically every field of physics and lies in the mainstream of research in the physical sciences. The potential of the team of scientists and engineers gathered at FIAN as it is today is huge; the team includes both world-class scientists headed by 22 members of the Academy and talented young scientists who have already made their mark by producing a number of outstanding results. To summarize: through a combination of the qualities of a center of research, education, information, and culture, FIAN has grown into, and remains, one of the best physical institutes in this country and in the world.

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