Solomon Borisovich Pikel'ner (obituary)

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The prominent astrophysicist, Doctor of Physical and Mathematical Sciences and Moscow University Professor Solomon Borisovich Pikel'ner met a tragic and premature death on November 19, 1975.

Pikel'ner was born on February 6, 1921 at Baku. His father was an accountant, his mother a hospital assistant. His father died when the lad was 11 years old, and his mother moved to Tula with him and his youngest brother. Here Pikel'ner completed his schooling with distinction in 1938 and was accepted without examinations into the Mechanics and Mathematics Department of Moscow State University. In his very first year, he began to occupy himself enthusiastically with scientific work in the Astronomy and Geodetics Society (resulting in two student papers).

After graduating from Moscow State University in 1942, Pikel'ner began graduate studies, and in 1946 he defended his Candidate's Dissertation "Ejection of Atoms from the Sun and Stars by Radiation Pressure."

Since 1945, he had been working as a junior scientific colleague of the USSR Academy of Sciences Astrophysics Commission, which was preparing to rebuild the Crimean Observatory after its destruction in the war. It was here that he acquired his profound and lifelong interest in the problems of solar physics. There appears to be no fundamental problem of the physics of the solar atmosphere to whose solution Pikel'ner did not make a significant contribution.

Even in his earliest papers, which were concerned with the dissipation of atoms from stellar atmospheres, Pikel'ner reached the conclusion that stars have coronas in which temperature is determined by the gravitational potential at the surface of the star, while the density at the base of the corona depends on the power of a nonthermal heating mechanism. Many years later, the ideas that he advanced were to come to full fruition in the theory of the solar wind, in which Pikel'ner's calculated flux of particles dissipating from the sun was found to be close to the present-day estimate.

A major factor during the Crimean period of Pikel'ner's life was his collaboration with the prominent Soviet astrophysicist G. A. Shaĭn, whose scientific and human influence on Pikel'ner was tremendous. The second decisive line in Pikel'ner's scientific career—the physics of nebulae and the interstellar gas—can be traced to this collaboration.

Beginning with systematic observations of galactic nebulae on the nebular spectrograph, that extremely capricious and uncooperative instrument, Pikel'ner showed himself to be a highly skillful and subtle experimenter and observer. He could "squeeze" literally impossible results from this instrument. It is sufficient to note that certain features in the luminosity of nebulae that were reported then by Pikel'ner were not investigated until some years later on the 120-inch reflector in the USA.

Concurrently with these studies, Pikel'ner began a theoretical investigation of physical conditions in the interstellar medium. In a 1951 analysis of the problem of trapping of cosmic rays in the Galaxy, he became the first to suggest the existence of a galactic halo—an extended quasispherical formation filled with magnetic fields and relativistic particles. Later, he estimated the gas density, the velocities of the motions, and certain other parameters of the halo from the equilibrium conditions of a gas acted upon by the pressure of the field and the cosmic rays. The galactic-halo concept initiated various further studies, and to this day is an important factor, for example, in the development of various versions of the origin and propagation of cosmic rays.

During the same period, Pikel'ner constructed a theory of emission in a shock wave formed by the expanding shell of a supernova in the interstellar gas. He indicated a mechanism for the formation of the filamentary structure (focusing of the front by density fluctuations of the undisturbed gas) and calculated the structure of the wave and its emission spectrum. All of these problems formed the content of his doctorate thesis, "A Study of the Motion and Luminosity of the Interstellar Gas," which he defended in 1954.

In 1956, Pikel'ner developed an elegant method for estimating the magnetic fields and particle energies in radio sources—the residues of supernovas. Assuming that the relativistic electrons of the Crab Nebula are generated continuously (the pulsar discovered there in 1968 provided a brilliant confirmation for this hypothesis), he calculated the emission spectrum with consideration of synchrotron losses and the decrease in the energies of the particles during expansion of the shell of the nebula. It was found possible to estimate the field intensity from the break in the spectrum. This method was later put to extensive use in radio astronomy on a wide variety of objects. Another highly productive idea was explanation of the observed acceleration of the shells of young supernova residues as due to the pressure of the magnetic field and relativistic particles.

In 1959, Pikel'ner competed successfully for a position as a Professor in the Moscow State University Astrophysics Department and moved to Moscow. The height of Pikel'ner's creative career coincides with a significant change in the traditional outlook of astrophysics. He was one of the first astrophysicists to recognize the fundamental importance of plasma physics and magnetohydrodynamics for understanding of the nature of cosmic objects. Present-day astrophysics would be unthinkable without the use of these fundamental fields of physics, and Pikel'ner's work was to a significant degree responsible for the present state of cosmic electrodynamics and especially solar plasma physics. He was among the first to understand the importance of collisionless shock waves under astrophysical conditions. In 1965, he proposed the first theory of type II solar flares as radiation from collisionless shock waves passing through the solar atmosphere. Later he consistently explained the basic patterns in solar activity on the basis of magnetohydrodynamics and plasma astrophysics.

The active regions on the sun are characterized by high temperatures in the upper layers of the photosphere, high density of the chromosphere and corona, and the presence of a magnetic field that is substantially weaker than the field in the sun spots. Pikel'ner found the relationship among these properties. He showed that although the field is not sufficiently strong to stop convection at the base of the chromosphere, it is strong enough to suppress eddy viscosity and render convective motions stable. The result is an increase in the velocity of the motions and stronger generation of acoustic and other waves, which explains the anomalous brightness of the chromosphere and corona over faculae (flocculi and coronal condensations). This idea provided the key to the nature of the active regions and stimulated a whole series of later papers by Pikel'ner and his students, as well as by other investigators. An orderly and physical picture of solar chromospheric structure emerged as a result; in it, a distinction is drawn between fine structure (the numerous small filaments) and spicules, i.e., high dense columns of gas that rise at velocities up to 20 km/sec and then vanish. Pikel'ner explained the fine structure as a result of emergence of weak magnetic fields in the active regions. These fields break up into individual tubes as a result of interchange instability, and the gas in each tube is shielded from heating by the hot corona, since the field lowers the thermal conductivity across lines of force. Thus the chromosphere extends high into the tube but ends at a low height outside of the tube as a result of heating. Such filaments will emit if they are observed on the limb or absorb if they are projected against the sun's disk. This is what is indeed observed. Thus, the middle chromosphere is regarded as an aggregate of filaments separated by corona.

The formation of spicules is, according to Pikel'ner, governed by the action of magnetic forces. Convection shifts force lines, and lines of opposite directions approach close to one another at certain points. Ion-acoustic turbulence develops at these points, and the lines close with one another to form magnetic loops, which lift gas. The calculated rise velocity and field strength agree with observations.

The prominences were also explained naturally in this picture. In this case, it is necessary to understand the appearance of dense gas high in the corona, at the peaks of the arches formed by the magnetic lines of force. Pikel'ner showed that the appearance of magnetic-field arches changes thermal conditions in the corona in such a way that a flow of gas begins from the chromosphere into the corona and then moves along the line of force into a depression at the apex of the arch, where the gas is condensed. It is this that may be responsible for the formation of dense prominences. The continuous outflow of gas is offset by the induction of neutral atoms through the plasma from below and by the development of hydrodynamic instabilities.

The deep understanding of plasma physics that Pikel'ner "honed" in finding explanations for the basic phenomena of solar activity enabled him to take part in the development of the actual physical theory as well. Thus, he contributed to the creation of one of the first Langmuir-turbulence schemes. In one of the latter papers, which opened a new approach to explanation of chromospheric flares, Pikel'ner showed that the development of plasma turbulence in the current layer may accelerate the particles that are observed in flares. His solution of the hydrodynamic problem of flow of a layer of chromospheric plasma that is invaded by a beam of accelerated electrons made an important contribution to our understanding of secondary effects in solar flares.

In the middle 1960's, Pikel'ner addressed himself to analysis of physical conditions in the interstellar gas. The explanation of the heating and ionization of this gas by radiation from the stars had by that time become a classical and, it would appear, closed division of astrophysics. At the same time, radio observations did not agree with the models that had been accepted. Working from analysis of these observations, Pikel'ner submitted the radical hypothesis that soft cosmic or, as they are sometimes called, subcosmic rays and, in part, soft x-radiation constitute the principal agent ionizing the gas far from the stars. A calculation of the heating and ionization of the gas showed that its pressure depends on density in such a way that the gas should generally decay into two phases: a dense cold phase and a rarefied hot phase. The former describes interstellar clouds, and the latter the medium between clouds. This study altered the old picture of the structure of the interstellar medium and forced a review of all of its basic parameters: density, temperature, ionization state, etc. Observations that had not been understood previously were explained, e.g., the absorption of low-frequency radio emissions in the clouds, the absence of dense clouds between the arms of the Galaxy, etc. The new concepts of the interstellar medium that were proposed by Pikel'ner have now been generally accepted and have undergone substantial development in the work of many other authors.

Working from the new understanding of the properties of the interstellar medium, Pikel'ner then turned to the problem of star formation. He considered a shock wave formed in the spiral arms of the Galaxy by the relative motion of the gas rotating around the center and the spiral structure. He investigated instabilities that result in fragmentation of the gas, its compression by the shock wave, and its transformation into stars. It was found that the accumulation of gas in large complexes that arise as a result of Rayleigh-Taylor instability creates dense, cold regions where fragmentation takes place, this time as a result of gravitational instability. Stars with small masses can also be formed in this process—a difficulty in earlier evaluations, which had not taken account of the possibility of strong cooling.

During the last few years of his life, Pikel'ner's scientific interest continued to embrace new areas. A far from complete listing of the problems that he considered would include the formation of bars in spiral galaxies, the astrophysical aspects of quarks, the origin of magnetic stars, observational cosmology.

Pikel'ner had the ability to construct a picture of a complex astrophysical phenomenon, "on his fingertips." Many of his ideas were simple, almost obvious, but this "simplicity" grew out of the incisiveness and profound physicality of his thinking. Another important quality of his scientific style was his astonishing skill in working a tangled pattern of facts into an ordered scheme that would make it possible to explain these facts from a unified standpoint.

During his comparatively short life—he did not reach his 55th birthday—Pikel'ner not only wrote about 150 scientific papers and monographs on a broad range of problems—from the physics of the solar atmosphere to problems of galactic structure and the cosmogony of the galaxies—but also taught dozens of students who became Candidates and Doctors of Sciences. Others found him attractive for his harmonic blending of high scientific and human qualities, his fortunate legacy from his teacher Grigoriĭ Abramovich Shaĭn. "Shain was not only an outstanding scientist," wrote Pikel'ner, "but also a remarkable man; he was exceptionally modest and devoted his entire life to science, was principled and strict in his convictions, which he never altered and adhered to firmly in his activity." These words apply in full measure to Pikel'ner himself, and we must add that where his fundamental scientific and human convictions were not affected, Pikel'ner was gentle, surprisingly deferential, magnanimous and benevolent to the point of self-sacrifice. It was natural that this rare combination of scientific and human qualities would literally draw people to him.

The world scientific community valued Pikel'ner's great contribution to modern astrophysics. For example, in March of 1971 he was elected a foreign member of the British Royal Astronomical Society. He was president of the commission of the International Astronomical Union on the interstellar medium, a member of the IAU Commissions on Magnetohydrodynamics and the Physics of Ionized Gases and of the IAU Commission on the Interplanetary Plasma and the Heliosphere, a member and President of the steering committees of many international symposia, and a member of the editorial staffs of four international journals. For a long time, he served as chairman of the "Cosmic Plasma" section of the USSR Academy of Sciences Council on Plasma, as well as a member of the editorial staff of the journal "Geomagnetizm i Aeronomiya." It is not possible to do justice to the role that he played as a member of the editorial staff and responsible secretary of the "Astronomicheskiĭ Zhurnal."

Pikel'ner gave much of his time to teaching, presenting the basic astrophysics courses at Moscow State University and supervising numerous students and graduates. His uncommon dedication to purpose and his astonishing ability to make use of every free minute enabled him to leave a profound imprint on his science in spite of his numerous obligations.

Sudden death cut him down in the prime of life. He was full of plans for new papers, articles, books... .

Happily, Pikel'ner was allowed time to accomplish a great deal, and his total contribution to astrophysics was so considerable as to be of lasting value. In the grateful memory of those who knew him personally, Pikel'ner will remain forever as a model of an exceptionally kind, high-minded and benevolent human being.

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Anatoliĭ Aleksandrovich Vlasov (obituary)

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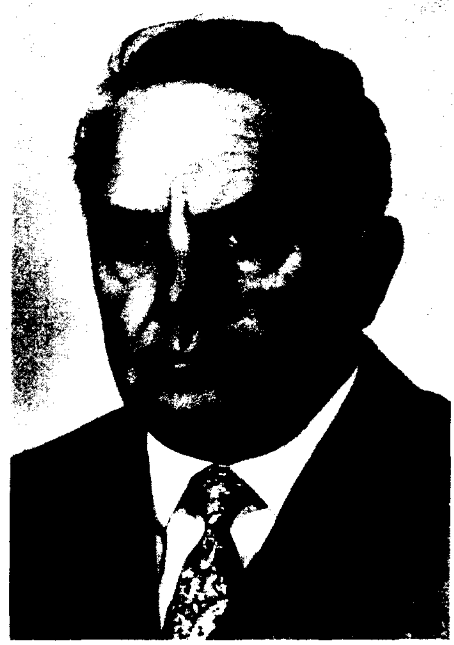
Anatoliĭ Alesandrovich Vlasov, a prominent theoretical physicist, a member of the Communist Party of the Soviet Union since 1944, a Lenin Prize Laureate, Doctor of Physical and Mathematical Sciences and a Professor in the Physics Department of Moscow State University, died on December 22, 1975, in his 68th year, after a grave illness.

Vlasov devoted more than 40 years of his life to the service of Soviet science and the education of youth. Vlasov's kinetic equation, which is the basis for statistical analysis of the properties of plasma, has become a part of the treasury of world science. His numerous students include dozens of prominent scientists—Candidates and Doctors of the Physicomathematical Sciences.

Vlasov was borne at Balashov, Saratov Oblast', on August 20, 1908 into the family of a steamfitter. He completed his intermediate schooling at Balashov and entered Moscow University in 1927 as a student in the Physics and Mathematics Department. After his graduation in 1931, he was accepted as a graduate student. In 1934, he defended his Candidate's Dissertation "On the Quantum-Mechanical Problem of Interaction," and stayed on as a senior scientific collaborator of the Moscow State University Scientific Research Institute of Physics. From 1934 to 1936 he worked in theoretical optics, developing a theory of spectral-line width based on consideration of molecular interaction. These studies gave impetus to many experimental and theoretical studies by Soviet and foreign authors.



Vlasov's paper "On the Vibrational Properties of the Electron Gas," which contained the first thorough analysis of the physical properties of charged particles (plasma), demonstrated that Boltzmann's gaskinetic equation cannot be applied to them, and proposed a new kinetic equation (now known as the Vlasov equation) that takes account of collective interactions between the charged particles, was published in the Soviet Journal of Experimental and Theoretical Physics in 1938. Vlasov was the first to recognize the nature of the interaction among plasma particles, which is qualitatively different from the interaction in an ordinary gas, and concluded even at that early date that "the plasma is not a gas, but a unique system that is held together by long-range forces." This paper formed the basis for Vlasov's doctoral thesis, which he defended in 1942.

