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VLADIMIR VASIL'YEVICH BELETSKII (on the occasion of his 70th birthday)†

On 2nd May 2000, one of the founders of the modern mechanics of space flight, Doctor of Physical and Mathematical Sciences, Professor and Corresponding Member of the Russian Academy of Sciences, Vladimir Vasil'yevich Beletskii, celebrated his 70th birthday.

The scientific interests of Professor Beletskii are multifaceted. He is credited with formulating and solving problems of the mechanics of rotational motion of spacecraft and the theory of space tether systems. His investigations of non-linear problems of celestial mechanics, the dynamics of biped robots, deterministic chaos in applied problems of solid-state dynamics and dynamical billiards have also received world-wide recognition.

He was born in Irkutsk. His childhood was spent in this town and in villages on the banks of the Angara and Baikal. In 1949, he left secondary school with a Gold Medal and the Honorary Certificate of the Central Committee of the Leninist Young Communist League, a fairly rare award in those days, related primarily to the active work of pupils in the restoration of Smolensk. In the same year, he entered the Mechanics and Mathematics Faculty of Moscow State University (MGU). The brilliant professors of mechanics and mathematics of those years instilled in him a passion for scientific research that has lasted to this day. His diploma, carried out under the supervision of Professor A. A. Kosmodem'yanskii, was published 20 years later, but lost none of its relevance during this time.

Graduating from the MGU in 1954 with distinction, he was assigned work in the Department of Applied Mathematics of the V. A. Steklov Mathematical Institute of the Academy of Sciences of the USSR; the Department was founded by M. V. Keldysh (now the M. V. Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences). This determined his scientific career as one of the group of seven brilliant scientists of the world renowned School of Space Flight Dynamics, founded by Keldysh and Okhotsimskii.

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At the end of the 1950s and the beginning of the 1960s, he carried out a cycle of investigations of unique innovation and volume into the motion of artificial satellites about a centre of mass under the action of the disturbing moments arising in flight, thereby opening up a new area in solid-state dynamics.

His first investigations were already well known and had gained the recognition of specialists in the field. For example, on 14th September 1956, Keldysh, in his paper (at that time, classified) at a session of the Praesidium of the USSR Academy of Sciences, on the stability of relative equilibrium of a satellite in orbit, remarked "... This most interesting problem of solid-state mechanics has been solved entirely by my young colleague V. V. Beletskii in the Department of Applied Mathematics".

The results of these investigations were summed up in a monograph of 1965 which, having been translated into English, is to this day a reference book for specialists. The main results of this group of studies are as follows. The theorem on the conditions of stability of the relative equilibrium of a satellite in a gravitational field was proved. The theory of the vibrations of a satellite in an elliptic orbit under the action of the moment of the gravity gradient was developed. The problem was formulated and the theory was developed concerning the evolution of rotation of satellites under the influence of disturbing moments caused by the gravity gradient and the influence of the Earth's magnetic field, the atmosphere and light pressure forces. This theory was used to describe the motion of many specific satellites. The surprisingly fine evolution of the rotation of satellites of the Proton and Prognoz type was discovered, for example. An investigation was made into the possibility of stabilization along a magnetic line of force of a satellite possessing its own magnetic moment, which was used, among many other things, to describe the motion of small spacecraft in the Active and Apex international projects. He was the first to formulate and examine the problem of the dynamics of "coupled" orbital bodies as a system with a releasing link. This problem was used as a model of the dynamics of projected and now launched orbital tether systems. The impact nature of connecting up in these systems can lead to chaotization of motions ("dynamical billiards").

During those years, he was the first world-wide to formulate the general problem of determining the actual orientation of a satellite and defining more accurately the parameters of the disturbing moments acting on it from the measurement data provided by orientation sensors onboard. He developed and used an effective procedure for solving this problem (the third Soviet artificial satellite, the Proton satellite). This approach is being used successfully to this day.

He obtained fundamental results in investigating the evolution of the orbit of a spacecraft under a small disturbing acceleration. He obtained approximate analytical solutions of the problem of the spiral acceleration of a satellite with a low-thrust engine with a circular to parabolic orbit and the problem of the optimum interplanetary flight of a low-thrust spacecraft.

These investigations are of great practical importance in relation to the launching in recent years of experimental spacecraft with ion-plasma jet engines and the prospects of using solar panels.

Possessing a fertile imagination and a well-developed sense of humour, from time to time he sets, solves and publishes problems that could be classified as science fiction were it not for the mathematically rigorous proofs of the feasibility of these proposals that he provides. Thus, he thought up the "gravilet" – a method of manoeuvring a spacecraft in a gravitational field without loss of mass on board merely by changing the dimensions or orientation of the spacecraft. He suggested that a space station in the neighbourhood of the libration point of the Earth–moon system could be stabilized (to prevent it flying away) by tying it to the moon with a tether (60 000 km long!). Analysing his theorem of the stability of a body (satellite) in orbit in a gravitational field, he obtained the constraints on the size of the body: for example, a dumbbell-shaped satellite is stable if its half-length does not exceed the radius of the orbit of its centre of mass by more than a factor of $\sqrt{3}-\sqrt{2}$. Otherwise it is unstable. Another result of this kind showed that a certain ring of flexible thread around the Earth is stable at a certain ring radius and law of stretchability. This law of stretchability is quite distinct from Hooke's law, according to which the ring is unstable.

From the start of the 1970s onwards, he carried out a group of investigations on non-linear problems of the dynamics of the rotational motion of satellites and planets taking into account existing resonances in their orbital and rotational motion, and also the influence of the dissipation of energy (the tidal effect) on the formation of the present pattern of the rotation of the planets, taking the probabilities of trapping in existing resonances into account. We will note here only one remarkable fundamental result: the creation of the resonance theory of "generalized Cassini laws" of the rotation of the planets, which gives a rigorous validation of Cassini's empirical laws of rotation of the moon (1693) and thereby closes a 300 year old problem which occupied Lagrange and Laplace.

His remarkable scientific achievements include the monograph *Essays on the Motion of Cosmic Bodies* (2nd edition published in 1977), which has been translated into many languages. In this work he combined what had hitherto seemed incompatible – a mathematically rigorous presentation of the analysis of the finest problems in space dynamics (most of which belong to the author) in the form of an engrossing literary composition. This, in the words of V. I. Arnol'd and Ya. B. Zel'dovich, was the "start of a new style of scientific literature".

He has published over 200 scientific works, including 10 monographs that have been reprinted at home and abroad. His works are easy to read because they are written with a regard for the reader and combine a rigour of analysis and an excellent style of presentation.

He has fruitfully combined his many years of scientific activity at the V. V. Keldysh Institute of Applied Mathematics with teaching, being a professor in the Department of Theoretical Mechanics of the Mechanics and Mathematics Faculty of MGU. Among his students there have been over 25 masters and doctors of sciences. The dissertations prepared under his supervision are noted for the innovative nature of the problems discussed, the originality of results and their practical significance.

His scientific achievements have been recognized both in Russia and abroad. He is a corresponding member of the Russian Academy of Sciences, a member of the National Committee on Theoretical and Applied Mechanics, a member of the International Academy of Astronautics, a winner of the von Humboldt prize (Germany) and a winner of the F. A. Tsander prize of the Russian Academy of Sciences. Among his awards is the M. V. Keldysh medal of the USSR Federation of Astronautics.

Many years ago, a remarkable Irkutsk doctor saved his life but was unable to give him back his hearing. Professor Beletskii possesses a rare quality: he is able to listen to people and is ready to come to the aid of anyone in need of help. He does not confine himself to his scientific interests but also loves poetry and painting, nature, travel and socializing, where he always exhibits his friendliness, humour and love of life.

The editorial staff and editorial board of *Applied Mathematics and Mechanics* and his students and friends wish him good health, a long life and further scientific achievements.

A LIST OF THE SCIENTIFIC PUBLICATIONS BY V. V. BELETSKII

1956

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1957

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1958

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1959

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1961

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