OBITUARY

Igor Maximovich Podgorny May 11, 1925 – October 4, 2018

On September 4, 2018, Igor Maximovich Podgorny, the outstanding scientist, who made an enormous contribution to the study of the physical processes in laboratory and space plasma, left us. The purpose of his scientific work was to correctly understand what processes occur in nature and to tell about it clearly in reports and articles, completely ignoring the possibility of spoiling his career if the stated point of view contradicts the opinion of influential bosses. In scientific, public and other matters, he honestly said what he thought. He firmly defended his point of view and did not adapt to anyone, due to which he had very serious troubles several times. He worried when injustices occur. Over the past thirty years, people who knew his works and understood the situation, from time to time asked: "Why has your father still not become an academician? Perhaps he said something that did not need to say?" I replied that his goal was not to become an academician, but to properly understand physical phenomena and it would be much better for me to be the son of a truly enthusiastic man of science, rather than of careerist who holds a high position.

Igor Maximovich Podgorny is the Soviet and Russian physicist and astronomer. He is the participant of the Great Patriotic War. After graduating from Kharkov State University in 1951, he worked until 1967 at the Kurchatov Institute of Atomic Energy. He was the head of the laboratory. From 1967 to 1992, he worked at the Space Research Institute, first as a senior researcher, and then head of the department. Since 1992, he is leading researcher at the Institute of Astronomy, RAS. Doctor of Physical and Mathematical Sciences (1969), Professor (1990). He has lectured at the Moscow State University and the Moscow Institute of Physics and Technology. His students are famous scientists of Russia and many countries of the world. He is the author of more than three hundred works on laboratory and cosmic plasma physics, solar physics and cosmic rays. He has published four books, including Topics in plasma diagnostic (Plenum Press, 1967). He is winner of the Lenin Prize, he was awarded gold and two silver medals of the Exhibition of Achievements of National Economy. He was awarded the Order of Glory and the Order of the Patriotic War of the first degree.

Igor Maximovich was born on May 11, 1925 in the town Krasnodar. During his school years, his fascination with phenomena occurring in nature was supported by a physics teacher, who loved his subject very much. Igor made a telescope and observed the movement of Jupiter's satellites. In the city house of the pioneers, he made an electromagnetic gun, shooting with gramophone needles, for which he received the first prize at the city exhibition. When Igor was 11 years old, his father died. Igor performed various odd jobs to help the family. At the age of 17, Igor worked in the evenings as a laboratory technician at the Institute of Chemical Technology to support his mother, who was sick, and his young sister. He participated in the development and manufacture of light signaling for the connection of our aircraft with the Crimean partisans and in its testing on the runway under combat conditions. In August 1942, German troops occupied Krasnodar. Igor was seized by policemen in the market. Together with other young people he was hijacked to the Crimea, and then to Romania. He experienced all the horrors of fascist bondage. In 1944, taking advantage of the conflict between the Germans and the Romanians, he fled from the camp for the hijacked. He crossed the front, was checked in Smershe and the NKVD. After the restoration of health in the hospital, Igor joined the ranks of the Soviet army. He participated in the battles as the gunner of the heavy machine gun on the 2nd Belorussian Front as part of the 102th Guards Division, 316th Regiment.

After Torn (Poland) was taken, on 23 February 1945, in order to break through the deeply echeloned German defense, on the 2nd Belorussian Front, at first it was made reconnaissance, and then the very powerful artillery preparation and shelling of the German positions by our planes IL-2 on a low level flight. Igor, without attracting attention, read the Lord's prayer. The powerful defense of the enemy was defeated without loss. A successful throw to the West was stopped by the next line of the German defense. It was impossible to attack under the fire of machine guns knee-deep in the mud, and the asphalt road was defended by a German rapid-fire machine-gun, located in a concrete cap with a narrow horizontal slit. Igor, with his machine-gun group, crawled with a machine gun along the ditch and opened the direct fire on the embrasure, forcing the enemy's machine gun to silence. After the destruction of the enemy's firing point, our infantry was able, without obstacles, make an offensive on an asphalt road. For this feat, Igor was awarded the Order of Glory, this is the highest soldier's award, corresponding to the Order of St. George the Victorious established earlier in Russia.

Two heavy wounds interrupted Igor's participation in the war. Complicated operations, the care of doctors and 5 months in hospitals in Vitebsk. The war ended, Igor returned to Krasnodar and entered the Krasnodar Pedagogical Institute. Having finished the 1st course of the Physics Faculty of the Krasnodar Pedagogical Institute, he transferred, after passing the necessary exams, to the 2nd year of the Physics Faculty of Kharkov State University. Simultaneously with his studies, he worked as a laboratory assistant at the Kharkov Institute of Physics and Technology, where he completed 2 works that were commissioned by I. V. Kurchatov. In the Igor graduate work the effective sections loss of electrons due to charge exchange of Li and Na ions in the energy range $80 \div 220$ keV were determined. For the first time the cross sections of multiply charged ions creation due to charge exchange is measured.

After graduating from the University, I. V. Kurchatov took Igor to work at the Institute of Atomic Energy (at that time Laboratory No. 2), where he dealt with the problem of plasma confinement and heating for thermonuclear fusion.

As part of a team led by L. A. Artsimovich, Igor was the first to receive plasma in the laboratory with a temperature of 1,000,000 degrees and to detect neutron radiation in a deuterium discharge. The team of scientists who made this discovery was presented for awarding the Lenin Prize. A fundamentally new mechanism for the acceleration of particles in a high-power pulsed discharge with electric currents through an ionized gas of hundreds of thousands of amperes was discovered. Further investigation of this mechanism helped Igor to understand the physics of cosmic rays.

The idea of creating an electrodynamic plasma acceleration was proposed. The world's first electrodynamic accelerator was manufactured, designed to fill a magnetic trap with plasma. Now the scientists are trying to improve such an accelerator for use as a new space weapon. Igor demonstrated these results in Geneva at the Second International Conference on the Peaceful Uses of Atomic Energy in 1958. Subsequently, the electrodynamic accelerator was used to create a plasma flow in a laboratory simulation of the interaction of the solar wind with the Earth's magnetosphere.

Because of a false denunciation, Igor was in big trouble. Academician A.P. Aleksandrov, who became the director of the Atomic Energy Institute after Kurchatov's death, said that he forbids Igor to give lectures at Moscow State University and also demanded that he be given combat awards and a badge of the Lenin Prize to the Human Resources Department. Igor had no choice but to send Alexandrov away. The decision of the party committee fully supported Alexandrov's opinion. At various times, various scientists and cultural workers sent protests against this lawlessness to the CPSU Central Committee and the Government. Among them are academicians L. A. Artsimovich, V. A. Ambartsumian. S. N. Vernov, A. M. Budker, E. K. Zavoisky, writer S. S. Smirnov, Marshal K. K. Rokossovsky, pilot M. V. Vodopyanov and many others. Finally, the Prosecutor General of the USSR became interested in Igor's case. A full prosecutorial investigation was carried out, and according to the decision of the Supreme Court of the RSFSR to protect the honor and dignity, the Directorate of the Atomic Energy Institute had to refute the slanderous accusations.

Igor formulated the principle of limited simulation of cosmic phenomena, which was later used not only for laboratory simulation, but also for numerical simulation. According to this principle, the main processes occurring in space can be studied by simulation, if dimensionless parameters that are much more than unit (or much less than unit), should remain for simulation much more than unit (much less than unit), although exact preservation of these parameters is impossible. Model experiments showed the formation of a current sheet in the tail of magnetosphere, the magnetic energy of which is released during a substorm. The appearance of a shock wave in the frontal part due to the interaction of the supersonic and superalvenic solar wind stream with the magnetosphere is shown. For the southern component of the magnetic field in the solar wind directed against the dipole field, the experiment showed the appearance of a vertical current sheet behind the shock wave. In the sheet, the reconnection of magnetic lines takes place, which confirms Dungey's hypothesis about the movement of reconnected magnetic lines to the tail, contributing to the appearance of substorms. For the first time it is shown that for the northern component of the magnetic field, two current layers (two places of reconnection) appear above and below the dipoles, where the direction of the magnetic lines emerging from the poles of the dipole is opposite to the field direction in the solar wind. In such a situation, there will be no effective movement of magnetic lines in the tail of the magnetosphere; therefore, substorms occur much less frequently. Laboratory simulation allowed finding out, also, a number of more detail effects for the processes occurring in the magnetosphere. Laboratory simulation for bodies that do not have an own magnetic field has shown the correctness of Biermann's hypothesis on the magnetic nature of cometary tails. The flight of the Comet explorer spacecraft to the Giacobini-Zinner comet confirmed the data of this laboratory experiment.

Igor's laboratory installations were barbaric destroyed by the director of the Space Research Institute Sagdeev and the head of the laboratory Zeleny. They even refused to hand over the installation to the head of the laboratory of Osaka City University Shigeyuki Minami. S. Minami continued laboratory simulation, re-creating the installation. For this purpose, he invited Igor to work at Osaka City University for four months in 1991. The Hall electric field directed toward the Earth along the tail of the magnetosphere was measured, and a number of other studies were carried out.

The results of laboratory simulation made it possible for Igor to choose the trajectory and orientation of the Soviet-Bulgarian satellite Intercosmos Bulgaria-1300, for the most effective study of the processes occurring during substorms. Igor was the head of the scientific program Bulgaria-1300, the spacecraft was launched in August 7, 1981 with a polar circular orbit at the altitude of 900 km. Based on measurements of all components of the magnetic and electric fields, currents and particle fluxes in the field of field-aligned currents on magnetic lines emerging from the tail of the magnetosphere made on the Bulgaria-1300 spacecraft, Igor suggested an electrodynamical model of a substorm. According to this model, the Hall electric field in the current sheet of the tail causes field-aligned currents in the outgoing magnetic lines from the tail, which is closed by the Petersen current in the ionosphere.

Igor participated in the study of the interaction of the plasma flow with the interplanetary medium in the active space experiment FLUXUS.

By analogy with the electrodynamical model of a substorm, using the results of numerical simulation and observation, Igor proposed an electrodynamical model of a solar flare. The model is based on the release of energy accumulated in the magnetic field of the current sheet. For a flare, this is no longer the current sheet of the magnetosphere tail, but the sheet created during the accumulation of energy of slow disturbances in the vicinity of the X-type magnetic field singular line in the solar corona above the active region. The processes of release of magnetic energy for a solar flare and for a substorm proceed in a similar way. The electrons accelerated in the field-aligned currents by the Hall electric field, interacting with the lower dense layers of the solar atmosphere, cause beam hard X-ray emission. For the substorm, electrons, accelerated by the same way in field-aligned currents, cause aurora in the atmosphere of the Earth. The electrodynamical model of a solar flare explains all the main observational manifestations of a flare: the appearance of thermal soft X-ray emission in the corona and beam hard X-ray emission on the solar surface, coronal mass ejection, acceleration of protons to energies ~ 20 GeV by the electric field in the current sheet (origin of solar cosmic rays), the divergence of Hα ribbons in the lower layers of the solar atmosphere, the emergence of flaring magnetic arches, the appearance of

radio emission caused by electrons which are accelerated in field-aligned currents in the direction from the Sun.

By numerical magnetohydrodynamic simulation in the corona above the real active region, Igor showed the appearance of a current sheet in the corona, whose position coincides with the position of the observed source of thermal X-ray emission. The study of contemporary observations of ultraviolet radiation in lines excited in hot plasma has confirmed that flare energy release occurs high in the corona. Analysis of emission in the 94 Å line appearing in a plasma with a temperature of 6.3 million Kelvin (MK) which is higher than the temperature of corona (1 MK), but several times lower than the temperature in the place flare (20-30 MK) showed that in some cases the same structure of glow appears for a few dozen hours before the flare. Analysis of emission in the 94 Å line appearing in a plasma with a temperature of 6.3 million Kelvin (MK) which is higher than the temperature of corona (1 MK), but several times lower than the temperature in the place flare (20-30 MK) showed that in some cases the same structure of glow appears for a few dozen hours before the flare. The appearance of such a structure can be used as the precursor for solar flare prognosis. It is possible that this is a current sheet, but in the future it will need to be checked.

In studies carried out together with colleagues from the Polar Geophysical Institute (Apatity), Igor showed that the spectrum of protons accelerated in the current sheet coincides with the spectrum of solar cosmic rays obtained from analysis of the worldwide neutron monitor network measurements. The spectrum of protons accelerated in the current sheet was obtained by calculating the trajectories of particles in the electric and magnetic fields, taken from the results of magnetohydrodynamic simulation above the active region. The study of the particle acceleration mechanism during the flare and the analysis of solar cosmic ray measurements on the GOES spacecraft allowed Igor to conclude that generation of solar cosmic rays occurs during the explosive process of releasing the magnetic energy of the flare. Part of the accelerated particles can reach the observer in the region of the Earth orbit in transit time along the line of the interplanetary magnetic field, having the shape of an Archimedes spiral. The other part of the protons will travel in the interplanetary space for several days, scattering on magnetic inhomogeneities, and will be registered by the spacecraft in the region of the Earth orbit. The recent discovery by the Kepler spacecraft of giant flares on stars of dwarfs of class G with energy exceeding the energy of a large solar flare by 3 to 4 orders of magnitude showed that a similar mechanism seems to be responsible for galactic cosmic rays generation.

Despite the fact that he was 93 years old, and he was sick, Igor's passing out was completely unexpected for us. He had serious plans to study the solar flares, which he was going to fulfill. It is necessary to study the flare situation above the active region with high precision by comparing the results of accurate magnetohydrodynamic calculations in the solar corona with modern observations with high resolution in the X-ray and ultraviolet ranges. For this purpose, more accurate magnetohydrodynamic calculations are to be carried out. They will also allow for a more accurate investigation of how high-energy particles are accelerated and propagated – solar cosmic rays – the most interesting manifestation of solar flares. Two years ago, the consequences of the heavy wounds received in the war made themselves felt. Igor was difficult to move around, he had permission to work at home at the Institute of Astronomy of the Russian Academy of Sciences. He did not lose hope that he could be heal up, that it would become easier. He continued to actively engage in scientific work. A week before his death at the seminar at the University, Igor performed the report on the series of flares at September 2017, where he analyzed in detail the physical mechanism of the flare and the appearance of accelerated particles from the flare of September 10 occur abroad of the solar disk. But everything happened unexpectedly - the heart stopped. Now we have to fulfill his scientific plans.

Kingdom of heaven to Igor Maximovich. God rest the soul of Thy servant Igor and forgive him for his sins voluntary and involuntary.

Alexander Podgorny