Sergei Ivanovich Syrovatskiĭ (Obituary)

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Sergei Ivanovich Syrovatskiĭ, prominent physicist, Doctor of Physicomathematical Sciences, Group Leader in the Division of Theoretical Physics of the I. E. Tamm Physics Insititue of the Academy of Sciences of the USSR, and Processor of the Moscow Physicotechnical Institute, died in his fifty-fifth year on September 26, 1979. He was an outstanding theoretician and was responsible for many fundamental results in various branches of space and plasma physics, and was the author of about two hundred papers and two monographs.

S. I. Syrovatskiĭ was born on March 2, 1925 in Bereznegovatoye in the Nikolaevsk Region into a family of scientists. In 1941, at the age of sixteen, he joined the active army and was wounded four times. In the course of his war service, he was twice awarded the Order of the Red Star.

After graduating from the Physics Faculty of Moscow State University in 1951, S. I. Syrovatskiĭ was admitted to graduate studies in the Theoretical Division of the Physics Institute of the Academy of Sciences, where he worked under the direction of S. Z. Belen'kiĭ. His first papers were devoted to magnetohydrodynamics. He put forward a closed set of equations in the form of conservation laws, and used it to classify possible types of discontinuity surfaces and shock waves. He established the existence of discontinuities in magnetohydrodynamics that were different from those in ordinary hydrodynamics.

Important results, subsequently widely used in space physics, were obtained by him as a result of studies of the stability of tangential magnetohydrodynamic discontinuities. At the same time, he generalized the analogous solution obtained by other authors for compressible fluids in ordinary hydrodynamics. He pointed out the instability of certain types of shock wave with respect to splitting into other discontinuities, and determined the structure of low-intensity shock waves. This series of papers also includes the discovery of a class of exact solutions of the equations of magnetohydrodynamics corresponding to the motion of the medium in the direction of an arbitrary magnetic field. This type of solution has turned out to be very important in elucidating the properties of real MHD flows. S. I. Syrovatskiĭ's papers on the expulsion of a sphere or a cylinder with arbitrary orientation relative to the magnetic field have found direct practical applications. These results were used in the design of magnetohydrodynamic separators for mechanical mixtures.

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The next group of papers published by S. I. Syrovatskiĭ was devoted to radioastronomy. This work was concerned with the development of the theory of synchrotron radiation in space, and is widely known. He put forward a method for calculating the intensity of synchrotron radiation with allowance for inhomogeneous distribution, diffusion, and energy losses by electrons. He then applied this method to the radioemission by the galatic halo and to the elucidation of the origin of the radiating electrons. These calculations showed that, of the two familiar assumptions about the origin of relativistic electrons in the Galaxy, i.e., direct acceleration in sources or appearance in the form of secondary products resulting from nuclear interactions of cosmic rays, only the former was satisfactory. This conclusion is important in cosmic-ray astrophysics and is currently widely used in world literature.

S. I. Syrovatskiĭ also derived and investigated the equations for the transformation of radioemission spectra resulting from energy losses by radiating electrons. This enabled him to estimate the age of cosmic radioemission sources in several instances. He investigated the polarization properties of synchrotron radioation emitted by ultrarelativistic electrons. He demonstrated the absence of elliptic polarization, and determined the connection between polarization and magnetic field inhomogeneity.

S. I. Syrovatskiĭ obtained many important new results in cosmic-ray astrophysics. Thus, he pointed out (in a paper written together with A. A. Korchak) the mechanism responsible for the preferential acceleration of heavy ions. This mechanism may well be operative in the envelopes of supernovas and on the sun during flares. In two other papers, S. I. Syrovatskiĭ showed that the

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cosmic-ray spectrum leaving the source may be universal, i.e., independent of the spectrum of relativistic particles in the source. This occurs when quasistationary equilibrium is established in the source with sufficient rapidity and is such that the magnetic energy density, the energy of the cosmic rays, and the kinetic energy associated with the turbulent motion of the gas are all equal. S. I. Syrovatskiĭ devoted major effort to the analysis of the chemical composition of cosmic rays and of their transformation as they traverse interstellar space. In gamma- and x-ray astronomy, he obtained a number of important results on the spectrum and intensity of electromagnetic radiation emitted in a number of different processes.

In collaboration with V. L. Ginzburg, S. I. Syrovatskiĭ frequently analyzed general problems in the theory of the origin of cosmic rays and reported these results in many reviews, in papers read to international and All-Union conferences, and also in the monograph "The origin of cosmic rays."

In recent years, S. I. Syrovatskiĭ concentrated his attention on the behavior of plasmas in strong frozen-in magnetic fields and the associated problem of the generation of fast particles in a nonstationary plasma. He discovered certain types of magneto-hydrodynamic flow of plasma in nonuniform magnetic fields, which led to a peculiar cumulative effect corresponding to the appearance of neutral current layers and the conversion of some of the magnetic energy into the energy of accelerated particles. His work in this field laid the foundations for the explanation of phenomena such as fast rearrangement of magnetic fields in well-conducting media, the appearance of accelerated particles and cosmic rays during solar flares, and the generation of cosmic rays in the turbulent magnetic fields of supernova envelopes, nonstationary galactic nuclei, and quasars. An experiment performed under the direction of S. I. Syrovatskiĭ confirmed the theoretical calculations. Thus, cumulative plasma flow near the zero line was achieved under laboratory conditions and a pinch current layer and pulsed acceleration of particles during its disintegration were produced. In solar physics, S. I. Syrovatskiĭ rapidly assumed a leading position, both in the Soviet and international commissions, councils and editorial boards of scientific journals.

Great talent, outstanding qualifications, and scientific integrity were the hallmarks of S. I. Syrovatskiĭ's style. He has great authority and his opinions were regarded with great respect in scientific discussions. S. I. Syrovatskiĭ established an atmosphere of sympathetic mutual respect but, at the same time, he was decisive and of strong character. His attitude to specific scientific problems and to people was always clear although perhaps somewhat diffident and reserved.

S. I. Syrovatskiĭ devoted much of his time to the education of young scientists and to teaching and lecturing as Professor at the Moscow Physicotechnical Institute. His pupils and successors can be found in many scientific centers of our country. After participating in the work of a number of seminars, S. I. Syrovatskiĭ organized some years ago a new seminar on space electrodynamics. In addition to his collaborators, the seminar attracted specialists in solar physics, high-energy astrophysics, plasma physics, and hydrodynamics from other Moscow institutes and often from other towns.

In recent years, S. I. Syrovatskiĭ was very ill but he did not allow this to reduce his scientific activity. On the contrary, we has even more active. He had many plans and ideas, and he genuinely loved science. The phrase, "he devoted his life to science" is not a cliché when applied to S. I. Syrovatskiĭ. It was literally true.

The premature death of Sergei Ivanovich Syrovatskiĭ is a heavy loss to physics, to astrophysics, and to his friends, pupils, collaborators, and all those who knew him.

Translated by S. Chomet