Entropy, Seismology and the View of Cosmology

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Origin and Evolutionary Theory

By

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"We successfully apply the theory of entropy seismology developed by S.Ts Akopian in monitoring and forecasting strong earthquakes and in constructing dynamic maps of seismic hazard for various regions of the world. I think that the formalization of this theory to describe the fabric of the cosmos and the origin of universes, given in this book, will arouse great interest not only among scientists, but also among a wide range of readers interested in modern problems of seismology, physics, and cosmology"

President of the Foundation
Lalayan G.G.

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PREFACE

In this book, the author presents the theory of entropy seismology, which describes the evolution of dynamic processes in an inaccessible geological environment and is based on the registration data of seismic wave emitters. Based on the law of seismic entropy production, a theory of describing seismic processes for open dissipative systems has been created, which allows describing the processes of occurrence of catastrophes in the virtual space of time, energy, and entropy. It allows one to develop a seismic formalism in terms that are acceptable for cosmology. A certain realistic model of the formation of primary fabric from dark energy and dark matter has been constructed, in which, under certain conditions, big entropy bangs occur, and universes are originated. The pre-Planck epoch is considered as a nonrelativistic stage in the formation of gravitational cells, as a medium of frozen dissipative space and gravity; this is an unimaginably small area of the lowest "granularity", consisting of gravitons and antigravitons. Dissipative entropy force – antigravity – is considered by the author as a new type of interaction in nature, permeating the entire space. The theory of entropy seismology can raise seismology to an interdisciplinary level, to the level of fundamental science; it can serve as an unusual laboratory for physicists. The book is intended for specialists in the field of seismology, physics, cosmology, earthquake prediction, theory catastrophe, etc. It can serve as a guide for scientists in the field of synergetics.

INTRODUCTION

In 1975, the author managed to solve the problem of "base-line corrections" when constructing standard models of the Earth (Akopian *et al*. 1975). This problem appeared in 1970–1975, when data on body seismic waves and free oscillations of the Earth began to be used together in the construction of Parametric Earth Models (PEM) (Dziewonski *et al*. 1975). The corrections were introduced formally, into travel times of body seismic waves, to coordinate models constructed in different frequency ranges from the short-period body waves to long-period normal modes of free oscillations of the Earth. The nature of the introduced baseline corrections was then unknown. The physical explanation of the appearance of this problem was given in Akopian *et al*. (1975). It was shown that in a real inelastic Earth, the elastic modules of the Earth's matter become dynamic, that is, frequency dependent. Therefore, when deviating from the standard (high frequency) model of the Earth, built at the frequency ω_0 to some arbitrary lower frequency ω, it is necessary to introduce corrections. It was proposed to consider as the baseline the classical models of the Earth, built from body waves at a frequency of 1 Hz ($\omega_0 = 2\pi$), and, when calculating the normal modes of the Earth, to introduce a correction for the dynamic shear modulus, measured from the standard frequency $\omega_0 = 2\pi$ (Akopian *et al*. 1976, 1977). Subsequently, the baseline corrections, which actually spoiled the standard models, were abandoned and the new models of the Earth were already being built considering the dynamic shear modulus (Dziewonski and Anderson 1981). From 1976 to 1985 the author constructed a perturbation theory for the free oscillation of the Earth, which was then generalized into the theory of excitation natural mods and surface waves in an inelastic, layered, spherically symmetric Earth (Akopian *et al*. 1978, Akopian 1983, 1985a, 1986).

In 1985, new parameters were introduced into seismology, on the basis of which a successful forecast of the devastating Spitak earthquake in Armenia, on December 7, 1988, was given (Akopian 1985b). 1990–1995 were devoted to the development and construction of a theory for the quantitative description of seismic processes based on the concept of a seismic system (SS) and new seismic parameters (cumulative energy and entropy), calculated based on seismic statistics (Akopian 1995a, 1995b, 1995c). Numerous SSs have been investigated and identified in different seismically active regions of the world (Akopian 1998). In 1995–1998 the theory of quantitative description of seismic processes was formulated. It became clear that in the field of seismicity, where the Gutenberg–Richter law does not function, there is a new regularity, the law of seismic entropy production.

Here I want to step back and clarify my relationship to the science of seismology. Seismology, as the science of earthquakes, can be divided into two parts. The first part, which includes the study of the earthquake source and the propagation of seismic waves, the registration of seismic events and the compilation of seismic catalogs, is well studied and is developing intensively (see, for example, Aki and Richards (1990)). And the second part, which studies seismic processes in a real environment, leading to the preparation of strong earthquakes, is in its infancy, since there is no theory for describing seismic processes based on seismic statistics (earthquake catalogs). The creation of such a theory would raise the science of seismology, as an applied one, to the level of fundamental. So, in classical mechanics and gravity, an information unit, a metric, is a material particle (mass), in electricity a charge, in magnetism a magnetic dipole, in statistical physics and quantum mechanics molecules, atoms, electrons, protons, and other elementary particles. In seismology, such an information unit can be an elementary microearthquake (Akopian 1995a). The theory built on the basis of such a metric should quantitatively describe and explain from a unified standpoint the regularities of seismicity in a real geological environment, penetration into which is still impossible, and predict their development within the framework of seismic statistics. The theory based on seismic sources will also accelerate the solution of dynamic problems of earthquake preparation and prediction.

There are some similarities between seismology and cosmology, which studies distant objects in the universe by registering different types of waves. A theory describing the evolution of dynamic processes in an inaccessible geological environment and based on the registration data of seismic wave emitters can raise seismology to an interdisciplinary level, it can serve as an unusual laboratory for physicists and for the study of cosmology, where there is also no unified theory of the origin and evolution of the universe (Lukash and Mikheeva 2007). The complexity of constructing a statistical theory in seismology and cosmology (except for the choice of the metric) also has objective difficulties. In both cases, we are dealing with unusual statistics that significantly distinguish them from statistics in classical physics. In classical statistics, a system consists of many, in general, equivalent particles (material points, atoms, molecules). In seismology and cosmology, we are dealing with unequal statistics of complex objects, the "particles" of the system (earthquakes and stars) have a wide spread in energy. The number of "particles" of the system decreases with the transition to energetically significant events (large earthquakes, giant stars), so the methods of conventional statistics become unacceptable.

In seismic statistics, there are, and are developing, separate methods and approaches based on empirical laws, of which the most famous is the Gutenberg–Richter recurrency law (GR) (Gutenberg and Richter 1954). However, this is not a physical law, it does not preserve the dimension. Still, in 1981 the Japanese seismologist K. Kasahara noted: "Despite many studies, it remains unclear why the release of energy follows the law of GR" (Kasahara 1981). This law is violated in the field of large magnitudes with a decrease in statistics (Kagan 2000); the shortcomings of the GR law in the description of seismic processes were also repeatedly noted by the author (Akopian 1995a, 1998, 2007). Since there are no criteria for choosing a seismically active volume in the geological environment in this law, there are unlimited possibilities for sampling statistics from a large data array and a large scope of research, depending on the preferences of the seismologist. The problem of choosing a seismically active volume arises both in earthquake forecasting tasks (Kostrov 1974; Dobrovolsky *et al*. 1979) and in probabilistic assessment of seismic hazard (Jordan *et al*. 2011). Approaches based on solving problems of seismicity and dynamics of earthquake preparation with the use of mechanics and laboratory models allow solving problems in general terms (Rice 1980; Sobolev and Ponomarev 2003). When switching to real media, the necessary empirical information is lacking to verify mechanical models, since the accumulation of stresses and strains in active structural elements of the lithosphere in time is not available for direct measurements with the required accuracy (Akopian and Rogozhin 2013).

The revealed regularities were confirmed by examples of significant strong earthquakes in different regions of the world, as well as by monitoring strong earthquakes conducted from 2008 to 2012 in real time on the internet. The geography of SSs has been expanded, and their number has been significantly increased, due to a decrease in the threshold magnitudes of strong earthquakes. Practical testing for real SSs and numerous forecasts by the end of 2011 finally confirmed the theory and method of seismic entropy. The results of monitoring in ON Line mode of catastrophic earthquakes in Japan (2011.03.11, M = 9.0) and in eastern Turkey (2011.10.23, M = 7.3) were published in Akopian (2013a, 2014b). Later, the law of seismic entropy production governing the ensemble of strong earthquakes in the macroscopic field (in the field of earthquakes above a certain threshold magnitudes M_h) was proved theoretically (Akopian and Kocharian 2014). The SS tends to the most probable macroscopic states with critical instability, where equilibrium is restored through a strong earthquake. SS is considered defined only when strong earthquakes form a canonical ensemble of (statistically) independent seismic events (Landau and Lifshitz, 1980a; Prigogine, 1980). On the basis of this law, a theory of describing seismic processes for open dissipative systems has been created, which makes it possible to simulate the processes of occurrence of catastrophes in virtual space time, energy and entropy (Akopian 2015b). Lowering the threshold magnitudes and dividing systems into subsystems made it possible to apply the seismic entropy method to control the induced and trigger seismicity of natural and man-made nature, to solve technological problems in the oil and gas industry and in the development of shale gas (Akopian 2014a, 2015a, 2017c).

By 2015, it had already become clear that the results obtained are, in a sense, universal, since it was possible to describe the evolution of a real complex geological environment, to describe the occurrence of instability and criticality (seismic catastrophes), bypassing the traditional approach of describing the stress-strain state of the medium, about which there is no available information. The theory was based on the registration of the reaction of the SS in the form of earthquake indicators to an external impact. The dynamics of the stress state of the medium were described through the elastic energy radiation of these earthquake indicators. In other words, the non-measurable flow of tectonic energy, leading to the emergence of a complex stress-strain state in the zones of interaction of lithospheric plates, turned out to be replaceable by another, accurately measured in seismology, type of energy, with the correct formulation of the problem. For the first time, it was possible to create a theory that allows one to control invisible processes, such as the inflows and outflows of energy and entropy into an open dissipative system, about which there was only limited information. It turned out that the preparation of disasters in a real geological environment can be represented in the form of spiral trajectories. By a special transformation of coordinates, one can go into a virtual three-dimensional environment (time, energy, and entropy), where the emergence of new structures can be represented in the form of spatial funnels into which trajectories are drawn.

On the one hand, the formal similarity of approaches in seismology and cosmology (meaning the remote study of unattainable structures by means of wave registration) and, on the other hand, the use of the description of the evolution of the Earth's lithosphere, which is quite well studied, makes it possible to develop a seismic formalism based on the theory of entropy seismology in terms acceptable for cosmology. Such an approach can create a plausible model of the fabric in which the origin of space, matter and time occurs, a model of the origin and evolution of the universe without attracting a singularity. This makes it possible to create a new tool for modeling arbitrarily small or arbitrarily remote objects. Until now, the models of the evolution of the universe have developed mainly at the junction of the two sciences of physics and astronomy. The solution to the problems that arose in the construction of standard models of the universe evolution rests on the development of these disciplines: physics deep into the microcosm and astronomy far and deep into space. There are new problems in physics and cosmology, the problem of dark matter and dark energy. There is a problem of creating a quantum theory of gravity. The development of a real, priority model of the universe against the background of many existing theories and problems that have arisen requires the development of existing, and the creation of new and advanced, technologies for observation and measurement (collider, space telescopes, and special observation systems), which facilitate penetration into the unknown, into the depths, and into the distance, but all this requires colossal investments of mankind. The advancement of science and the limited human capacity on Earth to provide an evidence base for this development is leading to a deadlock situation. Against the background of all this, the emergence of any scientifically grounded unconventional approach, method, technology, for penetrating the unknown, and not requiring new investments from humanity, can be very valuable and stimulate further development. It turned out that there is no need to look at deep space or look deep into matter but, in a rather unusual way, to look at what is hidden under our feet – at our Earth.

It was with such an unusual view that the author managed to look at the theory of entropy seismology. The unusual results obtained by the author stimulated not to dwell on the problems of seismology, but to go even further. By the middle of 2015, it became clear that a new look at seismology and the transfer of this knowledge to cosmology today will allow us to take a fresh look at the origin and evolution of the universe and more effectively carry out scientific research in physics and cosmology (Akopian 2017a, 2017b). The topic touched upon in the book concerns a huge layer of issues of modern physics, cosmology, and, of course, it is impossible to grasp and understand all this. Almost every day the author deepened and expanded the theory, developed the ideas of creating a seismic formalism, touching upon the issues of dark matter, dark energy, black holes, graviton, Planck units, singularity, big bang, grand unified theory, quantum, and classical mechanics. But the author's task was not to penetrate the depths of this ocean of scientific problems, in which one could immediately sink, but, if possible, to feel the boundaries of knowledge, to identify a chain of interrelated problems and look at them from the position of seismic formalism. As a result, a certain substance has been built, in which a closed chain of links in the origin, evolution, and death of the universe is traced. In the middle part, this chain on both sides should be aligned with the objective reality of our physical world. How this was done, how plausible it is, and what new problems all this will lead to is the focus of this book. I invite you to a pleasant journey.

What is this Book About?

Physics is an empirical science that originated on planet Earth due to the appearance and development of humanity on it. To identify certain patterns, physicists set up experiments, creating a certain structure or system. In fact, it is impossible to formulate the concept of a system or its parts without an environment. For example, to boil water, you need a kettle or flask containing water. The laws of thermodynamics cannot be understood without a steam engine, a cylinder with a piston, and a refrigerator. So, this conditional "environment" plays a fundamental role in understanding, for example, the Carnot cycle and the basics of thermodynamics. When we talk about physical and chemical processes on Earth, we mean that the processes take place in something, in a certain "environment". In classical physics, in the most general sense, the environment is space and time that performs the most important function of the arena in which all kinds of physical processes are played out. The actors in these processes are physical objects (particles and fields), obeying exact mathematical laws. It is believed that physical objects are matter, the measure of the amount of which is their mass. The fundamental problems of such a classical pattern of the world arise with the definition and behavior of light. The pattern familiar to us is violated at speeds comparable to the speed of light and when penetrating deep into matter. The wave–particle dualism in quantum theory was first discovered in the behavior of light (light is a stream of particles-photons and a wave). A material particle has a well-defined mass, but the mass of a photon of light is pure energy, and its own mass (rest mass) is zero. Mass, as a measure of the "amount of matter" for a photon, makes it a special category of matter.

By introducing the concept of an isolated system, or a certain body, physicists imply the allocation of some specific volume, or a complex system relative to some more homogeneous extended "environment". The concepts of thermal energy and entropy were introduced for the first time in thermodynamics. Regularities (the first and second laws of thermodynamics), identified by physicists in the conditions of the planet Earth, were quite rightly considered fundamental, relating to the universe as a whole. Note that by the time of the origin of thermodynamics in the 19th century, Newtonian mechanics dominated in natural science. But it is through the development of thermodynamics that the physics of dissipative systems, the physics of nonequilibrium processes, arose. But thermodynamics as it currently exists is based on the real world around us. Questions arise: what was this discipline like before the origin of the universe, when the world familiar to us did not yet exist, what were described by the laws of thermodynamics, how were energy and entropy determined? The laws of science are unchanged, but the evolution of the universe has led to the complication of the surrounding world and, as a result, to the evolution of the science of thermodynamics. The primary definitions of energy and entropy, as evolution progresses, should pass, or not contradict, modern definitions.

It became clear that open systems far from equilibrium can create order out of chaos by exporting and importing entropy. That is, the "environment" of an open system has become a powerful factor that determines the emergence and existence of the universe, the existence of life on Earth. In a new field of physics, the physics of dissipative systems (or synergetics), a new concept of entropy was introduced – informational. In physics, they do not talk about big and small; in physics, they compare. For example, an atom is much smaller than the bodies around us, objects, and so on. The smallest bacterium contains a huge number (10^9) of atoms. The concept of a system is based on a metric.

Quantum mechanics explains the observed phenomena of the microworld at the level of atoms, molecules, and other subatomic particles, which are fundamentally different from classical physics. In quantum theory, the "uncertainty principle" appears, which means that it is impossible to accurately describe the system at the particle level but uses only a probabilistic approach. Without delving into the theory of quantum mechanics, questions arise about the existence of the upper and lower limits of applicability of this theory, or about its transformation both in the transition to the description of macro-objects, and in the description of ultra-small objects of the Planck scale. Such a wide coverage of the description is necessary to build a complete evolutionary pattern of the creation of the real world, to explain modern problems of physics and cosmology. Classical and quantum theories describe the reality that can be "measured", which ultimately develops in the minds of physicists. This reality is our perception of the world and a demonstrative representation of the surrounding nature.

Theoretical physicists strive to describe the complete structure of the world as it really is but, at the same time, they are faced with at least two problems. The first problem is transparent, for describing objective physical reality, for expanding our knowledge in depth and breadth when looking into arbitrarily small or arbitrarily remote elements of the system, they are limited by the possibilities of "measurements". At the same time, the quantum states of the microsystem between measurements can differ from the states during measurements and be somewhat subjective, probabilistic. The second problem, which many physicists do not realize (or do not think about it), is associated with those modern theoretical "tools" (quantum mechanics, General Relativity, Special Relativity Theory) with which they are armed, but which may be insufficient, or very "rough", or even are inapplicable for studying the fine structure of objective physical reality, including dark matter, dark energy, deep space, gravity problems, etc. At the submicroscopic level, quantum laws do work, but questions arise about how the quantum world arises inside the classical one and how much the classical laws are transformed in deep space. Such questions arise because initially our mind was formed on planet Earth, our perception of the environment began at the threshold of our home – the Earth; it is based on the macroscopic world described by classical physics. We need to penetrate deep into matter and explore distant regions of space and even turn to the very beginning of time! But with this striving back in time, the achieved practical and theoretical possibilities are limited, problems of physics have appeared. Traditional approaches face great difficulties, which leads to various hypothetical theories that require an evidence base. We need to look for new, non-standard approaches. It is necessary to conduct an objective presentation of the theory chronologically, from the simple to the complex, from simplified theories describing the primary fabric in which the conditions for the big bang (BB) and the emergence of the submicroscopic quantum world were created, then everything else. It is possible that arbitrarily small and arbitrarily remote worlds are very close in nature and are described by the same regularities. Maybe they once constituted one single whole, a single substance of the entire universe. This substance should be exactly that environment, that absolute fabric and that scene, within which space and time should arise, universes should arise and perish, BB occur, leading to the emergence of our universe and the material world familiar to us. It is possible that in the evolutionary process the hierarchy of black holes pulls the complex structural elements of our material world into this substance and, like in a meat grinder, meal them, turns into simple, very small elements of the substance fabric. Logically, the theory describing the primary substance should be quantum, but very simplified; on the other hand, the elements of this substance should be encoded with properties that, with modern theoretical models, would lead to the origin of our universe. The book is dedicated to all of this.

PART I:

SEISMOLOGY AND COSMOLOGY

CHAPTER ONE

SIMILARITIES AND DIFFERENCES OF APPROACHES

1.1. Registration Methods

Seismology is a branch of geophysics and studies the seismicity of the Earth and the processes associated with it, while cosmology is a branch of astronomy that studies the properties and evolution of the universe as a whole. Seismology studies what is under our feet, and cosmology studies what is above us. Direct penetration deep into the Earth, where earthquakes occur and seismic waves propagate, is impossible. So far, the deepest borehole drilled on Earth is the Kola Superdeep Borehole (Russia), which reached a depth of 12.262 km (about 0.19 per cent of the Earth's radius). Seismic waves from earthquakes are recorded by seismographs. Until now, no earthquake deeper than 720 km has been recorded. However, the main observations of the seismicity are carried out on the surface of the Earth. The highest velocities of seismic waves in the Earth are of the order of 13 km/s, which is 4.3×10^{-5} of the speed of light. Earthquakes are recorded by seismographs of different frequency ranges (in the range from thousandths to several hundred Hz). The deepest earthquake observing system is in Parkfield, California (USA), the SAFOD observatory, at a depth of 3 km (Ellsworth *et al*. 2000, Zobak *et al*. 2007). By comparison, the most remote man-made space object with which radio contact is maintained is the American automatic interplanetary station *Voyager 1*, launched on September 5, 1977. *Voyager* speed is about 17 km/sec. In 2020, it crossed the line of 147 astronomical units (22 billion km) and the border of the solar system, the heliosphere. The radio signal from this distance takes about 19 hours. Electromagnetic waves, with the help of which a radio signal is transmitted in outer space, propagate at a gigantic speed – at the speed of light ≈ 300,000 km/s.

Among the bodies of the solar system, in addition to our planet, the Moon and Mars were studied in more detail from the point of view of seismology.

During lunar missions, many seismographs were placed on it, and seismic studies of the Moon became relatively continuous. Moreover, scientists were able to independently cause a moonquake by “dropping” a spent lunar module on it. After such a hit, the moon was shaking for an hour – it turned out that the seismic vibrations on the moon decay very slowly. The Moon is seismically almost inactive; a significant part of the seismic events of the Moon is caused by impacts of meteorites, as well as the impact of tidal forces from the Earth and the Sun. The study of seismic activity on Mars began in 1975 at the first research station *Viking-1*. During the year of operation of the seismograph installed on the descent vehicle, among the seismograms that recorded the wind noise in 1976, one was identified, which corresponded to the real Mars-quake with a magnitude of 2.8. Recently, a new mission of NASA *InSight* was carried out to deliver a seismometer to Mars. On November 26, 2018, the *InSight* probe successfully landed on the surface of Mars and installed the SEIS seismometer on the surface at 1.6 m from the landing platform. Since the landing of the probe, 322 events have been recorded in more than a year, several dozen of which, presumably, corresponded to the Mars-quake. The two largest Mars-quakes occurred in a geologically active zone, approximately 1600 km from the probe landing site. Nevertheless, it is believed that there are no active tectonics on the Moon and Mars, and the main seismic records are associated with the fall of meteorites.

The first seismograph (seismoscope, Chang Heng) appeared in 132 in China. The first seismographs of scientific importance were built at the University of California at Berkeley in 1877 and in Japan in 1879 by Jung. The first seismic station appeared in Berkeley (Lick Observatory) in 1887, and the very first electromagnetic seismograph in the world was built in 1906 by the Russian academician B.B. Golitsyn. Statistical instrumental data on earthquakes (catalogs) have existed since 1900. Cosmology receives information from astronomical objects through ground-based and space telescopes, radio telescopes that register signals of different frequency ranges. Modern space telescopes are placed in open space to register electromagnetic radiation in the ranges for which the Earth’s atmosphere is opaque. Due to the absence of the influence of the Earth’s atmosphere, the resolution of such devices is several times higher than that of ground-based analogs. Telescopes are divided into classes according to the main frequency bands, including X-rays, gamma rays, ultraviolet radiation, as well as infrared, visible, microwave and radio emissions. Optical astronomy is considered the oldest form of this science. This type of telescope includes the American Kepler, the SIM Life Observatory, and the famous Hubble Telescope, which is a joint project of the European Space Agency and NASA.

In fact, both seismology and cosmology are based on information received from remote sources by registering different types of waves, in the first case from inside, and in the second from outside, the Earth. In the first case, these are seismic waves from sources of earthquakes, rock bumps and explosions and, in the second, electromagnetic waves from stars, galaxies, etc. space objects. The level of development of these sciences depends on the sensitivity, accuracy of instruments and the organization of the network of observations and processing. Sensitive networks of seismic devices allow registering seismicity “clouds” in the Earth, while long-period seismographs and strainmeters register low-frequency free oscillations of the Earth.

Recently, gravitational waves have been recorded, which are ripples in space–time created by collisions between black holes and neutron stars. The discovery of gravitational waves was carried out by direct detection on September 14, 2015, at the American observatory LIGO (laser interferometric gravitational wave observatory) in cooperation with VIRGO (French–Italian gravitational wave detector) (Abbott *et al*. 2016). Improving the quality and accuracy of measurements in seismology and astrophysics is the basis for theoretical developments and scientific research in the field of problems of the evolution of the dynamics of the lithosphere and earthquake prediction in seismology and the creation of an evolutionary model of the universe in cosmology. In a sentence, the task is to discover the secrets hidden inside the Earth under our feet, and to penetrate the abyss of the universe. Seismology, as a branch of geophysics, is considered an applied science. Applied science takes basic knowledge from the fundamental sciences. It is believed that applied sciences can successfully develop, deepen and multiply solely on the basis of fundamental research. Each fundamental science has its own concepts, laws, principles, theories, and concepts. Theoretical problems in seismology are based on mechanics, and cosmology on the modern achievements of physics. Seismology, as a science, can be conditionally divided into two parts: wave and statistical. The first, which includes the registration of seismic events, the study of the source and the propagation of seismic waves, is well studied and is intensively developing. And the second part, which studies seismic processes in a real environment, leading to the preparation of strong earthquakes, is in its infancy, since there is no theory for describing seismic processes based on seismic statistics (earthquake catalogs). This refers to the absence of a theoretical basis, a theory based only on recorded seismicity data. The creation of such a theory would raise the science of seismology, as an applied one, to the level of fundamental.

Why is such a theory based on seismic statistics important? It will allow statistical seismology to close on itself, to make it more separate, independent of other disciplines. It will have not only its own observation system as in astronomy, but also its own definitions, concepts, laws, principles, supported by theory. Such a theory will make it possible to reveal the hidden patterns of seismicity processes, to develop criteria for the occurrence of instability and the preparation of seismic disasters in a complex geological environment, which will ultimately make it possible to practically solve the problem of monitoring and forecasting earthquakes. On the other hand, the construction of such a theory and its formalization will bring the formulation of tasks to study the dynamics and evolution of the Earth's lithosphere closer to the problems of cosmology. Such a theory is entropy seismology, to which the first part of this book is devoted. In classical mechanics and gravity, the information unit, metric, is a material particle (mass), in electricity a charge, in magnetism a magnetic dipole, in statistical physics and quantum mechanics molecules, atoms, electrons, protons, and other elementary particles. In seismology, an elementary microearthquake can serve as such an information unit. The theory built based on such a metric should quantitatively describe and explain the regularities of seismicity in a real geological three-dimensional environment, penetration into which is not yet possible. The formalization of such a theory and extrapolation back in time by 4.5 billion years to describe the evolutionary processes in the lithosphere and mantle of the Earth based on seismic wave emitters can serve as an unusual laboratory for cosmology, where there is also no unified theory of the origin and evolution of the universe.

The complexity of constructing a statistical theory in seismology and cosmology (except for the choice of the metric) also has objective difficulties. In both cases, we are dealing with unusual statistics that significantly distinguish them from statistics in classical physics. In classical statistics, a system consists of many, in general, equivalent particles (material points, atoms, molecules). In seismology and cosmology, we are dealing with unequal statistics – the "particles" of the system (earthquakes and stars) have a large spread in energy. The number of "particles" of the system decreases with the transition to energetically significant events (large earthquakes, giant stars), so the methods of conventional statistics become unacceptable.

In both disciplines, in seismology and cosmology, access to the studied environment is limited, and evolution models are built on the basis of recording remote information using seismographs and telescopes. Of course, cosmology has a powerful scientific base, physics, the development of which, together with astronomical observations, gives a powerful stimulus to the development of cosmology. The basic premise of cosmology is the statement that our universe is an expanding world. Interpolation of the expansion of the universe back in time leads to the understanding that about 13.7 billion years ago the universe was a point object (singularity) – a lump of primary matter and energy. The birth of the universe is explained by the concept of the BB. The observation of the relict radiation makes it possible to study the universe starting from the age of about 380,000 years after the BB. The main problems of the BB theory (among many others) are the questions of what the universe consisted of before the expansion, what is the singularity, inflation, and the issues of forecasting the future of the universe. However, to solve these problems and identify the evidence base of existing theories, the possibilities of modern physics are limited and run up against technological progress, more and more funds and investments are required from humanity; on the other hand, physicists when constructing theoretical models of the universe are limited by the rate of receipt of information, equal to the speed of light. Under such conditions, statistical seismology could provide invaluable assistance for the development and testing of evolutionary models of the universe, if knowledge is correctly transferred from one area to another. The second part of the book is devoted to this.

1.2. The Concept of a System

Research on the creation of a dynamic theory of the evolution of the Earth's lithosphere in seismology and on the creation of a model of the evolution of the universe in cosmology are based on the definition of the concept of a system. A system is a certain distinguished characteristic volume, described in detail in a particular task. The volume contains an unknown medium and discrete sources of energy radiation recorded by the observer. This information for the system is measured by means of some characteristic metric. The concept of a system is closely related to the concept of "catastrophe" (in the case of SSs, these are strong earthquakes).

The system is considered definite if the catastrophes in it are combined into an ensemble, obeying the law of entropy production.

Time and energy in our approach form the basis for understanding the origin and evolution of nature. The state of the system should be described by cumulative parameters, which makes it possible to explain the emergence of this state as an outcome of the previous evolution of the system. The question of the evolution of the system takes on meaning when the time symmetry is violated. The development and evolution of systems occurs during multiple breaking of temporal symmetry and its restoration through catastrophes. The state of a system with time symmetry is considered stable. Irreversible oriented time, instability and catastrophes are closely related to each other in the system. Let us give some clarification about the time.

In the Newtonian pattern of the world, matter, space, and time are separated: space and time act as passive “receptacles” of matter. In the canvas of the world created by Einstein, space and time have ceased to be independent of matter, they are generated by matter. In Einstein’s special theory of relativity, the speed of light is constant, and space and time are relative. Regardless of whether the object is at rest or moving, the term “motion” becomes an absolute concept (four-dimensional – in coordinates and in time). If the object is at rest in relation to you, then it is considered that all its “movement” occurs in time, and as soon as the object begins to move, then the movement in time slows down, and in space increases. The special theory of relativity establishes a similar law for all “motion”: the total speed of “motion” of any object in space and time is constant and always exactly equal to the speed of light. Hence it follows that, for example, for a photon particle, the movement in time is stopped, the photon clock does not tick. And when the speed of movement of a relativistic object decreases, it transforms part of its motion in space into motion in time, its speed of motion in time begins to increase, reaching a maximum at rest. The clock for such a state starts ticking at our usual pace. The effects of special relativity are most pronounced when the speed of movement in space is a tangible fraction of the speed of light. The lower the speed, the smaller the deviation from pre-relativistic physics.

It is important for us to distinguish not only movement in space from movement in time, but also the movement of which objects we are talking about. In physics, the movement in space and time of any material objects (for example, elementary particles, a person, a car, a rocket, and so on) is considered; in seismology, the movement of plates. At the same time, the complexity of the structure of the object itself is not considered in the special theory of relativity; it is important that the object was at rest or moved as a whole.

The concept of time in our approach acquires a different physical meaning; it is closely related to the concept of a system, which as a whole can be considered practically at rest. In this case, the concept of "motion" in time is closely related to the cumulative energy and entropy of the entire open complex system, and not from its movement. Such movement in time is heterogeneous and fully describes the evolution of the system through the periodic "maturation" of catastrophes. If we imagine that the entire universe is a system, then the question of its relativistic behavior and the need to apply the special theory of relativity to such a system as a whole practically disappears. But to describe the "movement" of material objects within the system (the universe), our usual idea of time will be preserved, and the special theory of relativity will function. However, the localization of the state of the system in space–time is the most important part of the theory.

In our approach, we will, in a certain sense, abandon localization in space. The state is determined for a certain finite volume of an open dissipative system, which is selected based on a set of informative parameters about the system and is determined by tasks regarding the behavior of the system as a whole and its interaction with the environment. Such a system has a beginning, an end period of life and death. The evolution of any system during a period of life, described entirely by the "movement" in time of the system itself, leads to a change in its complex internal structure. Once again, we note that in the special theory of relativity with complete "movement" in time of material objects, no internal changes in these objects are considered. The speed of the "movement" of time for the system differs from the usual, for us, full speed of the "movement" of time for material objects. In other words, the time for resting systems in our approach is inhomogeneous, and for material objects at rest in physics it is uniform. With this approach, it is possible to separate microscopic changes in the structure of the system from macroscopic changes that are responsible for irreversible changes in the system, but at the same time preserving it, preserving all the main characteristics of the system. The static duality of space and time at a material point is replaced by a more dynamic duality of space and time in the system. The system acquires an internal time that differs from the time of internal material objects and from external time. The description of the evolution of complex systems is greatly simplified and becomes self-similar, and all the complexity is transferred to the countless variety and diversity of observed multi-scale systems.

In all branches of physics, from mechanics and thermodynamics to quantum mechanics, and many modern statistical approaches are based on a generally accepted and unified understanding and definition of micro- and macro-states. Strictly speaking, for this reason, these disciplines appear differing in methods and approaches. Stochastic (random, probabilistic, chaotic, unpredictable) and macroscopic research methods are clearly separated; however, the relationship between these methods remains an unsolved problem. In our approach, we abandon the usual absolute understanding of microstates and macrostates, as these states become relative to the size of the system. Purely mathematically, these states can exist both for systems with dimensions of 10^{-50} cm and for systems with dimensions of 10^{50} cm. In our case, this is possible, since all parameters of the systems are discrete and can only be finite numbers other than zero and infinity. The problem is only in the possibilities of observations and measurements. This approach makes it possible to make the theory universal and allows us to combine different methods and approaches. It becomes possible to bypass the occurrence of a singularity and infinitely large numbers.

Note that systems can be not only real – material (physical, chemical, biological) that populate the universe – but also virtual (sociological (for example, history, economics, politics, and so on)), which are still poorly formulated and studied from the standpoint of open dissipative systems. Understanding and the role of dissipative structures, the emergence of self-organization, for objects within and entirely for the universe, an attempt to describe gravitational collapse and catastrophes within a single model is a problem due to objective and subjective reasons (restrictions on information, lack of a universal theory), and has not yet been resolved. Irreversible processes occur both in the macroscopic and in the microscopic world. As a fundamental physical fact, we have accepted the emergence of the "arrow of time" and the law of information entropy production in systems. This is a universal law of the entropy forces of attraction, which should act in all dynamic theories, be it classical mechanics, quantum mechanics or the theory of relativity. However, this law is observed only when cumulative energy parameters are introduced, and then not for all permissible states and volumes of physical systems, but only for a limited class of discrete specific volumes and states specified by a scale unit – a metric.

CHAPTER TWO

MEASUREMENT AND INTERACTIONS

2.1. A New Form of Existence of Matter

The new approach fundamentally changes our understanding of space, time, and dynamics. It puts time, energy, and entropy in the first positions. The existence of matter in the form of an open dissipative system with a finite volume, shape and properties is introduced. The internal time introduced by us exists only for unstable dynamical systems. For us to talk about the evolution of physical systems, it is necessary to ascribe to them the production of entropy at a "macroscopic" level in comparison with the size of the system. At the same time, the size of the system can be from the smallest quantities to the largest (with the size of metagalaxies). The choice of system sizes depends on the information unit of measurement (metric). Here we come to the basic concept for describing the system, to the act of measurement. The measurement process can be considered as a special kind of human interaction with the outside world. Measurement is the basis for obtaining information about the system. The more precise and detailed the measurement, the better and more accurately the system can be described and the more it is possible to expand the class of systems under study, splitting it into smaller and smaller areas. The more sensitive the measurement, the smaller and larger (distant) systems can be described and studied.

The description of physical systems in our approach is like the canonical transformation in integrable systems (Goldstein 1950). In this approach, energy is not divided into kinetic and potential. Potential energy is needed to describe the interaction of selected discrete domains, or particles within the system, which undoubtedly complicates the task. The exclusion of potential energy (Fig. 2-1) gives us a new idea of the system's environment, which allows us to talk about clearly distinguished bodies or particles (discrete energy sources) that can be recorded (measured) by instruments. The medium between the sources in the system will be considered "dark matter" (since there is no measurable information about