A Visit to the Physics Institute of the USSR Academy of Sciences

The Physics Institute of the Academy of Sciences, also known as FIAN or the Lebedev Institute, is the largest physics research establishment in the Soviet Union, employing 1000 scientists and 2000 other staff. When we recently visited Moscow, Nikolai G. Basov, who shared the Nobel Prize for discovery of the laser, gave us a tour of the quantum-electronics laboratory. His laboratory is famous for its diversity of research and the talent of its physicists.

We saw high-power picosecond-pulse lasers producing 2-keV plasmas and other lasers making plasma shock waves. The quantum-electronics lab is one of 20 that do research in just about every branch of physics you can name.

Laser-produced plasmas. Peter G. Kryukov showed us the laser being used to heat plasma and generate neutrons. A neodymium-doped glass laser that is mode locked is amplified through five stages and produces 10–30 joules in 10^{-11} sec. The beam is focused on a solid surface of lithium deuteride, and the experimenters look for neutron production in coincidence with the laser pulse. The reaction that they want to produce is $D^2 + D^2 \rightarrow He^3 + n^1$.

Out of 120 experiments, the group has observed one neutron from each of 20 experiments, according to Kryukov. Because the neutron detector has a small solid angle, it only picks up 10% of incident neutrons; so the experimenters infer that each positive experiment yielded 10 neutrons. On that assumption they calculate that the plasma temperature produced is 2 keV; this value agrees with that expected from the size of the absorbing sample. So they conclude that the neutrons observed were produced by thermonuclear fusion.

Kryukov informed us that his group plans to try their laser next on a target made of lithium deuteride and lithium tritide, since the $D^2 + T^3$ fusion reaction is about 100 times more probable than the fusion of two deuterons.

Plasma shock waves. In another laboratory we saw two high-power lasers teamed to generate a plasma shock wave, photograph it and measure its velocity. The work is being carried out by Basov, V. Boiko, Kriskov, O. N. Krokhin and G. Sklizkov. A Q-switched laser made of neodymium-doped glass emits 1.06-micron light in pulses of nanosecond width. The pulse strikes the surface of a target (such as calcium or carbon), which vaporizes and forms a shock wave.

A second laser, made of ruby, is used to illuminate the shock front as it progresses. The ruby light is broken into five beams, and each beam is delayed 15 nanoseconds with respect to the previous one. The ruby beam is shone on the shock front, parallel to the target surface.

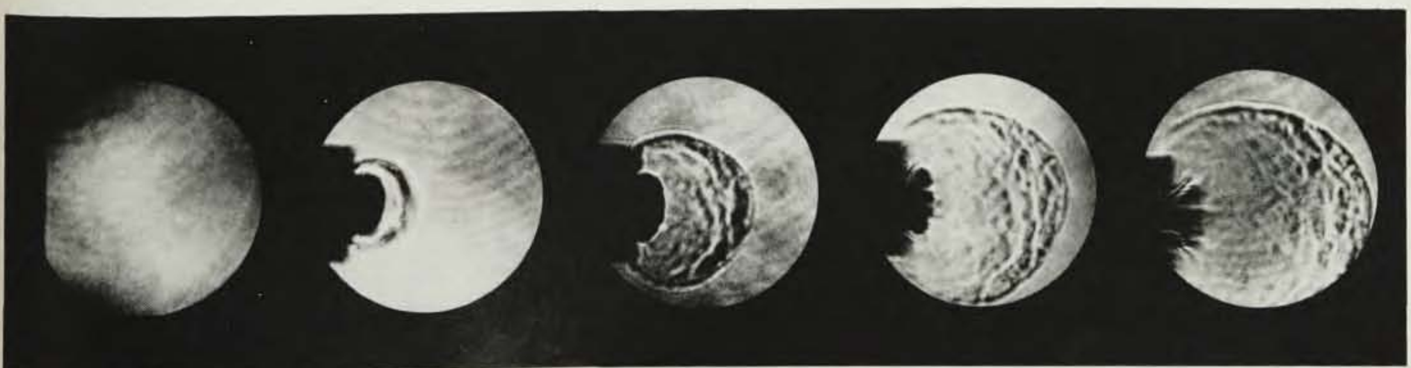
Knowing the mass of the ions and the measured velocity of the shock wave (200 km/sec), the experimenters calculate that they have an equivalent ion temperature of about 140 eV. The electron temperature is measured with a high-speed interferogram or a spectroscopic technique, and it turns out to be greater than 300 eV.

One interesting application of the technique is to obtain spectra of highly ionized atoms. From a calcium target the group measured spectral lines from 11 to 17 nanometers for the 14th, 15th, 16th, 17th and 18th ionization states (lines that had previously been observed only from stars).

Crystals and fields. Turning from hot plasmas to cold crystals, we saw an experiment in which an intense, energetic electron beam strikes a noble-gas crystal and strong ultraviolet radiation is emitted. O. V. Bogdankevich, Vladimir Danilichev and Yu. M. Popov showed us their 1-MeV 30-ampere electron accelerator, which was built by Andrei Budker's Nuclear Physics Institute in Novosibirsk.

The electron beam (300–700 keV) strikes the crystal, which is grown and maintained at liquid-nitrogen temperature, and radiation is detected. The group has used xenon, neon and krypton and plans to try helium next. From krypton and xenon they have produced exciton luminescence at about 170 nm. Eventually they hope to make a uv laser with this electron-beam excitation.

Another unusual laser material we saw, also grown at Lebedev, was dysprosium-doped calcium fluoride. To make the sample lase, it is cooled to liquid-nitrogen temperature, and the



SHOCK WAVE is produced when Q-switched laser pulse strikes surface of a carbon target (at left on each photo), which vaporizes and forms a gaseous plasma. To take pictures, a ruby-laser beam is shone, at 15-nanosecond intervals, on the shock front, parallel to the target surface.

crystal emits high-power infrared radiation.

We also saw a slotted gallium-arsenide diode laser that could be triggered by shining light on it, some Raman-laser experiments at 600-atmospheres pressure (the Raman line was narrowed by increasing pressure) and a large variety of semiconductor lasers.

The institute has an intense-magnetic-field facility with 9 MW available at two stations. Recently put in operation is a 176-kG continuous-field magnet, which will be used for a variety of solid-state experiments.

Administration. Founded in 1725 by Peter I, the institute occupied a building in Petrograd (later Leningrad) until 1934. At that time it moved to a building in Moscow near Mayakovsky Square. In 1954 it moved to its present quarters, along a street lined with institutes of the Soviet Academy of Sciences.

Besides several buildings in Moscow, the institute has facilities spotted all over the Soviet Union. A cosmic-ray station, at Tienchang, near Alma Ata, is one of several. In the Crimea is a 2.6-meter optical telescope, which has been used to locate the moon with a laser. At Serpukhov the institute has a radioastronomy laboratory with a 22-meter reflector and a 1000-meter-long crossed array. A large accelerator complex being built near Serpukhov will be used for low- and medium-energy nuclear physics; expected completion date is about five years from now.

Director of the entire institute is Dmitri V. Skobeltsin. The institute is divided into 20 laboratories. Those devoted to nuclear physics are directed by Alexei Isakov; the others are under Basov (see organization chart). The luminescence laboratory was first headed by Sergei I. Vavilov, who, when the institute moved to Moscow, changed it from a tiny physics laboratory into a modern institute with enormous scope. The optical laboratory was formerly headed by G. Landsberg, who independently discovered the Raman effect.

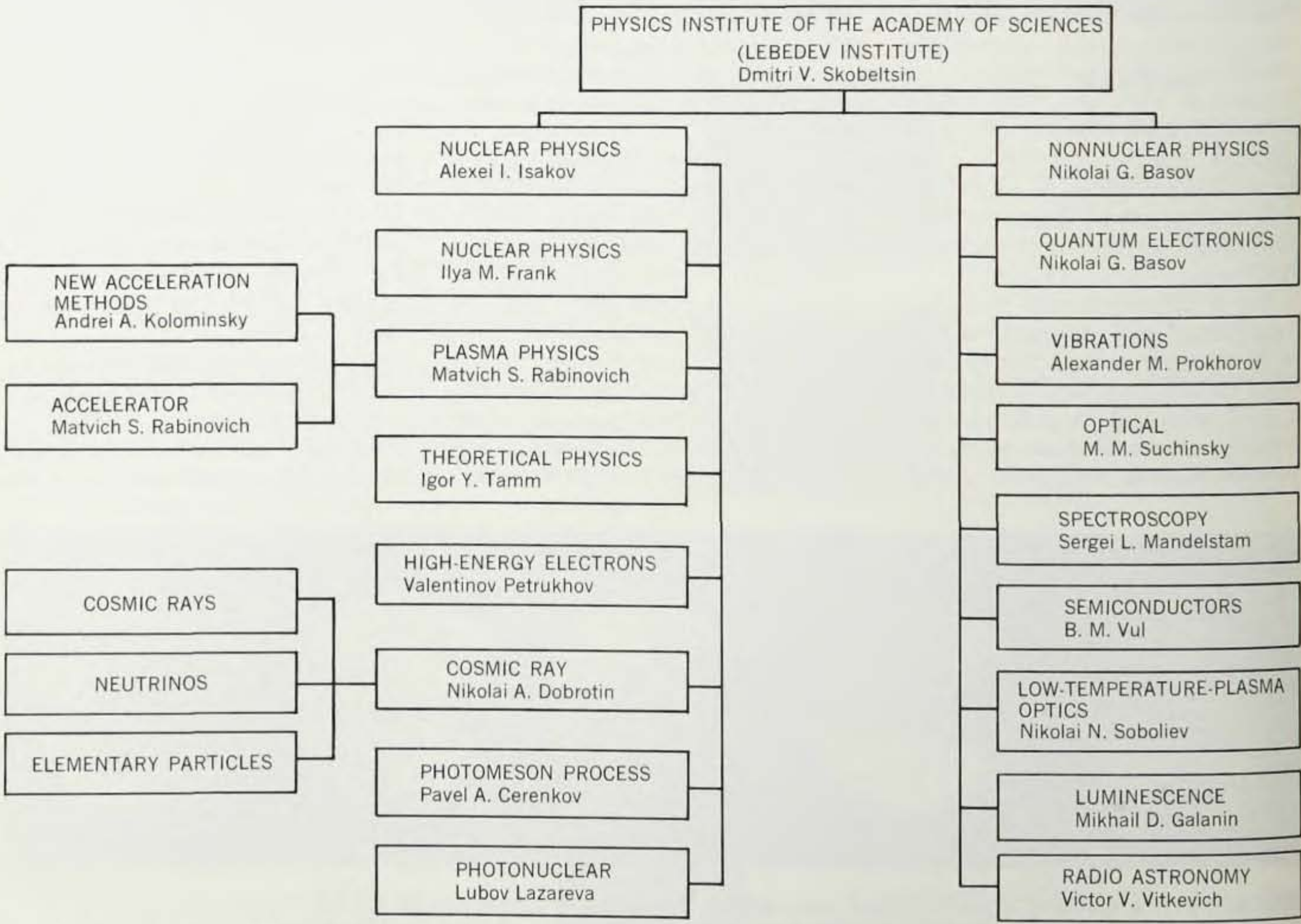
First head of the accelerator laboratory was Vladimir I. Veksler, who independently discovered the principle of phase stability required in synchrotrons. The photomeson-process laboratory and the photonuclear laboratory share a 680-MeV electron synchrotron. At the high-energy-electron laboratory is a synchrotron, now used for electrons, that served as the model for the Dubna proton machine.

Age of Scientists at Lebedev Institute

Age (years)	*Percentage*
<29	22
30–40	51
41–50	17
51–60	8
>60	2

People. The institute has five Nobel prize winners: Basov and A. M. Prokhorov, who, along with Charles H. Townes, won the prize for discovery of the laser, Pavel A. Cerenkov, I. M. Frank and Igor Y. Tamm, who shared the prize for discovery and explanation of the Cerenkov effect.

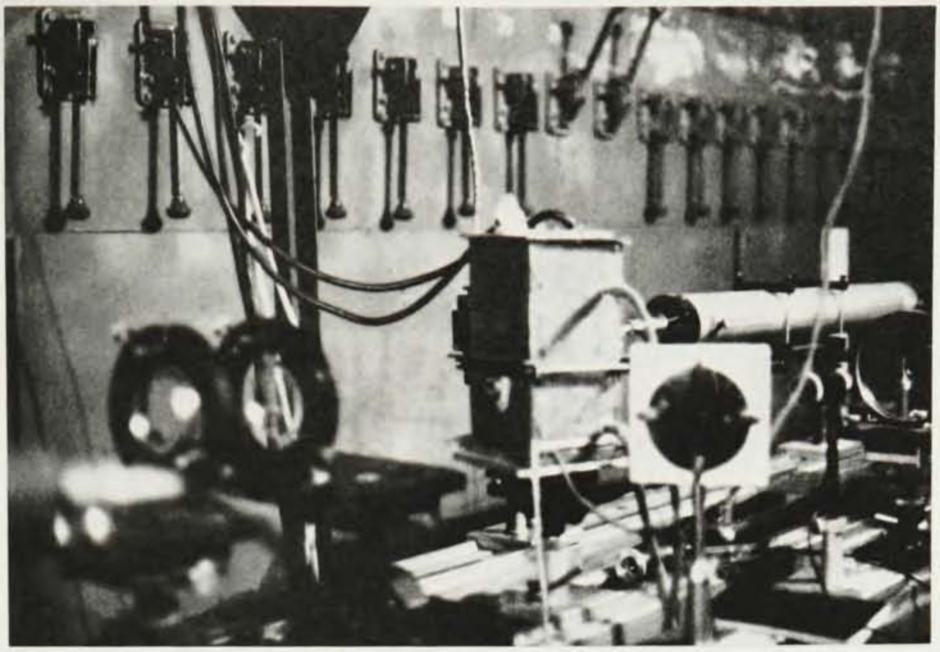
Among the 1000 scientists are six full members of the Soviet Academy



ORGANIZATION CHART shows that Lebedev Institute is divided into 20 laboratories. Institute is largest in Soviet Union.

PHOTOS BY GLORIA LUBKIN

NIKOLAI G. BASOV directs nonnuclear-physics research at Lebedev and also heads the quantum-electronics laboratory.



AUXILIARY LASER SYSTEM triggers high-power laser. Pulse lasting 10^{-11} sec strikes lithium-deuteride target, and experimenters observe neutron production in coincidence with pulse. Neutrons are attributed to fusion of two deuterons.

of Sciences, seven corresponding members, 15 winners of the Lenin Prize, 41 "candidates" (a higher degree than the Western PhD) and 225 PhD's. The average age of a Lebedev scientist is 35 years (see table).

Scientists are well supplied with technicians, we were told. Whereas in 1925 the ratio of technicians to scientists was 0.5, in 1967 the ratio had increased to 5.0.

Impressions. Our one-day visit ended before we could hear much about the institute's 19 other laboratories. The buildings we saw were dark and a little old fashioned (but no more than a typical Ivy League physics building). There were bright touches everywhere, like the melons ripening on a lab bench and the colorful flower beds that line the walks.

We came away impressed with the quality and imaginativeness of the work we saw at the institute, and delighted with the friendly enthusiasm of the physicists we met. —GBL

Illinois Building 30-MeV Superconducting Linac

The University of Illinois at Urbana-Champaign expects to be running a superconducting linear accelerator in about a year. The 30-MeV electron machine is similar to the one being developed for higher energies by William M. Fairbank and H. Alan Schwettman at Stanford (PHYSICS TODAY, January 1966, page 96). The National Science Foundation has

IN BRIEF

Two historic reactors are being phased out after about 20 years' service. British Experimental Pile 0 (BEPO) at Harwell in England was started in July 1948; its irradiation program has been transferred elsewhere. The Brookhaven Graphite Research Reactor, started in 1950, is on stand-by status; it can be started up again on 30-day notice.

Project Stormfury tried again this year to seed hurricanes with silver iodide in an effort to lessen their violence. Only two storms had been successfully seeded in the previous seven years. The project is sponsored by the Environmental Science Services Administration.

The National Bureau of Standards will adopt a new reference base for the volt 1 Jan. in a coöperative plan to bring the volt units of 10 countries into agreement. One present volt (US) will equal about 1.0000010 new volts (US).

A 178-cm cyclotron is producing 95-MeV protons at the Naval Radiological Defense Laboratory in San Francisco. It will be used for biomedical radiation research, nuclear chemistry and radiation-effects research, neutron physics and radiation-transport research and charged-particle physics.

Woods Hole Oceanographic Institution has launched its fifth research ship, the 245-foot (75-meter) RV Knorr. The ship will carry 60 scientists and crew members.

Joint studies of the upper atmosphere and near space by the US and four other countries have been worked out by NASA. Launches will be conducted from Brazil, Norway, Spain and Sweden.

Concentrations of dense material beneath the lunar surface have been discovered by analysis of slight speed changes of orbiting spacecraft. The mass concentrations ("mascons") were found centered below all five ringed seas on the near side of the moon, suggesting a relationship between the mascons and the origin of the seas.

Princeton physicists measured 3.3-mm microwave background radiation at the High Altitude Observatory, Climax, Colo. (3450-meters high). They found a radiation temperature of 2.46 (+0.40, −0.44) K, which is consistent with a blackbody spectrum necessary for the primeval fireball hypothesis.