

Preface to the Second Edition

The first edition of this book was published in 1987. Since that time new scientific and practical results in application of Jacobi dynamics were obtained. The results, which we include into the second edition, are as follows.

The oldest scientific problem of the origin and evolution of the Solar System bodies on the basis of the Jacobi's oscillating dynamics has found its resolution. We discovered by calculation that the present day orbital velocity of each planet is equal to the first cosmic velocity of the contracting Protosun having its radius reduced to the semi-major axis of the planet's orbit. And also the orbital velocities of the planet's moons are equal to the first cosmic velocities of the corresponding protoplanets having their radiuses successively reduced to the semi-major axes of the moon's orbits. It looks like the protoplanets and their protosatellites were created from the separating upper shells of their contracting parents. The Sun itself and the small bodies like the comets, asteroids, meteors and so on, have the same history of creation.

The discovered mechanism of the Solar System body creation proves to be the physical basis of the Kepler's laws and the inverse square distance law of the outer force field distribution of a self-gravitating body. It also proves the idea that the 'heavens power of gravity' of body's orbital motion has the electromagnetic nature and is induced by the parental body.

We succeeded in understanding physical meaning of the Jacobi's virial equation obtained from the Newton's equations of motion written for a system of n interacting mass-particles. It was found that in his n -body problem, Jacobi, while transforming the initial equations, has converted the Newton's forces and moments of the interacting particles into their volumetric values, namely, into the energy and oscillating moment of inertia. Doing like this, Jacobi has changed the force as a measure of the particles interaction by energy of their interaction. From physical viewpoint Jacobi's approach opens the way to search the common nature for all the known physical models of the matter interaction. In order to prove this idea, we show in the book that the Jacobi's virial equation, besides the Newton's equations, is also derived from the equations of Euler, Hamilton, Einstein and quantum mechanics. This allowed us to put the subtitle of the book as a 'Unified theory of the interacting matter motion'.

We discuss in the book the main scientific discovery, made by the geodetic artificial satellite study that the Earth and the Moon do not stay in hydrostatic equilibrium. It puzzles us because the hydrostatics, up to now, is accepted as the physical basis in dynamics of stars, planets and other celestial bodies. In addition to this, we found that the Earth has no equilibrium between the kinetic and potential energy ($K/U \approx 1/300$). This is because the existing theories in dynamics do not take into account the kinetic energy of the body's interacting mass particles. It makes incorrect formulation of the problem of the equilibrium state. The conclusion is made that the conditions of the dynamical equilibrium state, as an alternative to the hydrostatics, in celestial mechanics, stellar dynamics and astrophysics should be introduced.

We found that the above fundamental effects are well explained by the theory of Jacobi dynamics which considers just self-gravitating, but not hydrostatically state systems and where relationship between the energy and the polar moment of inertia is the basic physical effect. In this connection this problem and physical meaning of the Jacobi's virial equation in the new Chapter 2 are discussed. In order to demonstrate all new effects in dynamics of stars, planets and satellites, including creation and evolution of the Solar system, Chaps. 6, 7, and 8 were revised and updated by applying the above discoveries. Also, the new Chap. "The Nature of Electromagnetic Field of a Celestial Body and Mechanism of Its Energy Generation" is introduced. The former Chaps. 1, 2, 3, 4, and 5 under new numbers were as a whole preserved. The second edition was prepared by V.I. Ferronsky.

V.I. Ferronsky

Preface to the First Edition

This book sets forth and builds upon the fundamentals of the dynamics of natural systems in formulating the problem presented by Jacobi in his famous lecture series “Vorlesung über Dynamik” (Jacobi 1884).

In the dynamics of systems described by models of discrete and continuous media, the many-body problem is usually solved in some approximation, or the behavior of the medium is studied at each point of the space it occupies. Such an approach requires the system of equations of motion to be written in terms of space co-ordinates and velocities, in which case the requirements of an internal observer for a detailed description of the processes are satisfied.

In the dynamics discussed here we study the time behavior of the fundamental characteristics of the physical system, i.e. the Jacobi function (polar moment of inertia) and energy (potential, kinetic and total), which are functions of mass density distribution, and the structure of a system. This approach satisfies the requirements of an external observer. It is designed to solve the problem of global dynamics and the evolution of natural systems in which the motion of the system’s individual elements written in space co-ordinates and velocities is of no interest. It is important to note that an integral approach is made to internal and external interactions of a system which results in radiation and absorption of energy. This effect constitutes the basic content of global dynamics and the evolution of natural systems.

From the standpoint of methodology, the integral approach has an important advantage. In this approach the integral character of the principle of least action – the basic philosophical principle of mechanics and physics – is fully realized. It is achieved by using a canonical pair consisting of the Jacobi function and frequency in writing the basic equation of global dynamics. The practical use of this pair in Jacobi’s virial equation made it possible to farther generalize the forms of motion and to show that the non-linear oscillations of a system is such a generalization.

We note that the ten well-known integrals of motion in the many-body problem in its classical formulation should be regarded as historically the earliest equations of the integral type. These integrals, however, reflects not the specific nature of a system under consideration but the general properties of space and time, i.e. homogeneity of space and time and isotropicity of space.

The first non-trivial equation of dynamics in terms of the integral characteristics of a system is Jacobi's virial equation, which describes changes in the moment of inertia (Jacobi function) as a function of time. The next step in this direction was taken by Chandrasekhar (1969). He used and developed for solution of problems in mechanics the method of moments, so called in analogy to the method well known in mathematical physics. However, the problem of non-trivial solution of the non-linearized equations in terms of integral characteristics was not solved in either of these cases.

Our work began in 1974. As a result, a number of articles on the theory of virial oscillations of celestial bodies were published in the journal *Celestial Mechanics* and other periodicals (Ferronsky et al. 1978, 1979a–c, 1981, 1982, 1984, 1985). The theory was based on solution of Jacobi's virial equation for conservative and dissipative systems.

To solve Jacobi's initial equation, we first used the heuristically found relationship between the potential energy and moment of inertia of a system, which was expressed in terms of the product of the corresponding form factors. It was found that the product depends little on the law of distribution of mass density for a wide range of formal, non-physical systems. It was then demonstrated that in the asymptotic limit of simultaneous collision of the particles constituting a system, the observed constancy of the product of form factors remained valid without any restrictions within the framework of the Newton and Coulomb interaction laws. The invariant found was also demonstrated to be valid for the widely used relativistic and non-relativistic physical models of natural systems. It enabled us to derive from Jacobi's equation a simple form of the equation of virial oscillations with one unknown function and to find its rigorous solution. The equation obtained describes the dynamics of a wide class of physical systems ranging from empty space-time and collapsing stars to the atom. Thus, it was established that the theory of virial oscillations of celestial bodies was valid far beyond the limits of celestial mechanics based on Newton's law of equations.

The work was done on concepts of Professor V.I. Ferronsky and under his supervision. Chaps. 1 and 7 were written by V.I. Ferronsky and S.A. Denisik; Chaps. 2, 3, 4, 5, 6 and 8 were written by S.V. Ferronsky.

This book presents a systematic description of our research work. It is intended for researchers, teachers and students engaged in theoretical and experimental research in the various branches of astronomy (astrophysics, celestial and stellar mechanics and radiophysics), geophysics (physics of the Earth, atmosphere and oceans), planetology and cosmogony, and for students and postgraduates of classical, statistical, quantum and relativistic mechanics and hydrodynamics.

It is our pleasant duty to express sincere gratitude to Professor G.N. Duboshin of the M.V. Lomonosov Moscow State University for his constant support and encouragement. We are indebted to Professor E.P. Aksenov, Director of the Sternberg Institute of Astronomy, Moscow, who organized helpful discussions of our work at a number of seminars. We also wish to express our gratitude to Dr. L. Osipkov from Leningrad University and Drs J. Schmidt, A. Lorenz, M. Mehta and T. Akity from the Division of Research and Laboratories,

International Atomic Energy Agency, who read several chapters of the manuscript and made editorial contributions, and to Miriam Lewis, who edited the final manuscript. We also wish to thank Renate B. Blamhofer for assistance in preparing the book. We are particularly indebted to the International Atomic Energy Agency and its Division of Publications for support and assistance in preparation of the camera-ready manuscript.

The authors

Jacobi Dynamics

A Unified Theory with Applications to Geophysics,
Celestial Mechanics, Astrophysics and Cosmology

Ferronsky, V.I.; Denisik, S.A.; Ferronsky, S.V.

2011, XIV, 330 p., Hardcover

ISBN: 978-94-007-0497-8