OBITUARY

VADIM ANATOL'EVICH ANTONOV

B. P. Kondrat'ev and L. P. Osipkov

On July 8, 2010, the outstanding theoretical astronomer, doctor of physical and mathematical sciences, Professor Vadim Anatol'evich Antonov passed away at the age of 78.

Vadim Anatol'evich was born on May 20, 1933, in Perm. In 1955 he completed his studies at the Molotov (Perm) State University with a major in biology and he worked until 1960 at the Agricultural Research Institute. At the same time, he studied mathematics, physics, and astronomy seriously, and began to read the journal *Astronomicheskii Zhurnal*. Boltzmann's "Lectures on the Theory of Gases" had a strong influence on Antonov. Having familiarized himself with the articles by Prof. K. F. Ogorodnikov on the dynamics of stellar systems, he sent him a letter with some comments. After the ensuing scientific correspondence, Ogorodnikov invited Antonov to pursue postgraduate studies at Leningrad State University. This was a major change in his life.

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During the years of his postgraduate studies, Antonov published three articles which laid the foundations for a new area of stellar dynamics—the theory of the stability of stellar systems. In 1964 he defended his candidate's dissertation “Applications of the variational method to stellar dynamics and some other problems.” It is unfortunate that part of the dissertation was never published. For example, a quantity, known as the quasi-entropy, which determines the direction of the collisionless evolution of stellar systems, was introduced there. Nowadays, this quantity is known as the H-functional of Tremaine, Henon, and Lynden-Bell (1980).

After completing his postgraduate studies, Antonov worked at Leningrad University through 1989. The topics of his research expanded greatly and his two full reviews in the series *Itogi nauki* (Progress in Science) on equilibrium figures and stellar orbits became handbooks for specialists. He obtained a number of fundamental results in the general theory of dynamic systems and the theory of orbits which led to his doctoral dissertation. In reviews of the latter it was pointed out that Antonov's only predecessor was W. R. Hamilton.

In 1989 Vadim Anatol'evich moved to the Institute of Theoretical Astronomy of the USSR Academy of Sciences and began to develop the theory of local invariants which generalize the integrals of motion. After the ITA was closed in 1998, Antonov became a staff member of the Main Astronomical Observatory in Pulkovo. At that time he began some fruitful work in the problems of geodynamics and the dynamics of the interstellar medium. Together with B. P. Kondrat'ev he proved that, contrary to prevailing opinion, the tidal field of the moon has almost no effect on the motion of the earth's inner core, and discovered some serious errors in the mechanism that was generally accepted at that time for the propagation of ultralong waves on fractures in the earth's lithosphere.

A large number of Antonov's papers are concerned with detailed analysis of problems in the newly arising science of self consistent models for stellar systems and stellar orbits in various potential fields. During the 1970's he developed a method of Lagrange displacements in phase space for studying the stability of uniform models of stellar systems (such as homogeneous spheres or ellipsoids). Then Antonov extended the method of Lagrange displacements to nonlinear oscillations of stellar systems. Here he demonstrated the instability of spherical stellar systems with purely radial orbits for the stars and, together with his student S. N. Nuritdinov, studied radially oscillating homogeneous spheres. It is remarkable how this was done: under a space-time transformation, the problem reduces to finding the equilibrium of a nominal model, for which a study of its linear stability represents an analysis of the stability of nonlinear oscillations. Today, this sort of model plays an important role in studies of the evolution of galaxies.

Antonov's work on the theory of the stability of stellar systems was best known. He developed a variational method for studying the stability of spherical stellar systems with an isotropic velocity distribution and proved that the stability can be threatened only by perturbations which do not disrupt the spherical symmetry. A hydrodynamic analogy was developed, according to which the stability problem for a stellar system can be reduced to a substantially simpler problem of the stability of a gaseous system. Antonov's major results have been summarized in the form of “Antonov's four laws” by J. Binney and S. Tremaine in their basic book, *Galactic Dynamics*. Antonov's 1962 article, “The most probable phase distribution in spherical stellar systems and the conditions for its existence,” a continuation of K. F. Ogorodnikov's work on the statistical mechanics of stellar systems, received many responses. In this paper, beginning with the law of increasing entropy, Vadim Anatol'evich proved that (a) there is no absolute maximum entropy in gravitating systems and (b) a maxwellian velocity distribution corresponds to a relative maximum only if the contrast in density between the central and edge parts of the system is no greater than a critical value of 708.61.

If, on the other hand, the density contrast exceeds this value, then the system will be compressed without limit. This paper made a great impression on the Cambridge astrophysicist D. Lynden-Bell. In 1968, after five years of doubt, he explained the significance of the phenomenon discovered by Antonov and referred to it as a “gravothermal catastrophe.” This sort of catastrophe determines the final evolution of stellar clusters and the discovery in 1983 of gravothermal oscillations by Sugimoto and Bettwieser is one of its consequences.

Antonov’s work on the theory of dynamic systems was less noticed. Following H. Poincaré and G. D. Birkhoff, he examined the theory of area-conserving twisting transformations of a ring. Antonov’s theory, in particular, yielded a new method of finding periodic orbits in stellar systems.

In a number of papers V. A. Antonov developed gravitational potential theory and employed it for modelling the gravitational fields of the earth and planets. The basic results of these studies are reflected in the books “Introduction to the Theory of the Newtonian Potential,” by V. A. Antonov, E. I. Timoshkova, and K. V. Kholshevnikov (1988), and “Elements of Gravitational Potential Theory and some Cases in which it is Expressed Explicitly,” by V. A. Antonov, I. I. Nikiforov, and K. V. Kholshevnikov (2009).

It is impossible here to describe, even briefly, Antonov’s work on the theory of phase mixing in stellar systems (together with L. P. Osipkov), on the magnetohydrodynamic theory of gaseous galactic disks (together with O. A. Zheleznyak), the dynamics of protoplanetary clouds (together with A. S. Baranov), the destruction of cometary clouds (together with Z. P. Todriya), the three body problem (together with A. D. Chernin), the theory of random processes, the theory of tidal interactions, theoretical optics, etc. Together with B. P. Kondrat’ev, he published a number of papers devoted to the foundations of quantum mechanics, including a book, *Solving the Paradox of Schroedinger’s Cat. An Attempt to Construct a Nonlinear Quantum Mechanics* (1994).

V. A. Antonov’s talent was multifaceted. He had many students and the number of researchers in stellar dynamics and celestial mechanics who have been influenced by him is impressive. Whatever Antonov did in science and in life, he was always independent and original. In 1978 Leningrad University gave him its first prize “For the best paper of the year.” In 2008 the Pulkovo Observatory awarded him its Struve Medal. Vadim Anatol’evich is the only Russian Astronomer to whom the Division of Dynamical Astronomy of the American Astronomical Society has given (in 1999) its Brouwer award.

The passing of V. A. Antonov is an irreplaceable loss for Russian and world science.