530

Meetings and Conferences

JOINT SCIENTIFIC SESSION OF THE DIVISION OF GENERAL PHYSICS AND ASTRONOMY, USSR ACADEMY OF SCIENCES WITH THE DIVISION OF PHYSICO-TECHNICAL AND MATHEMATICAL SCIENCES, UZBEK ACADEMY OF SCIENCES

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AN excursion scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences and the Division of Physico-technical and Mathematical Sciences of the Uzbek Academy of Sciences was held on April 14, 15, and 16, 1971 at the Conference Hall of the Institute of Electronics of the Uzbek Academy of Sciences in Tashkent. The following papers were delivered:

1. S. A. Azimov, Major Research Trends in the Fields of Physics and Astronomy at the Institutes of the Uzbek Academy of Sciences.
2. U. A. Arifov, Basic Achievements and Problems in Research on the Interaction of Atomic Particles with the Surfaces of Solids.
3. É. I. Adirovich, Photoelectric and Photomagnetic Effects in Semiconductor Films.
4. V. P. Shcheglov, Prospects for the Development of Astronomy in Uzbekistan.
5. M. S. Saidov, Joint Impurity Distributions in Semiconductors.
6. Ya. B. Zel'dovich, G. S. Bisnovatyĭ-Kogan, E. V. Levich, and R. A. Syunyaev, Interaction of Matter and Radiation Under Astrophysical Conditions.
7. I. S. Shklovskiĭ, The Present State of X-ray Astronomy.
8. I. D. Novikov, The "Hot" Universe and the Chemical Composition of Prestellar Matter.
9. P. V. Shcheglov, Astroclimatic Conditions in Central Asia and Kazakhstan.
10. G. Ya. Umarov, Development of Research on the Utilization of Solar Energy within the System of the Uzbek Academy of Sciences.

We publish below brief contents or expositions of the papers delivered.

S. A. Azimov. Major Research Trends in the Fields of Physics and Astronomy at the Institutes of the Uzbek Academy of Sciences.

There are three physics institutes (Physico-technical, Electronics, Nuclear Physics) and an Astronomical Institute within the system of the Uzbek Academy of Sciences.

In the Physico-technical Institute, scientific research and scientific-technical development are advanced in two basic trends: semiconductor physics and solar physics and solar engineering.

In the field of semiconductor physics, the scientific groundwork is being done for a new trend in solid-state physics and electronics: dielectric electronics. Dielectric diode structures based on single-crystal silicon are being developed and studied. The laws governing double-injection currents in semiconductors are investigated.

Fundamental theoretical and experimental studies are being performed in the field of optical electronics—in the theory of the regenerative optron, the effect of anomalously large photoelectric voltages, photoelectric phenomena in heterojunctions, etc. A photomagnetic effect has been observed and investigated in semiconductor films.

Important results have been obtained in research on joint impurity distributions in crystals and on the influence of dislocations and point defects on the properties of the crystals. For example, a molecular-statistical theory of the distribution of impurities in the multicomponent substitutional solid solutions based on elemental substances and compounds has been developed, and the interaction of impurities in silicon, the growth of silicon carbide crystals, and other problems are being studied.

An efficient method has been developed for calculating the dynamic characteristics of semiconductor and dielectric diodes, and this has made it possible to clarify the influence of traps on the amplified mode of Gunn diodes.

A number of technological and instrumental developments have been recorded. For example, a technology for the industrial production of ultrapure silicon whose quality is on a par with the best world standards has been developed in collaboration with other organizations. Various types of optoelectronic and dielectric-electronic devices have been developed, as well as special semiconductor devices. An instrument known as the "nanotaumeter" has been put to use in the study of fast (10^{-7}–10^{-11} sec) relaxation processes in semiconductors.

The Physico-technical Institute of the Uzbek Academy of Sciences has been designated the organization responsible to the USSR Academy of Sciences for the development of dielectric electronics in the Soviet Union.

In the field of solar-energy utilization, the institute has completed a series of studies on production technologies for mirror and protective coatings and the design, construction, and testing of highly efficient concentrating systems—solar-power installations—for use in the national economy. Research has been done toward the development of self-contained solar-power installations with "Stirling"-type dynamic converters (efficiency 25–40%), as well as developmental work on high-temperature solar furnaces. Various installations for agricultural, communal, and domestic use (desalinators, solar water heaters, greenhouses, etc.) developed by the Physico-technical Institute of the Uzbek Academy of Sciences, are currently undergoing testing and have been submitted for acceptance. Construction of a factory for long-run production of solar-power units is planned for Uzbekistan; the planning phase should be completed in 1971.

By resolution on the Scientific Council on Power Engineering and Electrification of the State Committee of the USSR Council of Ministers for Science and Engineering, the Physico-technical Institute of the Uzbek Academy of Sciences has been designated the managing organization for the development of thermal solar equipment and concentrating devices.

The Institute of Electronics was organized on the basis of three departments (Physical Electronics, Solid-state Physics, Physics of Refractory Metals and High-temperature Research) of the Physico-technical Institute of the Uzbek Academy of Sciences and has been functioning since 1967.

In the field of physical electronics, which is the principal trend of the Institute's research, work is being done on the interaction of atomic particles and electromagnetic radiation with the surfaces of solids in a broad range of energies. This problem, which is in the border area between thermionic electronics and solid-state and plasma physics, is a highly promising direction in modern physics.

The Institute of Electronics has developed original research methods, which have served as a basis for clarification of the fundamental laws governing the interaction of atomic particles with the surfaces of solids.

Another group of Institute projects involves research in the field of physical materials science. Work on the following problems is being done in this trend: "Development of New Methods and Principles and Improvement of Existing Ones for the Acquisition of Pure and Ultrapure Elements and Their Compounds" and "Development of New Methods for Welding Metals, Alloys, and Other Materials." A technology has been mastered for the production of high-quality epitaxial silicon films, which may find uses in integrated circuits.

Research in metal physics has made it possible to improve the production technology of articles made from pure and alloyed refractory and high-temperature metals with specified internal structure and properties. These projects have been adopted in practice.

A new technology for production of semifinished articles with specified properties has been proposed on the basis of research on the crystallization processes of molten rocks in vacuum.

The Institute of Nuclear Physics was organized in 1956 and is now the largest scientific-research organization of the Uzbek Academy of Sciences. It is equipped with a 2-MW reactor, a cyclotron capable of accelerating protons to 18 MeV, a gamma installation with a source activity of 0.5 million gram-equivalents of radium, a radiochemical complex, and other major facilities. The institute does research in elementary-particle and cosmic-ray physics, the nuclear physics of low and medium energies, radiation physics and chemistry, and various problems of applied nuclear physics.

The following may be cited among the results obtained by the Institute of Nuclear Physics, Uzbek Academy of Sciences during recent years.

In high-energy physics, a series of studies has been made of reactions of diffractive coherent particle generation in interactions of pions and high-energy protons with complex nuclei (reactions with participation of protons were observed experimentally for the first time by the Tashkent group). A theoretical calculation made it possible to obtain a quantitative description of the basic dynamic characteristics of these reactions in the range of accelerator energies (7.5–60 GeV).

An original method applied to the study of pion-nucleon interactions with a slow recoil proton indicated the existence of heavy boson resonances with large spins in the mass range $\gtrsim 3$ GeV/c^2. A series of studies on the interactions of protons with nucleons and nuclei was performed.

An original magnet kicker was designed and built to meter beams into bubble chambers on the Institute of High-energy Physics accelerator at Serpukhov. Use of this kicker with the one-of-a-kind "Mirabel'" chamber has been proposed.

A unit for study of nuclear interactions at energies on the order of 10^{12} eV has been built and placed in operation at the High-Mountain Station (3200 meters above sea level).

In the field of nuclear spectroscopy, various methods have been used to measure the excited-state lifetimes of several dozen nuclei, the quantum characteristics of their levels have been determined, and their magnetic moments have been investigated. The obtained data have been compared with various theoretical models.

The characteristics of a number of nuclear reactions on light and medium nuclei have been investigated with the cyclotron.

In the field of radiation physics, data have been acquired on the mechanism of defect formation in semiconductors, dielectrics, and ferroelectrics under exposure to radiation.

Activation-analysis studies occupy an important position in the research of the Institute of Nuclear Physics. A whole series of methods has been developed for determination of various elements in minerals, ores and rocks, and biological and medical specimens, as well as highly sensitive techniques for determining impurities and microimpurities in specially purified materials (metals, semiconductors).

A number of the applied-physics developments have been or are being introduced into practice in many of the nation's cities. In 1970 alone, the total cost savings from the implemented and contracted projects exceeded 1.5 million rubles.

The Astronomy Institute was organized in 1966 on the basis of the oldest scientific-research organization in Central Asia—the Tashkent Astronomical Observatory, which began its scientific activity almost 100 years ago (in 1873).

During 1957—1959, the Observatory took part in research under the program of the International Geophysical Year on the problems of solar activity, time, and latitude. In connection with these studies, it was refitted with such major instruments as a chromospheric-photospheric telescope, a transit instrument, and a zenith telescope.

The Institute now consists of five scientific-research departments: the departments of time, meridian astronomy, photographic astronomy, solar physics, and variable stars. The Ulugbek Kitab International Latitude Station also ranks as an affiliate within the Institute.

Most of the Institute's problems are worked up in cooperation with other scientific organizations of the USSR. The research is coordinated by the Astronomical Council of the USSR Academy of Sciences. The investigations are based on observations made at the Institute. These observations, which cover long spans of time and are characterized by high density, offer extremely valuable material for study of the respective problems.

The Institute publishes transactions, circulars, and thematic collections. Its work is also published in special domestic and foreign editions.

U. A. Arifov. Basic Achievements and Problems in Research on the Interaction of Atomic Particles with the Surfaces of Solids.

In the years ahead, the scientific and engineering revolution in such modern industries as power, metallurgy, chemistry, electronics, space and interplanetary travel, harnessing of nuclear, thermonuclear, and solar power sources, development of materials with specified properties, and others, will be determined in decisive measure by the extent to which science is able to study and subdue a new working fluid for the industrial processes of the future—the ionized gases, i.e., controlled fluxes of atomic particles and low-temperature plasma.

There is no question that the immediate problematic tasks in industrial engineering and technology will involve the development and widespread use of approaches, methods, equipment, and systems that will permit establishment of monitoring and control of technological processes on the atomic and molecular levels.

It is therefore no surprise that interest in the phenomena accompanying the interaction of atomic particles (ions, electrons, photons, atoms, and molecules) with the surfaces of solids has shown a steady increase during recent years. Physical processes that were originally investigated only in connection with the work of ionic and electronic devices have now come into the spheres of influence of such important branches of science and engineering as the physics of plasma and magnetohydrodynamic devices, the physics of thermionic converters and gas lasers, supersonic motion of solid bodies in the ionosphere, ion engines, the erosion of the surfaces of the moon and other planets, ionic doping of semiconductors, and radiation physics. Research on the interactions of ion beams with single crystals is developing vigorously.

Emission processes are now widely used in various instruments and devices for measurement of very small currents, to obtain images of surfaces, for ionic etching, for production of thin films by cathode sputtering, in integrated circuitry, and in many other fields.

The stream of publications rises steadily, and new fields in which bombardment of solids with atomic particles plays an essential role are continually being turned up. Thus, studies of the interactions of atomic particles with the surfaces of solids are acquiring great importance for solid-state physics, nuclear physics, electronic engineering, space travel, power engineering, and many branches of today's and tomorrow's industry. During recent years, the physical-electronics school of the Uzbek Academy of Sciences has been responsible for important advances in the development of some of the aforementioned scientific trends.

Back in the 1940's, it was observed in a study of secondary emission that films of alkali halides are effective secondary-electron emitters. These early studies stimulated later broad-gauge investigation of the variety of phenomena that unfold simultaneously at the solid-vacuum interface. It was noted that the early studies were performed under inadequately controlled conditions, so that the nature of the phenomena attending the bombardment of metals by atomic particles was not clearly recognized at that time.

To keep the investigated surface clean up to and at the instant of measurement, it is necessary to use high surface temperatures and fast, inertialess methods of measurement under the conditions of surface bombardment by transient particle pulses. The dual-modulation method developed by the Institute of Electronics of the Uzbek Academy of Sciences satisfies these requirements.

It was established with the aid of the dual-modulation method that the scattering process is independent of target temperature and that the group of low-energy ions that appears at high target temperatures actually consists of evaporated ions and has the temperature-dependent lifetime that is characteristic for evaporation of an adsorbed film. Also detected was another group of secondary ions with substantially higher inertia that appear only at high temperatures as a result of evaporation, from the surface, of primary ions that have penetrated deep into the target. Use of the dual-modulation method made it possible to register for the first time the entire picture of the phenomena that take place on bombardment of metals by ions and to begin more profound study of the elementary phenomena of primary-ion scattering, evaporation and diffusion of interstitial ions, cathode sputtering, and secondary-electron emission.

The studies performed at the Uzbek Academy of Sciences over nearly a quarter of a century have aided substantially in the illumination of various aspects and features of the interaction of fast atoms, ions, and electrons with the surfaces of solids.

The basic laws governing the scattering of ions, electrons, and atoms of medium and low energies have now been ascertained; the characteristics of ion and electron emission have been determined, and peculiarities of cathode sputtering under the conditions of atomic-particle bombardment of targets have been established. The manner in which these phenomena depend on conditions on the bombarded surface and on many other interaction parameters has been studied. The mass- and charge-balance relationships of the colliding particles have been investigated experimentally and theoretically. Research is being done on the energy balance in the action of atomic particles on solids. Profound study is being given to the aforementioned phenomena and to possibilities for their practical application.

For the future, it would appear appropriate to develop scientific research in the following directions:

1) Interaction of low- and ultralow-energy atomic