Dynamics of the Earth
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Theory of the Planet’s Motion Based on Dynamic Equilibrium
To the Memory of

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Teacher and Preceptor
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Preface

The book sets forth and builds upon the fundamentals of dynamics of the Earth as a self-gravitating body whose movement is based on its dynamic equilibrium state. The term “self-gravitating body” refers to the Earth capacity for self-generation of the gravitational energy that gives it planetary motion. The idea of applying this dynamic approach appeared after the classical dynamics of the planet’s motion based on hydrostatics had failed. It also followed an analysis of the geodetic satellite orbits and discovery of the relationship between the mean (polar) moment of inertia and the gravitation potential of the planet. The dynamical equilibrium of a self-gravitating body, which generates energy by means of interaction of its mass particles, was applied as an alternative to hydrostatics. In order to derive the equations of a dynamical equilibrium state, the volumetric force and volumetric moment were introduced into Newtonian equations of motion. Here the hydrostatic equilibrium state appeared to be the particular case of a gravitating uniform body subjected to an outer force field. It was based on the theory that the basic mode of motion of a self-gravitating Earth is its interactive particle oscillations which represent the main part of the planet’s kinetic energy and appear as oscillations of the polar moment of inertia.

In the second part of the twentieth century, continuous study of space by artificial satellites opened a new page in space sciences. It was determined that the ultimate goal of this scientific program should be an answer of the Solar system’s origin. At the same time, in order to solve geodetic and geophysical problems, investigation of the near Earth cosmic space was initiated.

The first geodetic satellites for studying dynamic parameters of the planet were launched almost 50 years ago. They gathered vast amounts of data that significantly improved our knowledge of the inner structure and dynamics of the Earth. They made it a real possibility to evaluate experimentally the correctness of basic physical ideas and hypotheses in geophysics, geodesy and geology, and to compare theoretical calculations with observations. Success in this direction was achieved in a short period of time.

On the basis of satellite orbit measurements, the zonal, sectorial and tesseral harmonics of gravitational moments in expansion of the gravitational potential by a spherical function, up to tens, twenties and higher degrees were calculated. The
calculations have resulted in an important discovery having far-reaching effects. The obtained results proved the long-held assumption of geophysicists that the Earth does not stay in hydrostatic equilibrium, which, in fact, is the basic principle of the theories of dynamics, figure and inner structure of the planet. The same conclusion was made about the Moon.

This conclusion means that the model used to determine hydrostatic equilibrium of the Earth, which was applied in order to interpret the outer and central force field, does not satisfy the observed dynamic effects of gravitational interaction of mass particles and should be revised. But the state of scientific knowledge of this phenomenon has been found to be not ready to cope with such a situation. The story of the condition of hydrostatic equilibrium of the planet begins with Newton’s consideration, in his famous work “Philosophiae Naturalis Principia Mathematica”, of the Earth oblateness problem. The investigation based on hydrostatics was further developed by French astronomer and mathematician Clairaut. Later on the hypothesis of hydrostatic equilibrium was extended to all celestial bodies including stars. The authority of Newton was always so high that any other theories for solution of the problem in dynamics and celestial body structure were never proposed. But in current times the problem has arisen of the cause of the discrepancy between theory and observation and a movement has appeared to take over this crisis in the study of fundamentals of the Earth sciences. A situation like this happened at the beginning of the twentieth century when the radioactive and roentgen radiation was discovered and the corpuscular-wave nature of light was proved. This was the starting point for development of quantum mechanics. We seem now to have a similar situation with respect to planetary motion.

The conclusion about the absence of hydrostatic equilibrium of the Earth and the Moon was a reason to start our work with this interesting problem, the results of which are presented in this book. We found a still more serious discrepancy related to the Earth hydrostatic equilibrium, which is as follows. It is known that the planet’s potential energy is almost 300 times more than the kinetic one represented by the body’s rotation. This relation between the potential and kinetic energy contradicts the requirement of the virial theorem according to which the potential energy of a body in the outer uniform force field should be twice as much of the kinetic one.

Considering the Earth’s observed potential energy, its angular velocity should be about seventeen times as much as it is. However, the planet has remained for a long time in an equilibrium state. In fact, the Earth appears to have been deprived of its kinetic energy. Some of the other planets, such like Mars, Jupiter, Saturn, Uranus and Neptune, exhibit the same behavior. But for the Mercury, Venus, our Moon and the Sun, the equilibrium states of which are also accepted as hydrostatic, their potential energy exceeds their kinetic energy by $10^4$ times. A logical explanation comes to mind that there is some hidden form of motion of the body’s interacting mass particles, together with their respective kinetic energy, which has not previously been taken into account. It is known that the hydrostatic equilibrium condition of a body existing in the outer force field satisfies a requirement of the Clausius virial theorem. The same requirement follows also from the Eulerian equations for
a liquid-filled uniform sphere. The virial theorem gives an averaged relationship between the potential and kinetic energies of a body. A periodic component of the energy change during the corresponding time interval is accepted as a constant value and eliminated from consideration. From this evidence it is not difficult to guess that the hidden form of motion and the source of needed kinetic energy of the Earth and the planets including the Moon and the Sun might be found in that eliminated periodic component. In the problem considered by Newton, that component was absent because of his concept of the central gravitational force field, the total sum of which is equal to zero.

Taking into account the relationship between the Earth’s gravitational moments and the gravitational potential observed by the satellites, we came back to derivation of the virial theorem in classical mechanics and obtained its generalized form of the relationship between the energy and the polar moment of inertia of a body. In doing so, we obtained the equation of dynamical equilibrium of a body in its own force field where the hydrostatic equilibrium is a particular case of a uniform body in its outer force field. The equation establishes a relationship between the potential and kinetic energies of a body by means of energy of oscillation of the polar moment of inertia in the form of the energy conservation law. An analytical expression of the derived new form of the virial theorem is based on Newton’s laws of motion and represents a differential equation of the second order, where the variable value is kinetic energy of the body’s oscillating polar moment of inertia. In this case the earlier lost kinetic energy is found by taking into account the oscillating collision of the interacting mass particles, the integral effect of which is expressed through oscillation of the polar moment of inertia. That effect fits the relationship between the potential and kinetic energies in the classical virial theorem. At the same time a novel physical conception about gravitation and electromagnetic interaction is discovered and mechanism of the energy generation becomes clear. The nature of the gravity forces as a derivative of the body’s inner energy appears to be discovered.

We initiated the study in dynamics of a self-gravitating body, based on dynamical equilibrium, in the seventies. The results were published in a series of papers (Ferronsky et al., 1978–1996; Ferronsky, 2005, 2008, 2009; Ferronsky, 1983, 1984) and in the books “Jacobi Dynamics” (Ferronsky et al., 1987), and “Dynamics of the Earth” (Ferronsky and Ferronsky, 2007). Recently obtained results related to the problem of the Earth’s dynamics are presented in this work. We show here that the new effect, which creates dynamics of the Earth, is its own force field. Earlier, the sum of the inner forces and their moments being affected by the outer central force field were considered as equal to zero. We find that the mass forces of interaction being volumetric ones created the inner force field which appears to be the field of power (energy) pressure. That field, according to its definition, cannot be equal to zero. The resultant of the field pressure appears to be a space envelope. The envelope has a spherical shape for a sphere and an elliptic shape for an ellipsoid. It was found that dynamic effects of the body’s force field occur in oscillation and rotation of the shells according to Kepler’s laws. A body that has a uniform mass density
distribution realizes all its kinetic energy of motion in the form of so-called virial oscillations. It was assumed, earlier, that wave properties of this nature, like oscillations for mass particles in mechanics of bodies, are unessential. We found that virial oscillations of a body initiated by the force field of its own interacting mass particles represent the main part of its kinetic energy. Theories based on hydrostatics ignore that energy. But, as it was noted above, in this case the potential energy of the Earth and other celestial bodies by two or more orders exceeds their kinetic energy represented only in the form of axial rotation of the mass. Such an unusual effect has a simple physical explanation. Still in the beginning of the last century French physicist Louis de Broglie expressed an assumption, proved later on, that any micro-particle including electron, proton, atom and molecule, acquires particle-wave properties. The relationship, discovered by the artificial satellites between changes of the Earth’s gravitational potential and the moment of inertia, shows that interaction of the planet’s masses takes place on their elementary particle levels. It means that the main form of motion of the interacting mass particles is their oscillation. Continuous “trembling” of the planet’s gravitational field, detected by satellites as the gravitational moments change, is another fact proving the de Broglie idea and extending it to the gravitational interaction of celestial body masses.

The dynamical approach to solution of the problem under consideration allowed the authors to expand the body’s potential energy on its normal, tangential and dissipative components. The differential equations which determine the main body’s dynamical parameters, namely its oscillation and rotation, were written. A rigorous solution of the equations was considered on the basis for bodies with spherical and axial symmetry. The solutions of problems relating to rotation, oscillation, obliquity and oblateness of a body’s orbit and itself was considered on the basis of the general solution of dynamics of a self-gravitating body in its own force field. It was found that precession and wobbling of the Earth and irregularity of its rotation depends on effects of the polar and equatorial oblateness and the separate rotation of the planet’s, the Sun’s and the Moon’s shells. The outer force field of a body follows rotation of the resultant envelope of the shells, but with some delay because of the finite velocity of the energy propagation in the outer force field. Also the problems of inner structure of the Earth, the nature of the planet’s electromagnetic field and mechanism of the energy generation are considered. Methods for studying some practical tasks like orogenesis, earthquakes, volcanism and climate change are discussed. The theory we present is applicable not only to the planets and satellites, but also to the stars, where hydrostatic equilibrium is considered as an equation of state. Finally, the theory opens a way to understand the physics of gravitation as the internal power (energy) pressure which occurs at matter interaction on the level of molecules, atoms and nuclei.

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