YAKIV MYKHAILOVYCH FOGEL
(to the centenary of his birthday)
27.02.1909–27.09.1977

This year, we mark a centenary of the birthday of the known physicist Yakiv Mykhailovych Fogel, one of the leading experts in the physics of electronic and atomic collisions and physical electronics, the founder and the head of the Laboratory of Atomic Collisions at the Kharkiv Institute of Physics and Technology (KhIPT) of the National Academy of Sciences of Ukraine (NASU), the initiator of this physical direction at the Kharkiv State University, Doctor of Science in Physics and Mathematics, Professor. Ya.M. Fogel's name is connected with the elaboration of original facilities for x-ray diffraction analysis and mass-spectrography of molecular beams, the pioneer works in the physics of electronic and atomic collisions, the development of a new method for studying the processes that occur at the solid surface – the secondary ion mass-spectrometry (SIMS). His achievements in those scientific branches found a wide recognition both in our country and abroad.

Ya.M. Fogel was born on February 27, 1909, in a town of Lugansk (in the Ekaterinoslav province at that time) in a miner's family. Here, he graduated from a mechanical professional school and, in 1928, entered the Physico-Mathematical Faculty at the Kharkiv Institute of Physics, Chemistry, and Mathematics (now, the National Technical University "Kharkiv Polytechnical Institute"). In 1931, being a student, Ya.M. Fogel started his scientific activity at the Ukranian Institute of Physics and Technology, where, in 1932–1934, he was a participant of the researches, the first in the Soviet Union, dealing with the splitting of lithium and boron atomic nuclei.

In 1934–1940, Ya.M. Fogel worked as a senior scientific researcher at the Ukrainian Institute of Applied Chemistry. As early as that time, a certain feature revealed itself in his activity, which became later a key characteristic in all his following scientific work – the active search for new ideas and the development of nonconventional methods of study. The x-ray spectrographs and x-ray tubes with a high luminosity, which were the first in our country, were created with his participation. These devices allowed the pioneer works in the x-ray spectroscopy of alloys to be fulfilled. The results of those researches were generalized by Ya.M. Fogel in his Ph.D. thesis, which was defended in 1940.

Along with scientific researches, Ya.M. Fogel was actively engaged at that time in a pedagogical activity. He headed the Chair of Physics at the Kharkiv Hydrometeorological Institute. Under hard conditions of the war-time, the enthusiasm and an exclusive working ability of Ya.M. Fogel revealed themselves in full. He managed to provide the chair headed by him to work continuously and without interruption.

After the liberation of Kharkiv, Ya.M. Fogel returned back to the Ukrainian Institute of Physics and Technology. In 1943–1950, he studied issues connected with the magnetic focusing of particles with a magnetic moment and developed mass-spectrographs for molecular beams. This activity was stimulated by the problem of isotope separation, challenging at that time. In 1950, owing to the necessity to create ionic sources for electrostatic accelerators, Ya.M. Fogel began regular studies of elementary processes which run when atomic and molecular beams pass through rarefied and dense media. Long-term researches gave rise to the determination of characteristics of the process of one-electron recharge of positive ions. For the first time, the phenomenon of the capture of two electrons by positive ions in a single collision was found and studied. The processes of ionization, dissociative ionization, and recharging of two-atom molecules were studied in a wide range of collision velocities. The excitation functions of particles that are formed in elementary collision events were determined. Those researches made a large contribution to the development of the concept connected with mechanisms of atomic collision processes and provided a wide international recognition to Ya.M. Fogel.

In 1961, Ya.M. Fogel defended his doctoral thesis. Its contents generalized results obtained while studying the processes that generate negative ions at atomic collisions. On the basis of these data, Ya.M. Fogel's disciples proposed later and developed (for the first time in the world practice) a method for probing a hot plasma making use of accelerated beams of atomic particles (neutral atoms of hydrogen). This method, being based on the interaction (collisions) between the probing beam and plasma particles, was used to determine the key parameters (the density and the temperature) of plasma under investigation, in particular, in plasma fluxes (Kharkiv), in an "Alpha" installation (Leningrad), and in its modification (the Unites States). The following stage in the development of this method is the plasma probing by heavy-ion beams (cesium, thallium, and so on). Nowadays, this modification is widely used in modern thermonuclear installations (tokamaks and stellarators) throughout the world. Ya.M. Fogel's disciples use this technique to carry out measurements in Kharkiv (Ukraine), Moscow and Saint-Petersburg (Russia), Madrid (Spain), and Greifswald (Germany). It is also planned to be applied at the Joint European Torus (United Kingdom).

Along with the scientific and research activity, Ya.M. Fogel was engaged in a pedagogical one. From 1945 to 1958, he lectured at the Faculty of Physics and Mathematics of the Kharkiv Teachers College, and – from 1952, simultaneously – at the Kharkiv State University (now, the N. Karazin Kharkiv National University). From 1952 to 1973, he supervised over the yearly essays and degree works of university students.

Since 1960, Ya.M. Fogel had been the head of the laboratory of atomic collisions at the KhIPT of the Academy of Sciences of UkrSSR (AS UkrSSR). The secondary ion mass spectrometry method proposed by him made it possible to start intensive researches of the processes that occur at solid surfaces (adsorption, catalysis, gas and electrochemical corrosion, diffusion, and a number of others). Even the results of the first works revealed an exclusive potential of the new research method. For example, a new interpretation concerning the mechanism of such catalytic reactions important for industry as ammonia oxidation on platinum and ammonia synthesis on iron was suggested and substantiated. Possessing a wide scientific outlook, Ya.M. Fogel managed to estimate the importance of the method discovered by him for the whole country. With an energy and an enthusiasm inherent to him, he began to popularize and introduce this method at scientific institutions of the Soviet Union. In 1967, on the basis of his report, the Presidium of the AS UkrSSR passed a resolution about the necessity of the development of the secondary ion mass spectrometry method. Within short terms and with Ya.M. Fogel's personal participation, this research method was adopted at a good many scientific centers of our country. In particular, these are the E.O. Paton Institute of Electric Welding of the AS UkrSSR (Kyiv), the All-Union Institute of Single Crystals (Kharkiv), the All-Union Institute of Aviation Materials (Moscow), the Institute of Gas-Discharge Devices of the Ministry of Electronic Engineering (Ryazan, Russia), and others.

Ya.M. Fogel had an unquenchable thirst for knowledge and a large potential of scientific inquisitiveness. Working intensively and fruitfully as the head of a laboratory at the KhIPT, he was an initiator and a manager of researches in two directions at the Kharkiv State University in the 1960s: the interaction of fast electrons with molecules and damages in near-surface layers of solids and thin films induced by ionic irradiation. After a short period, the researches were extended by including the study of the interaction between medium-energy ions and solids; these are secondary ion emission (SIE) and ion-photon emission (IPE). In 1968, the pioneer research group at the

University served as a basis to create a task-oriented research laboratory for studying ionic processes, and Ya.M. Fogel became its first head and, then, a scientific manager.

The investigations of the interaction between fast electrons and atmospheric gases, which were started at this laboratory, were extended to include multiatomic molecules into consideration. As a result, a conclusion was drawn that the radiation emission by dissociation fragments plays a significant role. Therefore, according to Ya.M. Fogel's proposition, the researches of electron–molecule interaction processes were extended further to include the studies of dissociation fragment distributions over the degrees of freedom, as well as the processes of dissociative excitation of multiatomic molecules. These researches gave an important information about the redistribution of the energy, which was transferred by an electron to a molecule, within the molecule itself.

On Ya.M. Fogel's initiative, a comprehensive study of radiation-induced damages in thin metal films irradiated with medium-energy ions of various gases has been carried out at the task-oriented laboratory of the Kharkiv University since the beginning of the 1960s. Thin-film metal coatings subjected to ionic irradiation are widely used in various branches of engineering (microelectronics, space vehicles, a number of devices for thermonuclear reactors, etc.). That is why the results of this research dealing with radiation-induced defects emerged in thin metal films due to ionic irradiation are quite topical. Moreover, the thin films compose an absolutely new object to study, because a number of specific features in the defects' behavior, owing to dimensional effects, can be observed both in the course of defect generation and during the defect lifetime.

Since the mid-1960s, the task-oriented laboratory of the Kharkiv University study the processes running on solid surfaces making use of the SIMS method proposed by Ya.M. Fogel. Later on, those researches have been extended upon physico-chemical processes running in monomolecular and submonomolecular layers on metal and semiconductor surfaces, and at the metal–insulator–semiconductor interfaces (heterostructures). The results of those investigations were used at several leading scientific and industrial institutions throughout the country. For a cycle of those researches, Ya.M. Fogel's disciples were awarded in 1981 by the prize of the First Republican Competition on the best scientific research work that had been fulfilled at higher schools of the UkrSSR.

Besides the works devoted to a practical application of the SIE phenomenon to studying the physico-chemical processes at the solid surfaces, Ya.M. Fogel carried out a wide cycle of fundamental works aimed at researching the mechanism of SIE from metals, semiconductors, and insulators. In the same time period, Ya.M. Fogel put forward a new direction in the investigations of the interaction between medium-energy ions and solids. It is based on the analysis of the radiation emission by excited particles that leave the solid surface due to its irradiation with medium-energy ions (1–100 keV). Later on, this method was coined as ion-photon emission. It was an absolutely pioneering idea. Nevertheless, the researches of the IPE phenomenon have been extended considerably over the world already since the end of the 1960s. A large information content concerning the regularities of the IPE phenomenon has been collected. Unfortunately, the available experimental data cannot be described in the framework of a single IPE model. This circumstance is associated with a great complexity of the problem, because the parameters, which characterize a solid (the bond type and the electron structure), the dynamics of the interaction between particles of the irradiating beam and particles of the solid, as well as the parameters that characterize the excitation state of a leaving particle, has to be taken into consideration from the viewpoint of common ideas. These researches still remain to be actual, because the IPE phenomenon is the basis for the development of methods for quantitative and qualitative studies of compositions of solids with different origins, in particular, biological objects.

In 1962, Ya.M. Fogel created two new scientific groups at the Kharkiv Institute for Low Temperature Physics and Technology (KhILTPT) of the AS UkrSSR. One of them was aimed at developing a 200-keV proton-electron injector. The other dealt with the creation of a simulator of the vacuum ultra-violet (VUV) radiation of the Sun, which was intended for studying the action of the short-wave Sun's radiation on the materials of space vehicles. The functioning principles of a simulator were based on a new method proposed by Ya.M. Fogel for the electromagnetic radiation generation, namely, the excitation of a supersonic gas jet in vacuum with the help of a dense electron beam. Later on, the method was defended by three inventor's certificates. The uniqueness of the method consists in the capability to obtain the spectra of various substances in the jet that can be in different aggregate states belonging to the atom–cluster–microcrystal sequence. Then, owing to the new possibility, Ya.M. Fogel's disciples managed to establish the structural, electron, and emission properties of inert gas clusters in a wide dimension range and to trace the evolutions of the energy spectrum and the relaxation

processes on the quasicontinuous transition of atoms to a solid. In addition, a new type of radiation emission – polarization bremsstrahlung (PB) on the electron scattering by inert-gas atoms – which emerges due to the dynamic polarization of an atom in the field of an incident electron was discovered, and the regularities of PB and its electron component in the ultrasoft x-ray (USX) spectral range were found. For their discovery and researches, the Presidium of the NASU awarded Ya.M. Fogel's disciples the I. Pulyui Prize in 2003.

Today, various structural versions of the UVU and USX Sun's radiation simulators are used in testing the elements of space vehicles. In addition, the scientists of the KhILTPT of the NASU use them to study the structure and emission properties of mixed van der Waals clusters.

Intensively working in experimental physics, Ya.M. Fogel carried out a large scientific and managerial activity. For many years, he had been a member of Scientific Councils of the AS of the USSR on Physical Electronics and Plasma Physics and a member of the Spectroscopy Commission of the AS of the USSR. A reflection of active managerial activity of Ya.M. Fogel and a recognition of his outstanding contribution to a number of scientific branches is the fact that, for many years, he had been a member of the program and organizing committees of All-Union and International conferences on the physics of electronic and atomic collisions, emission electronics, collisions of atomic particles with a solid, and vacuum ultraviolet physics.

The quantitative yield of Ya.M. Fogel's activity is amazing. He published more than three hundred scientific papers, including several invention certificates. Ya.M. Fogel paid a large attention to the training of skilled scientific researchers. He was a supervisor over 28 Ph.D. theses successfully defended. For his great services to the Soviet science and for his scientific-pedagogical and active managerial activity, Ya.M. Fogel was awarded government awards.

Ya.M. Fogel had a universal scientific erudition. He was distinguished by his profound general culture. These qualities of Yakiv Mykhailovych manifested themselves most brightly at scientific seminars. The seminars headed by him were a school of scientific skill which worked like a clock-work. His "a few words" at the end of seminars were their invariable feature: after any report or discussion, Ya.M. Fogel precisely and shortly generalized all major things from that report. He also – and this is a cornerstone issue – determined the place of this work in a series of similar researches, told about the authors of those researches and about their other works. It is clear that only a scientist, who possesses the encyclopedic knowledge in a good many fields of science, can do it.

His work was marked by dynamism, zeal, and purposefulness. Yakiv Mykhailovych was a widely erudite person. He loved music and knew it well. W.A. Mozart was his favorite; especially, he enjoyed his symphonies. He knew painting well, and admired Rembrandt's portraits of old men. Ya.M. Fogel was well acquainted with motion-picture art. He spoke three foreign languages and read not only scientific, but also belletristic literature in French, German, and English. At the same time, Yakiv Mykhailovych was a modest, benevolent, and extremely sensitive person. For everyone, who was lucky to work together with Ya.M. Fogel, he will remain forever as an example of a creative unselfish service to his affair.

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and Ya.M. Fogel's disciples