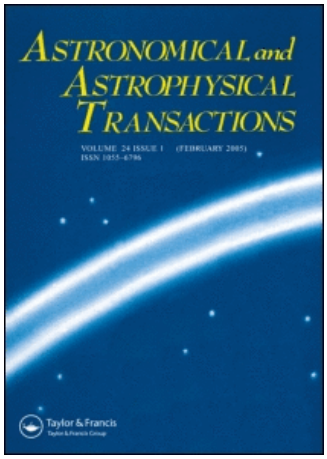

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GEOLOGY, GRAVITATION, COSMOLOGY

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This paper is devoted to the memory of G. A. Gamow and considers basic problems of standard cosmology and its modern development including quantum cosmology. Therefore, the paper marks the difficulties in this branch of science (among the myths, religion, and the physical aspects) and pays attention to cosmological conceptions being shaky and to the necessity to take into account some existing gravitational and cosmological versions for working out a more generally accepted one. The potential fruitfulness of using modern concepts of synergetics, fractal and soliton-wavemechanical theory is noted, too.

Attention is also payed to the significance of the newest geological and geophysical data to extend the observational material. It is shown that the cyclic character of the processes, the hierarchy of the structures, and the planet energy, being studied in detail and thoroughly, are of universal significance. It is shown too, that, from these materials on the universal cyclicity, structureness and transformation of gravitation energy into electromagnetic radiation, it should be useful to undertake new studies and to find possible improvements of standard cosmology and of its modern developments, including quantum cosmology.

KEY WORDS Cosmology, gravitation, geology

Devoting this paper to the memory of our great countryman, Georgy Antonovich Gamow we should note that his works, by inexplicable way, were not only important landmarks in the development of cosmology. They have something in common with its modern progress and, definitely, with scientific studies in I. I. Mechnikov State University (Odessa), in spite of the fact that Gamow had no contacts with his native city Odessa.

The noted American expert in cosmology arranged in chronological order portrays of modern quantum cosmology founders (Halliwell, 1991). The second person after Schroedinger is Gamow. This clearly reflects the significance of each scientist's contribution. The wave-mechanical equation of Schroedinger is the basis of quantum science. As to the development of cosmology for hot Universe, it would have been impossible to establish the "standard" Fridman–Gamow cosmology and to have its modern progress too without the development of quantum nuclear physics, to which Gamow made the fundamental contribution (Brush, 1992).

In this respect, the interests and role of Gamow in astronomical science are analogous to the role of Laplace. Really, Laplace after Newton became the main founder of the cosmogony of the Solar System. And Gamow, after works of Einstein

and Fridman, became the main founder of cosmology of hot Universe and forerunner of modern quantum cosmology.

1 PROBLEMS OF PHYSICAL COSMOLOGY

Principally it was always connected with the lack of knowledge and the irrepressible aspiration of person to "complete" understanding of the surrounding World. This is clearly observed, beginning from the development of "primary" notions about the Solar System. In this evolution of concepts, it is seen that the myths were modified step by step, imbibing the scientific experience. The most important point here was the discovery of gravitation forces. But the situation does not change principally in our period of telescopical and rocket astronomy: on the whole, we have learned more, but we remain far from understanding the Solar System evolution, and myths have not gone away completely.

And it is still more difficult to reflect cosmologically. This is the typical opinion of an astronomer-observer: "It is simply nonsense to speak about the origin of the Universe – World in general. It means that beforehand and arbitrarily it is accepted finite both in time and in space. How can we speak about the origin of infinite space in infinite time? We can speak only about the origin of one or another form of matter in the definite, known region of the Universe"... On the essence, it has something in common with the new discrete information approach to the natural sciences as a whole (Harmut, 1988), where continual approach traditionally existed.

Continuum, continuous space and time is the basis of classical quantum mechanics, and also of the theory of relativity. And infinite space comes into physical usage as the integral property of the World with Newton's gravitation (Harmut, 1988). Therefore, to mention the possibility of this great reorganization of physical ideology, from the continual-infinite one to the discrete-finite one, is actual, because this helps us to make out the relative vacillity of cosmological concepts based on physical ideology. Really, even a smaller reorganization – the advent of quantum mechanics and theory of relativity, without cardinal changes in concepts of space and time, made new landmarks in ideas of the Universe, gave the possibility of its thorough understanding as a separate physical object, simultaneously posing new psychological and objective problems. That is why the unification of theories of the expanding Universe and of nuclear physics made by Gamow and having led to the calculations of hydrogen and helium concentrations observed in space consolidated this new landmark and confidently led to the modern cosmology of hot Universe: nucleosynthesis of atomic nuclei can occur only in very dense matter under colossal temperature. At the same time, only helium can be generated in substantial quantity because of the fast expansion at the pre-stellar stage (Davise, 1985).

The confirmation of this scenario in the observation of microwave background radiation, the cold relic of the primary hot state, promoted further analysis of evolution: to the null moment, the Big Bang out of some superdense singular mi-

crocondition, where unusual physics with quantum-gravitation phenomena is to be accounted for.

This model of modern concepts on the evolution of the Universe, in spite of the prospects to unite them with future common theory of physical interactions, has raised some objections and different opinions about the events separated from us by billions of years. Among them, the idea on the impossibility of physical solution for the Universe origin problem is also put forward: the science can investigate only observable events. And the attempts of some cosmologists to study creation and beginning are severely critisized. "Metaphysics but not Science is the place for such attempts" (Burbidge, 1992).

It can be agreed that sequence and caution are necessary in such particular case for discussion where reasonable limits can be easily lost. The formation of cosmology as a science can occur only if one strictly separates measured observational data and their mathematical relationships from other factors. Newton and Kant who had extraordinarily acute physical intuition exactly followed this rule. They strictly divided science from problems with religious content: the search of finite causes for all real, which can neither be fixed nor measured. The same approach is characteristic for Gamow, for the founders of gravitation theory, quantum theory (Narlikar, 1984), and information theory which becomes consolidated more and more in the vanguard of modern science (Harmut, 1988).

2 GEOLOGY AND COSMOLOGY

In this intricate tangle of cosmologic problems, the most significant role must be played by geology, physics of the Earth, rocket planetology (Zelinsky *et al.*, 1993; Zelinsky and Kuzjmenko, 1994; Kuzjmenko, 1984), their data being more available and trustworthy in comparison with the astronomical data. The approach to the more complete geo-astrophysical information should correspond to Gamows ideas. In this concept we include the selection of the most important observed factors which are characteristic of the Universe as a whole and also the application of fundamental theoretical knowledge to analyse them.

The following factors should be taken from geophysics and geology:

(1) the cyclicity of processes;

(2) the hierarchical structure;

(3) the flows of the terrestrial internal heat.

These factors are universal for all bodies in the Universe, but they are seldom discussed in this way. So we will observe their cosmological significance briefly.

The first and the second factors are highly related, this follows from general reasons. Therefore, the cyclicity of a process observed in a definite place graphically presents the structure in the expansion of the process's properties in time. The structuring itself presents an expansion of properties for extended objects in space. In this connection we have defined a special concept for the Universe's cyclicity in agreement with the observed cyclicity and structure from atomic to various

spatial objects, in the limits – to Metagalaxy. Indeed, geology fixes various cycles and structures reliably (Zelinsky *et al.*, 1993; Zelinsky and Kuzjmenko, 1994; Kuzjmenko, 1984; Kuzjmenko *et al.*, 1993). But the atomic micro-oscillations and structures are known too (Davise, 1985; Ivanenko and Krechet, 1980).

At present, the complex soliton – wavemechanical equation is developed, it desribes the macro- and microworld from a unified point of view (Zelinsky and Kuzjmenko, 1994; Kuzjmenko, 1984; Skorobogatov, 1987):

$$\Delta\psi - \frac{1}{2mb^2}\frac{\partial U}{\partial w}\psi + \frac{i}{b}\frac{\partial \psi}{\partial t} = 0. \tag{1}$$

It includes Schroedinger's quantum equation as a particular case for the value of Markov's constant $b = h/4\pi m$ and linear dependence $U = wV$, where V is the potential binding energy of a particle with mass m in the quantum system, $w = \psi\psi^x$.

In the system with macroscopic mass transport, for non-linear relations $U = (\alpha w + \beta w^2)V$, where V is the interaction energy in a non-quantum system, the equation (1) results in the soliton equation with non-linearity $|\psi|^2\psi$. The significance of soliton-synergetic relationships in geological phenomena was already noted (Zelinsky *et al.*, 1993).

At quasi-elastic potentials V/m, a description of geophysical oscillations and also a forecast of solar activity can be obtained from the stationary equation resulting from (1). The structural equations based on (1) lead to the observed hierarchy of astrophysical and geological structures (Zelinsky and Kuzjmnko, 1994; Kuzjmenko, 1984).

Therefore, the very general concept of cyclicity throws light on the evolution and the properties of the Universe. Really, the general theory of relativity gives the following idea: if the mean density of matter is $\rho \gtrsim 10^{-28}$ g/cm^3, compression will come after extension in the Metagalaxy. But the order of real density has not been exactly determined. If we proceed from the assumption that all the observed geo-astrophysical cyclicity is a bounded hierarchy of cycles, i. e. from our concept of the Universe's cyclicity, the conclusion on the Metagalaxy's cyclicity should be made. Conversely, it can be more definitely confirmed that its density ρ corresponds to the above-mentioned value.

Possible modifications or improvements of standard cosmology (Burbidge, 1992; Narlikar, 1984) and theory of matter (Ivanenko and Krechet, 1980) should take into consideration the Universe's cyclicity which is wider in its sense than the gravitational results concerning the cyclicity of expansion and compression of the Metagalaxy – one object – without any connection with the processes in its parts. Additionally we note that the present intense development of wavemechanical concepts emphasizes the integral unity of the whole and the parts, i. e. our soliton-synergetic concepts for the Universe's cyclicity being correct (Davise, 1985).

The third factor is also closely connected with the possibility of some improvements. Really, only the readily available and rather exact geological data (Zelinsky and Kuzjmenko, 1994) disclosed the general law of energy distribution: the internal thermal flows of "cold" geological bodies, planets, and hot stars are common phenomena in the Universe.

The energy of objects is described in a united form:

$$Q = Q_{\text{cl}} + Q_{\text{cosm}}. \tag{2}$$

Here Q_{cl} is the classical contribution of atomic and nuclear processes; Q_{cosm} is the cosmological contribution presented by the formula

$$Q_{\text{cosm}} \simeq \alpha^n \frac{\gamma m^2 c}{R^2}. \tag{3}$$

where R is the effective size of the galactic lattice (1.7×10^{18} cm) derived from the observed radiation of the Sun and the Earth; n is the exponent of the quantum constant for electromagnetic interaction $\alpha = 1/137$. The Hertzsrung–Russell classification obtains at last its numerical definitions: the least intense, non-thermonuclear radiators – white dwarfs and planets have the intensity level $n = 1$; sub-dwarfs have $n = 1/2$; stars of the solar type have $n = 0$; giants have $n = -1/2$; supergiants and pulsars have $n = -1$.

For galaxies and pulsars being "particles" with mass μ in Metagalactic lattice with size $R_M \simeq 10^{28}$ cm and $M \simeq 10^{56}$ g, the formula is similar:

$$Q \sim \frac{\gamma M \mu c}{R_M^2} \tag{4}$$

Here the calculations give the range of the observed values $10^{44} \div 10^{48}$ erg/s (in early Universe, for quasars, $R_M \simeq 10^{27}$ cm).

The semi-empirical formulae (3, 4) can be obtained by means of modelling (Rozovsky *et al.*, 1987) and also from Mach's principle (Narlikar, 1984) which was actively used by Gamow in his cosmological studies (Gamow, 1970). The derivation of these formulae by combining gravitation and quantum theories would be very demonstrative here. In the meantime, the known result of the mentioned studies is the theory of black hole evaporation, but it has considerable drawbacks. Simultaneously these shortcomings point out the prospects of generalization of concepts of entropy and hydrodynamic turbulence to the gravitational field (Keith, 1984). So, considering the neighbouring stars in the galactic lattice, the mechanical momentum of the Newtonian force $\frac{\gamma m_1 m_2}{R^2} R$ can be compared with the mechanical momentum of the vortex created by graviton circulation in the flow tube passing through two similar stars which are at the distance $2R$ in the line perpendicular to the direction $m_1 m_2$ ("the galactical experiment of Cavendish"). The equality of momenta takes the following form when $m_1 = m_2 = m$:

$$\frac{\gamma m^2}{R^2} R = \frac{1}{2\pi} \oint m^x c \, dl. \tag{5}$$

In (5), m^x is the mass flow rate of gravitons circulating through the star cross-sections per second. After reduction of R, additional multiplication of left and right parts by the velocity of light and taking into consideration the relation $Q_{\text{cosm}} = m^x c^2$, we really obtain the core of equation (3). All these equations (2–5) evidence

for transformation of gravitational energy into electromagnetic one in celestial bodies: the decrease of the absolute value of gravitation energy in the Universe as the result of its evolution follows the law of conservation, because the equivalent quantity of radiation is released (Kuzjmenko, 1984).

These results make the gravitation theory correct, help to select its best versions, but some of them are more attractive, and we may expect elaboration of the generally accepted version. This is especially so because the basic version, the general relativity, continues to be improved (Krotov, 1993). It is remarkable that it occurs by the generalization of concepts of continuum – elasticity, plasticity, friction, which are the basic physical factors of geological experience (Zelinsky *et al.*, 1993).

So, completing the paper, we point out once again the role of geology in cosmological science, being fundamental to the same extent as the astronomical examination of deep space. Even under the possible significant transformation of standard cosmology (Burbidge, 1992; Narlikar, 1984), Gamow's model of hot Universe is cardinal. It is provided by nuclear physics, after all by geology and geochemistry, which discovered uranium and radium for the science.

3 CONCLUSIONS

1. The necessity to apply the accumulated data of geology and geophysics, which were not used completely at present, in addition to astrophysical methods to solve the modern problems of physical cosmology is demonstrated. The further effective development of cosmology as a science is difficult without it.

2. The appropriate theoretical base for the mentioned problem, in our opinion, is the application of synergetics, fractal theory, and wavemechanic solitonics developed during the recent decade, essential contributions to the science made after the creation of standard Fridman–Gamow cosmology. At the same time, the more strict account of the existing theoretical possibilities and their coordination with the observed events is necessary too.

3. The examination of standard cosmology and its modern development including quantum cosmology is needed in order to make possible corrections on the basis of geological and geophysical data on the Universe's cyclicity, its structure, and transformations of gravitational energy into electromagnetic radiation.

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