PHYSICAL THEORIES (MATHEMATICAL MODELS) ADEQUATE TO THE REALITY — A NECESSARY CONDITION FOR PROGRESS OF NATURAL SCIENCE OF THE XXIst CENTURY*

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1. Interdisciplinary conferences on mathematical problems of space-time physics of complex systems

The most important problem confronting the Science in the whole world at the present time, on the threshold of the new century and new millennium, is to secure a stable historical future of the mankind. All countries, in one way or another, are faced with extremely difficult problems such as, for example, problems of energy supply, ecology, and health protection. It becomes evident that most of these problems are a result of direct or indirect, conscious or subconscious, violation of the laws of Nature.

Under these conditions, it is extremely urgent *to work out a correct* world outlook, i.e., an outlook based on the scientific picture of the world, the picture that is *actually adequate* to the reality, is truly compatible with the reality in which man exists and acts. As is known, the scientific picture of the world is based, first of all, on notions and concepts of physics. It is generally accepted that physics should be a theoretical basis of the natural sciences. The foundation of the physics of the XXth century is composed of two theories: the quantum theory and the special relativity theory as a theory of space-time. A special place in the field of worldwide investigations of mathematical properties of the physical reality, the space-time, has been for a long time occupied by works of researchers from the Sobolev Institute of Mathematics (SIM) of the Siberian Branch of the Russian Academy of Sciences (SB RAS), the works developing the *chronogeometry* of A. D. Aleksandrov.

According to Aleksandrov, the chronogeometry is a field of studies which is close to the foundations of geometry and whose purpose is to find the most simple and intuitively clear system of axioms that would be equivalent to the special relativity theory (SRT). Aleksandrov used this term in 1967 in the title of his paper dedicated to the 60th jubilee of H. S. M. Coxeter [1]. His paper contained a series of theorems characterizing bijective mappings that preserved cones in an affine space, and also contained a discussion of the obtained results as a possible new foundation of SRT.

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The starting concept of the chronogeometry is Minkowski's representation of the space-time as an absolute World of events equipped with a four-dimensional pseudoeuclidean geometry of the signature $<+---->$. However, this geometry is not introduced from the very start but has to be derived from some sufficiently simple system of axioms which is imposed on the World of events. The choice of the system of axioms is made by the researcher who uses either a practical experience, subject to a philosophical comprehension, or some theoretical interpretation of experimental data. In the first case, special attention is paid to cause-and-effect relations, while in the second case — to physical concepts, for example, to the principle of the constancy of the speed of light.

A. D. Aleksandrov started to actualize his goal in the most active way in the years when he worked in the Institute of Mathematics of the Siberian Branch of the USSR Academy of Sciences (IM, SB USSR AS—former name of SIM, SB RAS). He succeeded in attracting a group of students from the Novosibirsk State University (N. F. Tishchenko, A. K. Guts, A. V. Kuz'minyh, A. V. Shajdenko, A. V. Levichev, S. N. Astrakov *et. al.*) and research workers of the Institute (A. P. Kopylov, V. K. Ionin, V. Ya. Krejnovich) to this work [2]. The results of investigations of that group of "chronics", as they called themselves, are partially presented in two reviews by A. K. Guts [3, 4]. Two things became clear. First, it turned out that the principle of the constancy of the speed of light does not play such a defining role in determining the geometry of the space-time as it was thought previously (compare with the approach of N. D. Mermin [5]: the relativity theory without the postulate of the constancy of the speed of light). Second, although cause-and-effect relations point unambiguously to the pseudoeuclidean character of the geometry of the World of events, nevertheless, various axiomatizations of the causality principle did not succeed in providing a satisfactory answer to all of the questions concerning the sources of group, topological, those connected with differentiability, and metric properties of the Minkowski world [6, 7].

Unfortunately, a critical analysis of the successes and failures of Novosibirsk "chronics" in their studies of the sources or, more exactly, of the essence of the structure of the space-time has not been made. One thing is certain: the work of the *"Chronogeometry"* seminar headed by A. D. Aleksandrov, which continued for more than ten years, has demonstrated a special significance of the views on the space and the time as mere "shadows" (as was first figuratively said by Minkowski) of the universal and absolute World of events, whose metric structure can be explained not only by cause-and-effect relations between 'events', relations closely associated with concepts of temporal order, but also by relations that eliminate the concepts of temporal order in the World of events (consideration of the so-called double cones), which is one of the most important achievements of chronogeometry.

In 1987, investigations of mathematical properties of the World of events (at that time, these studies in the Institute of Mathematics were continued only in the works of A. V. Levichev and his students[†]) were supplemented by investigations of physical properties (this was connected with the transfer of the Department of Conditionally Well-Posed Problems from one of the institutes of SB USSR AS to IM). The latter investigations actually implemented the program advanced in the 20's of the XXth century by A. A. Friedmann in his book *"World as the Space and Time"* and which was devoted to the problem of *"restoring to the time its exceptional position in physics"*, the position connected with causality[‡].

[†] In those years, A. V. Levichev got deeper into the problems and applications of I. E. Segal's chronometric theory as an alternative to the contemporary 'standard model' of theoretical physics, having judged it as the "completion of the special relativity theory" [8].

[‡] Unfortunately, A. A. Friedmann died before he could develop his program. Nevertheless, assessing his approach retrospectively, one should note that for its realization, as a preliminary, it was necessary to make a decisive principal step in the development of fundamental physical concepts: it was necessary to recognize the deep-rooted "scholasticism" of the 'space-time' and to raise the

Thus, the actuality of co-ordination and mutual ideological enrichment of investigations of the physical properties of the World of events, which are currently in progress in various branches of physics and in other natural sciences, has come to a head. In this connection, four years ago we have advanced a proposal: to hold regularly, once in two years, small interdisciplinary conferences on mathematical problems of space-time physics of complex systems (the abbreviation for the conference name is STP). The First Conference was held in August 1996, the second was held in June 1998, and today we are opening our Third Conference.

At the First Conference, the results of studies of physical properties of the World of events initiated by the Institute of Mathematics and utilizing proper experimental bases were presented and the present state of well-known physical problems connected with concepts of the theory of space-time was discussed. Over 80 scientists (mathematicians and natural scientists of the broadest range) took part in the Conference. Thus, for example, there were reports devoted to the newest concepts in biology and medicine concerning the functioning of the unique complex system of Nature – the human organism with its space-time laws. As a result of discussions and scientific contacts that arose at the First Conference, a creative "interdisciplinary collective" of researchers from SB RAS and other Novosibirsk institutions was formed and continued to work on the basis of an interdisciplinary seminar at the Institute of Mathematics. This collective arranged the next, Second Conference.

The Second Conference was held with the aim of systematizing various investigations of the fundamental mathematical laws of the Universe; discussed were concrete, basically new physical ideas, approaches, and concepts. Fundamental laws of the creation, existence, and development of complex organized systems of micro-, macro-, and megaworld were at the center of discussion. About 40 reports were attentively heard and discussed in detail at the Second Conference during nine days of its work. Scientists from Novosibirsk, Omsk, Tyumen, Krasnoyarsk, Yakutsk, Dubna and Moscow, Kiev and Alma-Ata took part in the Conference. A noted USA scientist Professor O. D. Jefimenko was a guest of the Conference; his speciality is electromagnetism and he is the originator of *retardics*, a direction in theoretical physics in which the corresponding cause-and-effect relations are explicitly introduced into solutions of equations describing physical phenomena. Retardics makes it possible to look at many basic problems from a new vantage point and to obtain fundamentally new results and correlations in electromagnetism and gravitation.

A broad range of problems presently studied in physics were covered at the Second Conference from common positions. These problems ranged from the structure of elementary particles to wave properties of the Universe, and from the fractal properties of space-time to global processes of self-organization in the world. All reports were notable for non-standard approaches and for the wealth and diversity of new ideas. However, it became evident at once that they reflected the same methodological and philosophical positions: a unified approach to physical phenomena of micro-, macro-, and megaworld, and the priority of the adequacy criterion in assessing the mathematical models of the physical reality. It was exactly this logical concord that has united the main participants of the Conference into a creative collective; and the availability of electronic means of communication has allowed to continue cooperative work after the Conference had ended. The proceedings (a collective volume) of the Conference were published in *"The Search for Mathematical Laws of the Universe: Physical Ideas, Approaches, and Concepts"* [9].

The themes of this collective volume are integrally connected with many general fundamental physical problems of electric and magnetic fields, special relativity theory, gravitation, the structure of microsystems in atomic and nuclear physics, elementary particle physics, and astrophysical megasystems. In the papers of this collective volume, the authors raise problems related to the four-dimensional pseudoeuclidean World of events and propose methods for investigating its physical

question about the "physical" 'World of events'.

properties, raise problems related to wave astrodynamics, retardics, classical physical fields, and irreversible electrodynamics, discuss the universality of the laws of self-regulation of dynamical systems and the universality of the Huygens principle of resonance synchronization, and also discuss questions of the integration of the physical knowledge.

Scientific co-operation and further contacts showed that it would be reasonable to dedicate our Third Conference to discussions of several conceptual physical theories (mathematical models) pertaining to investigation of the physical aspects of the space-time. Such theories (models) include chronogeometry, nonlinear dynamics of hadrons, Clifford's algebras and discrete transformations of the space-time. They also include the theory of the space-time (the World of events)—methods and results of investigations of its physical aspects, a physical model of the unity of natural systems which emerges on the basis of the Huygens principle of resonance synchronization, and, lastly, atomic physics which is *actually adequate* to the microworld.

In connection with the presented below discussion of the above-mentioned conceptual physical theories (mathematical models), I would like to dwell on one important point that is a necessary prerequisite for a progress of natural science in the XXIst century. In recent times, this prerequisite has manifested itself, in one way or another, in many particular works connected with studies of the existence of complex systems in physics and astronomy, geology and biology. What I have in mind here is a criterion for evaluating the efficiency of conceptual theories (mathematical models). The former enthusiasm for criterions reflecting assessments of the levels of sophistication and peculiarity of the mathematical apparatus used in the model is now being replaced by a return to the fundamental, natural requirement: *the requirement that a model should be adequate to the physical reality.*

It is no secret that the sophistication of mathematical description allows, in cases when one deals with *separate* experiments or observations, to create an impression that the theory corresponds to the factual data. But this illusion disappears at once when the factual material is treated not fragmentarily but as a whole, i. e., when we require that a proposed physical theory (mathematical model) corresponds to the *whole* of the experimental (observed) material. Then, in the case of inadequacy, *the adjusting nature* of the various procedures that ensure the so-called "agreement" with the experiment springs to the eye at once.

An obvious indication of inadequacy is also the absence of predictions of new effects and phenomena that are eventually discovered. If a model only "explains" but does not actually predict anything at all, it cannot provide further directions for the development of theoretical insights, for the development of really new knowledge. Consequently, it cannot in principle contribute to the progress of cognition in natural sciences.

And now, prior to considering the adequacy of the above-mentioned conceptual physical theories, it is reasonable to take a look at the entire discussion field of our Conference.

2. Physical concepts presented for discussion at the Conference STP-2000, their interconnection, achievements, and perspectives

2.1. *M. Gryziński's atomic physics*

Undoubtedly, the deterministic atomic physics, originated by M. Gryziński, is rightfully at the center of attention of our Conference. This is so because, firstly, the spatial-temporal concepts associated with the microworld are most essential for developing a physical aspect of the World of events of complex systems and, secondly, because the history of this fundamental physical theory is remarkably instructive. It so happens that as early as in 1965, Professor M. Gryziński, who is

internationally renowned for his universally recognized outstanding achievements in nuclear physics in his capacity as an active supervisor of the Polish National Program *"Plasma Physics and Controlled Fusion"*, proposed a deterministic atomic model [10]. His idea about electron's precessing spin[§] resulted in the conclusion that classical dynamics using Coulomb's law successfully and in full agreement with experiments describes phenomena occurring in the world of atoms and that electrons in an atom in the ground state move radially. Thus, the picture that an electron exists as a cloud of the Ψ-function, which has been generally accepted in physics for as long as seventy years, is in fact an inadequate, erroneous conception.

In his three reports *"On the nature of the atom"*, M. Gryziński will tell in detail that his atomic model (he calls it the free-fall atomic model), which was developed on the basis of experimental data on nuclear collisions and in which electrons are positioned symmetrically around the nucleus and move co-operatively along radial (almost radial) trajectories, describes correctly all the main properties of atoms.

Comparisons of theoretical calculations with experimental data for a broad range of energies and for various experiments [11–13] have shown that classical dynamics does indeed work in the microworld as well, and that the electron moving radially in the Coulomb field of a nucleus should be treated as a physical reality[¶]. It follows therefore that the well-known correspondence principle, which was introduced by N. Bohr and which states that classical mechanics is inapplicable in the world of atoms where a fundamentally different mechanics, quantum mechanics, must be used, turns out to be a unnatural, erroneous idea.

As is known, in the literature as well as in scientific circles, there exists a firm and long-established conviction that the agreement between quantum-mechanical theoretical predictions and experimental data is *"impeccable"*. However, after an in-depth investigation of the origins of this conviction, M. Gryziński promptly discovered unquestionable facts of a large-scale disregard and hushing up of the true and rather unhealthy state of affairs, which he reported in his brochure *"True and False Achievements of Modern Physics"* [14]. Most likely, the motivations for such a scientific policy are quite different from the motivations for the well-known scientific crimes of Claudius Ptolemy (see the book *"The Crime of Claudius Ptolemy"* by R. R. Newton [15]), and yet, willy-nilly, one must acknowledge the existence of a strong "corporate" scientific bias, possibly even incompetence or falsification. One should not be surprised therefore that the excellent adequacy of Gryziński's atomic physics to the physical reality, which is convincingly manifested by:

- the required agreement between theoretical calculations and numerous well-known experimental data pertaining to atomic phenomena (without any adjustment of parameters!), see [14];
- the creation of a dynamical theory of molecular bonds, see [16];
- an explanation of the Van der Waals forces and of the Ramsauer effect by the asymmetry and oscillations of the atomic electrical field [17];
- the resolution of the mystery of the 'corpuscular-wave dualism', thereby revealing the actual physical significance of the electron's 'wave nature', see [14];
- a possibility to compute correctly physical characteristics of solid bodies over the entire Mendeleev table, see [14];

[§] Now one can only wonder and be puzzled why the idea of spin precession occurred neither to N. Bohr nor to other investigators of the generally accepted quantum-mechanical model of an atom even when they used the "planetary model". After all, the idea of a precessing spin of an electron in an atom is much more natural (very much so in the light of the well-known motion of planets) than the idea of a strictly fixed spin.

[¶] It should be specifically emphasized that the theory proposed by M. Gryziński does not contain any adjustable parameters so that the agreement of theoretical results with experimental data is really *a test* of the theory but not *an adjustment* of the theory to an experiment.

was summarily ignored by law-makers of the adaptive modeling in quantum mechanics ... None of them appeared capable of saying in the Aristotle's manner: *"Amicus Quantum mechanics, sed magis amica est veritas"* and be overjoyed by the creation of an *actually adequate* atomic mechanics, whose gnoseological significance can hardly be overstated.

The veil of the Ψ-function was stripped from the atom, and the world of the atom's electrons, extremely ordered and co-ordinated in time and space, has appeared before us. Gryziński's concept of atomic physics will undoubtedly exert influence on the general formulations of particle physics and on specific investigations. At this time one can see in it a theoretical foundation for explaining the wonderful universality of the Huygens's resonance synchronization principle. This principle is used by F. A. Gareev as the basis for his physical model of the unity and harmony in the Nature. Ignoring actually from the very beginning the quantum mechanical principle of correspondence and operating with classical concepts, Gareev has already obtained a number of interesting and novel results concerning the properties of matter in micro- and macrosystems, see, e. g., [18]. The order and co-ordination in the atomic world and the properties of this world discovered by Gryziński harmonize with the picture of the inner world of stars revealed half a century ago by the discoveries of N. A. Kozyrev [19, 20].

Taking into account that the *List of "especially important and interesting problems" of physics and astrophysics of the XXIst century* compiled by V. L. Ginzburg [21] does not contain problems connected with the birth of stars and with the nature of the stellar energy, which cannot be considered solved[‖], the next important topic of our Conference is the discussion of N. A. Kozyrev's works [19, 20] dealing with the setting and the study of the problems of the internal structure of the stars and of the nature of the stellar energy.

2.2. *N. A. Kozyrev's stellar physics and the concept of the physical World of events*

The results of Kozyrev's studies on the inductive solution of the problem of the inner structure of stars based on an analysis of relationships obtained from astrophysical observations, so that equations for the state of the substance and for radiation in the interior of stars are a consequence of an *investigation* rather then of *a priori* assumptions, were mind-boggling for adherents of the hypothesis of thermonuclear nature of stellar energy. As was proved, the hypothesis, which is widely exploited in astrophysics and on the basis of which, to put it figuratively, one could "compute and compute", actually turned out to be an illusion: when this hypothesis was confronted with astrophysical observations as *a whole*, rather then with fragmentarily observations, its unsoundness became evident.

Kozyrev's works encountered a prompt reaction from law-makers of adaptive modeling in astrophysics: a review by A. G. Masevich [23] and a criticism by D. A. Frank-Kamenetskij in [24] served to create an opinion that Kozyrev's approach was "erroneous". The tools of the criticism were standard for events of such kind: a viewpoint (misrepresenting the true state of affairs) was invented by the opponents and was ascribed to the author, and this fictitious viewpoint was then discussed. As a result, if the reader was not acquainted with Kozyrev's works[**] published in *"Notices of Crimean Astrophysical Observatory"*, it was possible to deceive the reader about Kozyrev's approach and, consequently, create distrust toward his results.

At present, as well as half a century ago, *"the question of the internal structure of stars is extremely complicated and entangled in many theoretical investigations"*

[‖] For a criticism of the presently prevailing concepts, see the book *"Stars, Galaxies, and the Metagalaxy"* by T. A. Agekjan [22].

[**] By the way, D. A. Frank-Kamenetskij completely ignores the main, final, paper [20]: this paper is not considered and is not mentioned at all!

[19, p. 5], and the problem of the nature of stellar energy remains, as before, an open fundamental problem of physics. Therefore, a retrospective analytical review of Kozyrev's approach and his results is quite timely. It will be presented in considerable detail by I. A. Eganova in her report *"On the nature of the stars: N. A. Kozyrev's approach and his results"*.

Kozyrev considered the world of stars as a giant laboratory in which substance and radiation exist in the broadest range of states. Clearly, in order to begin the deciphering of the physical mechanism of the energy release in stars, one needs information about the physical conditions under which the release occurs. Therefore Kozyrev decided to find these conditions as some unknown quantities in tentative theoretical equations based exclusively on fundamental physical concepts and on empirical relations obtained in this "giant laboratory". He noted from the start all the unknown physical conditions revealed by investigations of the internal structure of stars, and they always stayed within his eyesight, their interconnection and interdependence being constantly taken into account. Thus, without any *a priori* assumptions, step by step, a theory necessary for a physical interpretation of the Hertzsprung–Russell diagram was created. This fundamental empirical law of astrophysics correlates effective temperatures of stars with their luminosities, both of which are undoubtedly controlled by the physical characteristics of the energy release in stars. Therefore the necessary information on physical conditions responsible for the release of stellar energy can be deduced from the Hertzsprung–Russell diagram (provided that an appropriate theoretical base is available). With this information at hand, one can really *study* the question of the nature of stellar energy instead of *guessing* the answer by proposing this or that physical hypothesis.

Kozyrev's analysis of the Hertzsprung–Russell diagram based on his preliminary theory of the internal structure of stars lead him to the following three principal conclusions:

> **1.** The hypothesis that thermonuclear reactions are the main source of stellar energy is unsound.
>
> **2.** The heat production in a star is determined only by heat emission, consequently, the mechanism of the heat release in stars is, quite generally, not all of a 'reaction' type, but as in a self-regulating 'machine'.
>
> **3.** Violation of the laws of classical mechanics and thermodynamics occurs much earlier and under different circumstances than as follows from the special relativity theory.

These deductions as well as all the peculiarities of the diagram of star states considered by Kozyrev, see [20], became the foundation for his subsequent conclusion that physics should adopt the ideology about which, as a matter of fact, A. A. Friedmann spoke thirty years ago, namely: to overcome the widely spread in physics idea that 'time' and 'duration' are the same things, to restore to the time its exceptional position associated with causality, to treat the time as a form of existence of the material world, and to find adequate means for investigating the physical properties of the temporal aspect of the existence of material systems. Thus, in the course of the study of a fundamental astrophysical problem connected with the mode of existence of natural systems, there appeared a recognition, historically linked to that study, that it is necessary to explore directly the temporal aspect of the World of events, its physical properties, and its role in existence and development of material systems. Kozyrev's concept of time and the implemented by him purposeful investigation of the physical properties of time, based on this concept and conducted (for 35 years) in such a way that each subsequent step utilized theoretical conclusions from experimental results of the previous step, can be used as a methodological foundation for direct studies of the physical properties of the World of events and of its temporal aspect, see [25]. Clearly, it is necessary to form a concept of the *physical* World of events. Let me explain. The space-time, the four-

dimensional mathematical model of the physical reality, is defined as a manifold of points (x, y, z, ct), which are called 'events'. In connection with this definition, two things should be kept in mind. First, there is a certain *schematization* of reality: an 'event' is considered to be only a set of spatial (x, y, z) and temporal (ct) coordinates, complete devoid of any concrete physical or some other information about this event as *a phenomenon of reality*. Second, there is a certain *idealization* of reality: events are treated as "pointlike" phenomena, i.e., as taking place in such a small space and during such a short time interval that they are thought of as occurring at a "point" and "instantly". Moreover, a certain system of axioms is accepted which ascribes to the space-time a topological structure, connectedness, separability, and metric. Thus, no matter which particular noneuclidean space is being considered, be it pseudoeuclidean or Riemannian (Minkowski's 'world' or Segal's 'universal cosmos'), in either case we deal with a mathematical model of the physical reality which from the very start presents and reflects only its *'geometric'* (*'chronogeometric'*) aspect. (This is similar to the ordinary geometry which studies only the geometric properties of real bodies: lengths, areas, volumes, etc., but not their physical properties and phenomena occurring in them.)

The 'space-time' is one of the objects in the world of mathematical models of the physical reality, subject to the above-mentioned schematization and idealization of the concept of an event affecting the physical reality itself. This model, which contains only purely geometric information (coordinates) about actual events, can reveal, accordingly, purely geometric (more exactly, chronogeometric) laws of the physical reality and therefore, as far as the goals and problems of physics are concerned, is not sufficiently adequate. It is necessary to have a physical 'World of events', i.e., a mathematical model that not only reflects the chronogeometric parameters of events but also provides the information on their physical properties and peculiarities; it is necessary to restore to the events the properties that have been abstracted from them. In other words, it is necessary to consider the 'World of events' as a totality of entities which are called events and are characterized by a comprehensive set of properties: 'chronogeometric' (spatial and temporal coordinates) and 'physical' (which are determined by the particular nature of the real phenomenon under consideration). Clearly, the 'World of events' is a more adequate model of the physical reality than the 'space-time'.

As was mentioned above, the concept of the physical World of events was presented in detail at our first two Conferences in the reports by I. A. Eganova, which also contained the following results of investigations of the temporal aspect of the World of events:

- an analysis of the action-at-a-distance [26, 27] as an interconnection in the temporal aspect:

1) action-at-a-distance as a manifestation of the interconnection between events resulting from the space-time metric(*a priori* connection of events separated by zero proper time interval—development of Kozyrev's and N. D. Mermin's approaches to conceptions of SRT),

2) action-at-a-distance as manifestation of the universality of time (independence from the physical or any other 'mechanism' of the standard clock—development of G. J. Whitrow's approach),—

investigation of the temporal structure of the World of events;

- *the results of investigations of the celestial sphere by an Earth-bound observer as his World of events:*

- registration of the true position of the stars β *Pegasi*, α *Andromedae*, δ *Andromedae* [26, 28, 29],

- registration of the event *'true Sun'* and its influence on the state of complex systems of various nature [30, 31, 26, 27],

- registration of unknown large-scale anomalies during the scanning of the daily parallel of the star α *Arietis* [32];

• *the results of the investigations of the manifestations of properties of the World of events in the dynamics of key characteristics of complex systems:*

- results of observations of the dynamics of complex systems during the collision of fragments of SL9 with Jupiter [33],

- determination of the fractal dimension of the temporal structure of the space-time, physical interpretation of the Hurst's empirical law for natural phenomena [27, 34].

The concept of the physical World of events is the keystone of the ideological foundation of our Conferences, whose purpose is to bring together and to consolidate the major conceptual physical theories (mathematical models) that are actually adequate to the physical reality. That is why, from the very start, in the discussions taking place at our Conferences, references were made to the well-known works of the Academician A. A. Logunov. The concepts and results obtained by A. A. Logunov and by his collaborators aroused a strong positive response at our Conferences, firstly, in connection with the "return" to the Minkowski metric, secondly, in connection with some results of the relativistic theory of gravitation (RTG) in the light of V. A. Ambartsumjan's conception about the formation of stars from an ultradense matter, and, thirdly, in connection with O. D. Jefimenko's generalized theory of gravitation that is based on essentially the same physical concept of gravitation as RTG.

2.3. *A. A. Vlasov, A. A. Logunov, and M. A. Mestvirishvili's relativistic theory of gravitation, V. A. Ambartsumjan's conception of astrogenesis, O. D. Jefimenko's generalized theory of gravitation, and I. A. Shelaev's irreversible electrodynamics*

First of all, we should mention the recent analysis of the physical essence of the special theory of relativity made by A. A. Logunov [35]. It is important to note that, together with the special theory of relativity, basically new concepts about the physical reality entered into the theoretical physics. They include new ideas about time and space, about motion and interactions, and about the general requirements that should be satisfied by physical theories and by their mathematical formulations. At the same time, in the broad scientific circles, there is no common attitude toward these questions and toward the general contents of SRT. As was stated by A. D. Aleksandrov in his paper [36] devoted to the contents of SRT, at the present time "two different approaches to the relativity theory have been formed. The first one is the approach of Minkowski, which is based on the idea that the space-time is the real and absolute form of existence of the material world. The second one is a purely relativistic approach ; its most important element is one or another frame of reference" [36, p. 122]. This fact is a very essential circumstance in the development of the physical concepts of reality, in the creation of a scientific picture of the world.

Indeed, the first approach is conducive to the creation and development of physical theories (mathematical models) that are *adequate* to the objective reality, exerts an influence on the formation of concepts of natural sciences about the fundamental functional and organic interrelation of the spatial and temporal aspects of the existence of material systems. The historical material pertaining to the major physical theories and discoveries indicates that they in one way or another were connected with the development of the general, philosophical, conceptions about the universe, matter, motion, and interactions as well as with their concrete practical applica-

tions. Exactly within this context the first approach, which appeared for the first time in H. Poincaré's work [37] and then was formulated by Minkowski [38], who clearly preesented the idea of the unbreakable unity of space and time and of their pseudoeuclidean geometry, manifests itself as a discovery of a new way for the development of physical concepts about the reality. It is precisely this approach that provides fruitful ideas and promising directions for concrete natural-scientific investigations and expedites the development of methods and techniques for a study of the fundamentally new interconnections and processes as well as of fundamental laws of existence of complex self-organizing systems.

The second approach actually ignores the essence of SRT that became clear after the well-known contribution by Minkowski [38], the significance of which was emphasized by A. Einstein [39]. According to A. D. Aleksandrov, this approach is a consequence of the fact that "Minkowski's view on the relativity theory was not perceived by physicists in all its depth" [36, p. 121]. In fact, the second approach refuses to accept the adequacy of the four-dimensional mathematical model (Minkowski's 'world', 'space-time') to the physical reality, considers it to be merely a comfortable fictitious formalism, and is purely "positivistic, denying that the relative is just a facet, a manifestation of the absolute" [36, p. 122]. An indubitable "accomplishment" of this approach is that "dogmatism and faith, which are always alien to the science and are always accompanying it, have done their deed. They have limited, almost up to present day, the level of understanding and, as a consequence, narrowed the field of application of the relativity theory" [35, p. 3]. Therefore, the recent analysis of the essence of the relativity theory, which was made by A. A. Logunov in his work [35] and which presents SRT as a theory of the space-time, remains as timely as ever.

The exposition of SRT in [35] is centered around the ideas of Minkowski, who in essence was the first to realize that a "purely mathematical reasoning" connected with the special relativity theory actually leads to "new views concerning the space and time", because behind all its mathematical results there stands the fact of the existence of the 'world' ('space-time') with a singular geometry. Therefore the content of SRT is a qualitative, basic step in the development of concepts of the physical reality. More accurately, "the relativity theory is a discovery of the unified pseudoeuclidean geometry of the space and time for electromagnetic phenomena and its extension, as a hypothesis, to all forms of matter [35, p. 3]. A statement is frequently found in the literature that this formulation is just "a mathematical interpretation of the relativity theory". However, this is exactly its 'essence' rather then 'interpretation'.

A. A. Logunov has shown [35] that the concept of the pseudoeuclidean geometry of the indivisible space-time makes possible to treat both the inertial and accelerated reference frames in a unified manner and makes possible to formulate a generalized principle of relativity. The postulate of the constancy of the speed of light is a particular consequence of the pseudoeuclidean geometry of the space-time for inertial reference frames and, consequently, cannot be regarded as a starting point of the theory. Therefore, the idea that the relativity theory is the postulate of relativity plus the postulate of the constancy of the speed of light is wrong in principle. Almost at the same time, but on the basis of different considerations, the same idea was convincingly demonstrated in a fundamental work by N. D. Mermin *"Relativity without light"* [5].

It is interesting to note that actually everything that was done in [35], as was at once noted by the author, *"could be done long ago, after Minkowski's work, and probably he himself would have explained everything if he had not died so early"* [35, p. 3]. "Dogmatism and faith", as the author has put it [35], were never helpful. And it is necessary to state that the very same dogmatism and faith prevented an immediate unbiased evaluation of A. A. Logunov's and his collaborator's work: proponents of the second approach to the essence of the relativity theory immediately

began to circulate an opinion in scientific circles that "Logunov has errors"[††] (just as it was alleged earlier about the works of Kozyrev and An. Al. Vlasov).

The relativistic theory of gravitation, proposed in the works of A. A. Vlasov, A. A. Logunov, and M. A. Mestvirishvili, revives and reestablishes the concept of the classical gravitational field as a physical Faraday and Maxwell field, see [40]. The same physical concept is used in O. D. Jefimenko's generalized theory of gravitation [41, 42], but there a different model of the physical reality is utilized.

The authors of RTG use the World of events of the special relativity theory; instead of the Riemannian space-time and the 'geometrical' concept of gravity of the general relativity theory (GRT) they use the pseudoeuclidean space-time and the 'physical' concept of gravity. In this connection it is useful to note that the experimental investigations of the temporal aspect of the World of events in astronomical observations confirm the reality of exactly the Minkowski metric (see [43]). In addition, it behooves to pay attention to the above-mentioned N. D. Mermin's approach: its results also testify to the reality of the Minkowski metric within the considered range of phenomena.

During the development of RTG the following points concerning the general relativity theory were consecutively shown:

- GRT does not have the fundamental laws of the energy–momentum conservation and of the conservation of the moment of momentum of matter and gravitational field taken together, consequently, the inertial mass and the gravitational mass defined in it are unequal;
- GRT does not give definite predictions for gravitational effects in the Solar system; in some effects the ambiguity of solutions manifests itself even to the first order in the gravitational constant;
- GRT does not have a concept of the gravitational field as a physical field possessing energy–momentum density, therefore, the well-known Einstein's formula for gravitational radiation is not a consequence of GRT.

The Riemannian geometry, which is the foundation of GRT, is not used in RTG as a mathematical model adequate to the physical reality when components of the metric tensor are considered to be gravitational potentials, but this geometry is not discarded. In the RTG, the Riemannian metric, which enters into the Hilbert–Einstein equations, appears naturally as the sum of the metric tensor of the Minkowski's space-time and of the gravitational field tensor. This ('effective') metric enters also into additional equations that together with the Hilbert–Einstein equations (in Minkowski's space-time!) form a complete system which uniquely defines gravitational interactions in material systems and satisfies all physical conservation laws.

The predictions of RTG were already discussed at our Second Conference in the light of the factual material of observational astrophysics, in particular, in connection with the so-called 'black holes', and also in connection with V. A. Ambartsumjan's idea concerning the formation of stars from ultradense matter, see *Editor's foreword* in [9]. This material will be considered in more detail in V. A. Leus's report.

It is known that the scientific ideology of the prominent astrophysicist Academician V. A. Ambartsumjan[‡‡] was notable for his adherence to that direction of cosmogony which seeks to obtain knowledge about the origin and evolution of stars

[††] It was strange to hear how confidently this was asserted in a narrow circle by a person of a high rank in RAS, but who, as it turned out, had never read Logunov, or Segal, or Synge, or A. D. Aleksandrov, or Wheeler and Taylor, or Friedmann, or Minkowski, or Poincaré, or Einstein's later works, i. e., had not read a single one of these distinguished scientists who understood SRT as a theory of space-time the key idea of which is *'event'*.

[‡‡] It should be noted that at the beginning of their scientific careers V. A. Ambartsumjan and N. A. Kozyrev worked together for a long time (1925–1933) and published 16 joint works, see [44, pp. 432–433].

not by means of adaptive modeling but on the basis of an analysis of observation data [45, p. 496]. It was exactly in such a way that he discovered a new type of stellar systems, groups of young stars (stellar associations) that are dynamically unstable and disintegrating, and thus proved that the process of star formation in the Universe continues even at the present time. It was exactly in such a way that he conducted his fruitful investigations of the problem of the origin and evolution of galaxies. Not sharing the prevailing viewpoint on the formation of stars from gaseous matter, which is based on the assumption that the source of stellar energy is thermonuclear, V. A. Ambartsumjan advanced a hypothesis that stars in associations emerge as groups from *"some other, unknown objects"*—ultradense bodies of non-stellar nature containing huge quantities of energy. This hypothesis became a guideline for its author in all his studies and was continually developed by him in the course of all his subsequent life; at present it is virtually an established concept. It will be presented in V. A. Leus's report in the light of his assumption that the collapsars of RTG are direct candidates for the role of unknown ultradense objects appearing in V. A. Ambartsumjan's concept.

In spite of the acknowledged achievements and worldwide recognition of its author, Ambartsumjan's idea of astrogenesis did not escape persecutions from lawgivers of adaptive modeling in astrophysics; the works of the renowned astrophysicist were not criticized and "errors" were not ascribed to him, to a person of such a high standing other "measures" had to be applied: he was simply accused of ... propagandizing and of spreading idealism in science. Things have taken a turn for the worse, and only an effective and timely defense by Academician M. A. Lavrent'ev saved this prominent scientist from public condemnation and excommunication from the science and active life.

Now let us turn to another realization of the concept of the classical gravitational field as a Faraday and Maxwell physical field: O. D. Jefimenko's generalized theory of gravitation (GTG).

GTG is one of the major results of retardics*. Retardics, as well as Kozyrev's causal mechanics, confirm to the requirements of the causality principle: an event-cause precedes in time an event-consequence. The difference between these theories is that Kozyrev's causal mechanics considers the so-called elementary link of the cause-and-effect chain, while retardics considers 'causes' and 'consequences' (effects) separated by a finite distance in space. In analyzing physical phenomena, retardics takes into account the *'delay time'*—the time interval between an event-cause and an event-consequence; the basis of its mathematical apparatus are the so-called "retarded integrals" [41, 46].

One might ask what essentially new results can this approach give to physics? After all, it only introduces in an explicit form the requirements of the causality principle into the equations of theoretical physics. However, in reality this is extremely important, because it assures the adequacy of the mathematical model to the physical reality. Indeed, a consideration of known phenomena on the basis of retardics made possible to obtain at once answers to a number of open questions of electrodynamics and also to view major "old" problems of physics in a different perspective. At our Second Conference, O. D. Jefimenko spoke about some such problems in detail in his three reports *"Retardics, relativity theory, and gravitation"* [42]. The initial results of retardics were as follows:

> • The widespread opinion that a time-variable electric field and time-variable magnetic field generate each other does not correspond to reality: there is no causal connection between them. Electromagnetic field is a dual entity that always has an electric and a magnetic component produced simultaneously by a common source — time-variable electric charges and currents. Having been produced once, the two fields co-exist without affecting each other, but they cannot exist without each others,

* From the word *retardation* ; this term was proposed by Yu. G. Kosarev.

just like two sides of a coin, see [41, 46], and this is the essence of the duality of the electromagnetic field.

• There is only one kind of electromagnetic induction: Faraday's induction; "Maxwell's electromagnetic induction" that is occasionally discussed in the literature does not exist.

• The Lenz's law expresses the causal connection between a changing electric current and changing *electric field* generated by that current.

• The third Newton's law is strictly valid only as a momentum conservation law but not as a law of equality of action and reaction.

• Gravitation, as well as electromagnetism, has a dual nature: there exist a gravitational field acting on all masses and a co-gravitational field acting exclusively on moving masses.

• Cosmic electromagnetic fields emit energy, while gravitational fields absorb energy.

As one can see, the initial achievements of retardics demonstrate that if the conceptual foundation of a model is actually adequate to the physical reality, then the essence of a phenomenon under investigation emerges immediately. Such a model will at once yield new results both on the level of explanations and on the level of prediction of new phenomena.

Applying retardics to gravitation, O. D. Jefimenko succeeded in revising constructively Newton's gravitational theory and, having revived Heaviside's articles on gravitation†, created the generalized theory of gravitation, see [42] and the works cited therein.

At the end of XIXth century, O. Heaviside generalized Newton's gravitational theory to the case of time-dependent gravitational interactions. (By the way, this step completely corresponds to the rules of retardics!) In so doing, Heaviside assumed that the gravitational field, similar to the electromagnetic field, consists of two force fields: the usual Newtonian one, which is created by all masses and acts on all masses, and a field created only by moving masses and acting exclusively on moving masses. There is not yet a generally adopted name for the latter field and, following Jefimenko, we will call it the 'co-gravitational' field. It is known that Heaviside himself presented his theory merely as an *analogy* to the electromagnetic theory. Retardics has made it possible to answer positively a fundamental question: that of the adequacy of Heaviside's gravitational theory to the physical reality. Jefimenko has shown [41] that Heaviside's theory follows rigorously from Newton's theory and from the two following principles:

1) the gravity propagates with finite speed;

2) the momentum conservation law is not violated in gravitational interactions.

This is how the *generalized theory of gravitation*, as its author has named it, i. e., Heaviside's gravitational theory (whose adequacy has been substantiated) supplemented with the general solutions of Heaviside's gravitational equations that express the gravitational and co-gravitational fields in terms of "retarded integrals" ‡, was created.

It is important to note, that, according to GTG, gravitational interactions between bodies involve not just one gravitational force but five forces: three gravi-

† It should be noted that they were reprinted in O. D. Jefimenko's book [41].

‡ It should be underlined that contrary to Heaviside's equations these integrals directly contain the density of mass and the density of mass current that generate the gravitational and co-gravitational fields, see, e. g., [42].

tational and two co-gravitational forces. A description of all these forces is given in [41]; it is also given in [42]. On the whole, GTG casts doubts on the validity of Einstein's GRT and on the validity of the so-called experimental proofs of GRT; it also provides an independent confirmation of the position of RTG on this question.

Taking into account the common view on the physical nature of gravitation in RTG and GTG, and noting the differences of the mathematical formulations of this view in RTG and GTG, a comparative analysis of these two gravitational theories would unquestionably be of great interest.

For our present Conference, Jefimenko presented the report *"New results of retardics: the effect of radial acceleration on the electric and magnetic fields of circular currents and rotating charges"*. This report contains two very important results:

1) contrary to the generally accepted opinion, the electric field of a rotating spherical charge is not a Coulomb field;

2) a solenoid carrying a constant electric current generates a heretofore unknown external electric field.

Without a doubt, these results will arouse keen interest because rotating spherical charges and current-carrying solenoids are encountered in many areas of physics and are associated with many experimentally observed effects, for example, with the Aharonov and Bohm effect. A clear and convincing physical interpretation of this effect is given by Jefimenko in his report[§].

Gravitational theories are discussed at our Conferences in parallel with problems of classical electrodynamics, see [9]. In this survey I will mention only Shelaev's irreversible electrodynamics [47].

Shelaev's irreversible electrodynamics is a mathematically well-founded theoretical description, a model of the physical mechanism of many electromagnetic phenomena, both those that are already known and those that have not yet been observed. The author realized his physical conception in terms of a rather harmonious mathematical model based on Huygens's wave principle extended by definitions of potentials.

The most important point distinguishing this theory is the author's view on the physical reality: having a considerable experience of many years in experimental investigations in high energy physics, he emphasizes *"the third object of any wave process"*: the medium. *"According to the wave principle, this medium is material and meets only one requirement: it ensures a "steady" propagation of an elementary disturbance at constant or variable (for media with dispersion) velocity. For an electromagnetic field in a free homogeneous space, the speed of propagation of the disturbances is assumed to be equal to the speed of light"* [47, p. 262].

In the monograph [47], the main propositions of a new nonlinear and irreversible electrodynamics of a moving point charge are presented. It is shown that in such an electrodynamics, the scalar potential of a point charge moving at an arbitrary speed has a singularity only at the point where the charge is located at the present moment. The scalar potential of a moving point charge satisfies the wave equation with a non-zero right-hand side, that transforms it into a nonlinear and irreversible partial differential equation of the second order.

Using the extended Huygens's wave principle as a base, Shelaev has shown that one can construct a new electrodynamics axiomatically just like the classical geometry is constructed. *"This new electrodynamics, while losing the former phenomenological character, describes adequately the nature of electromagnetism by a broader class of differential equations"* [48, p. 117].

[§] We are publishing this report in the original English because, without a doubt, the "dogmatism and faith" will not allow a prompt publication of this work in European and American journals, although everything in it is, figuratively speaking, very transparent.

With the help of the ideas developed in the irreversible electrodynamics, Shelaev gives an interpretation of familiar unique phenomena observed in the practice of operation of modern accelerators of charged particles and also suggests solutions to problems on potentials generated in space by various systems of moving charged bodies.

From the viewpoint of retardics, irreversible electrodynamics is a *'causal'* theory: the "delay time" appears explicitly in its foundations. However, Jefimenko's retardics is based on Maxwell's equations. Undoubtedly, a comparative analysis of Shelaev's irreversible electrodynamics and Jefimenko's retardics (in its electrodynamical part) and of their approaches to the same physical phenomena, to the same problems, would reveal points important for development of both these theories.

It may be noted that, firstly, both retardics and irreversible electrodynamics are primarily concerned with phenomena involving motion and, secondly, that the noninvariance of Maxwell's equations under relativistic transformations, discussed by Jefimenko in [42], provides an interesting fact for the ideological position of the author of irreversible electrodynamics.

2.4. *Nonequilibrium dynamics of hadrons*

At present one cannot avoid stating that *"the strategy of investigating strong interactions with the aid of experiment and ad hoc models constructed along the lines of the direct scattering problem has led to the next dead-end: after 50 years, there is neither a consistent theory nor a conceptual definiteness in the theoretical interpretation of the experiment"* [9, p. 9]. Therefore, at our Second Conference we also discussed the foundational character of the inverse scattering problem for high energy physics, i.e., the problem of reconstructing the properties of the "target" and of the "projectile" by observing the aggregates of products of their scattering on each other. Considered were two new mutually supplementing approaches to the statement of the inverse scattering problem in high energy physics: a system-dynamical, nonlinear, approach and a evolutionary-dynamical, non-Euclidean, approach. They form the contents of the program *"The Lobachevski–Poincaré program in high energy physics"* that is being developed by E. G. Bubelev and I. A. Kuchin [49, 50]. At our present Conference, I. A. Kuchin's report *"Formation of a nonequilibrium hadron dynamics"* analyzes a change of the prevailing concepts in particle physics; it shows that this process takes place in accordance with T. S. Kuhn's general idea about peculiarities of the transformation of knowledge. Basic ideas of the linear paradigm are refuted by an ever increasing number of new experimental data, and the in-depth study of soft and semirigid processes leads to a nonequilibrium dynamics that is nonlinear in its essence.

Many problems of particle physics are due to the lack of understanding of what happens to an object when it in reality passes from one inertial frame to another, due to the luck of knowledge of the physical significance of the Lorentz transformations in SRT. For example, it is known (see [51]) that the relativistic character of the motion of particles in the initial and final states is in principle incompatible with the condition of their "preparation" and conservation as "integral" dynamic systems. SRT ensures only the kinematics of particle scattering but does not throw light on the dynamics of the particles. But as Kuchin shows in his report, this dynamics has a rather diverse and sometimes nonequilibrium character, although 'on the outside' all conservation laws hold and the scattering can be globally described in terms of the 'regular' dynamics and invariant variables.

I. A. Kuchin draws attention to *how* problems of such kind are set and solved in nonlinear physics. In nonlinear media, the superposition principle does not hold, therefore *stable* particular solutions of equations and the intermediate asymptotic solutions become of foundational importance: a particular solution for some initial boundary conditions turns out to be an asymptotic particular solution for another set of initial boundary conditions, and the transition from one solution to another,

described in terms of intermediate asymptotic solutions, represents the evolution of a dynamical system in time (or over some other control variable). Because the geometric space is three-dimensional, only three kinds of self-similar solutions of the shock wave type are possible: plane-, cylindrically, and spherically symmetric. The author of the report has shown that they all occur in particle physics, and the total cross-section is representable as a sum of the diffraction, jet, and pointlike components.

On the whole, the report is a study of a transition from 'regular' dynamics to 'irregular' one in the course of the formation of new conceptions in the theory of soft processes of strong interactions in particle physics. The author actively implements the ideas of G. Holton's thematic analysis [52], considering retrospectively the development of the three main directions in the investigations of soft particle scattering:

1. Investigations of elastic and quasi-elastic scattering of nucleons.
2. Investigations of the nature of many-particle production.
3. Investigations of peculiarities of the structure of the proton as an open system.

As the energy of interaction increases, the above directions draw close and intersect, which is interpreted, according to Holton, as an indication of the formation of a new research field: nonequilibrium hadron dynamics. Basic facts of this new theory are presented in the report and the general consequences of these facts are discussed. The author also emphasizes the complex hierarchic character of the theory that reflects the hierarchy of the dynamical structure of the object under study and represents on the whole a system of separate theories which are relatively independent but mutually co-ordinated in a certain way.

Using many examples, the author shows how a change of paradigms takes place in high energy physics in the course of the last decades under the pressure of the developing experimental investigations: the linear paradigm, which in essence constitutes the foundation of quantum mechanics, quantum electrodynamics, quantum chromodynamics, and of other theories, is clearly being replaced in the field of soft processes at high energies by the nonlinear paradigm. I. A. Kuchin draws a conclusion that drastic changes are imminent in the formulation of the conceptual problems of quantum field theory.

In fact, the unhealthy state of the quantum field theory is already recognized and worries the high-level specialists. This is evidenced, for example, from the conference that was held in 1996 in Boston University (USA) and that was devoted to conceptual problems of the quantum field theory, see [53].

Acknowledging the large work made by Kuchin during the preparation of his report and its significance for the development of concepts of high energy physics, and in the interests of further discussions, we should call attention to the following. At the time of the preparation of his report the author, unfortunately, had not been acquainted with M. Gryziński's atomic physics. Therefore, he could not even suppose that now one should treat all 'quantum theories' as mathematical models that are rather "kindred" to the model not adequate to the physical reality. Consequently, one should determine the limits of usability of their application. Moreover, if the author of this report stood on the platform of Gryziński's atomic physics (instead of upholding the illusory conviction that the agreement of quantum mechanics with experiment is "immaculate"), he would have recognized interesting possibilities of using in the high energy physics ideas of the physical model of unity and harmony of Nature that is being developed by F. A. Gareev.

2.5. *Wave conceptions: A. M. Chechel'nitski's wave Universe and F. A. Gareev's resonance synchronization*

The necessity to investigate the World of events is becoming more and more urgent. This is evidenced, on the one hand, by the latest investigations in the field of gauge theories when, for example, a five-dimensional reality with the energy as the fifth coordinate is introduced (J. Maldacena), by the latest studies of the possibility of the violation of the Lorentz invariance (R. Cowsik, B. V. Sreekantan), by works on the investigation of localization of events (M. Toller), by the *"The Lobachevski–Poincaré program in high energy physics"* that is being developed by E. G. Bubelev and I. A. Kuchin. On the other hand, one cannot avoid noticing that in the last decades new, "unconventional" approaches to a unified systematization of objects and phenomena in natural systems of micro-, macro-, and megaworld have appeared and continue to be developed. In these works, new types of laws and relations are considered, reflecting numerical values of physical characteristics intrinsic to these systems and phenomena and reflecting the experimentally established relationships typical of them, see Chechel'nitski's and Gareev's reports in [9] and the literature cited therein.

In Chechel'nitski's and Gareev's works, a deep unity of natural systems and phenomena belonging to different, as usually thought, physical levels of organization of the matter manifests itself. Therefore, it is appropriate to recall that the idea of a 'universal' connection of phenomena as the most general law of the Universe, the idea about its existence as an 'all-encompassing world process' has been always considered in philosophy, whose object of study is the general unified image of the world and which has a deeper view on the diversity of connections between objects and processes than any concrete natural science has. In the materialistic dialectics, it is stressed that the real world is indivisible in the sense that all the thing that exists in it are different forms of the manifestation of the matter and that therefore there are no totally isolated objects, they all are united in their essence.

Chechel'nitski's conceptions about the wave structure of the Universe were presented by him at our Second Conference in several reports [54] about the megawave structure of the Solar system as a wave-dynamic system and about some of his new predictions that are consequences of his concept of the wave astrodynamics. The Sun is treated as a generator of megawaves, and the heliosphere as a cosmic resonator of oscillatory rhythms in the Solar system. Using the idea that the mechanisms of the interaction of the Sun with the heliosphere are of a wave character, he explains the genesis and qualitative characteristics of the rhythms that have been observed for a long time. They are a consequence of the existence of stable waves of long wavelengths (megawaves) in the interplanetary plasma. Chechel'nitski has proposed a new method for determining the location of the heliopause; this method is based on the use of a well-known fundamental physical constant—the fine-structure constant. With the help of this method he predicts that the heliopause will be detected at the heliocentric distance of 90.5 a. u. Of interest is also his analysis of the red shifts of quasars. By means of this analysis it should be possible to trace the wave structure on a scale of the Universe and to predict the discovery of the most probable values of red shifts of distant objects.

The universality of the wave phenomenon is also fundamental in F. A. Gareev's investigations. His search for a physical indicator of the unity of the world and its harmony is based on the universality of Huygens's resonance synchronization principle and corresponds even to the viewpoint of F. Dyson, one of the originators of quantum electrodynamics, expressed, e. g., in [55]: *"all the variety of the nature should be perceived by physics as one of its central topics"*, just like biology accepts the unity of the genetic apparatus as its basic law.

By generalizing the Huygens's resonance synchronization principle, Gareev has shown that his generalization corresponds to Schrödinger's conclusion that interactions between microscopic systems are controlled by specific laws of resonance, see [18]. Moreover, this conclusion holds true for *all* interacting systems where the wave phenomena take place.

Testing his hypothesis about universality of Huygens's resonance synchroniza-

tion principle for its viability in the microworld, Gareev performed theoretical calculations of the corresponding parameters and compared them with experimental data for *hundreds of thousands* (!) nuclear states and γ-quanta. The fact that these computations reproduce the experimental data on the energies of γ-quanta and nuclear states to within several KeV (in many cases to within errors of experimental data) proves irrefutably that a physical principle has been discovered which touches the innermost processes of self-organization of the matter and reveals a fundamentally new interconnection between phenomena in the Nature.

By its essence, Huygens's synchronization principle belongs to the temporal aspect of the material world: the main concepts appearing in it (frequency, synchronization) are purely temporal concepts (just like wavelength is a purely spatial concept), and the correlation of phenomena revealed by this principle has the same nature. Therefore the significance of the universality of this principle (the principle that has been confirmed by hundreds thousands of examples) also points out the urgency of direct physical investigations of the temporal aspect of the World of events for clarifying the "role of time" in the Universe.

In the physical model of the unity and harmony of the Nature, which is being developed by Gareev on the basis of the resonance synchronization principle, the phenomenon of *'commensurability'* of the corresponding physical characteristics comes to the foreground. (Two physical values are called commensurable if their ratio is equal to the ratio of two integers.) Gareev discovered a great many instances of the manifestation of commensurability in the groups of structural characteristics of micro- and macrosystems. One cannot avoid agreeing with the author of these investigations that these facts are a manifestation of certain unity of Nature, a manifestation of common principles of the functioning of its systems on various levels of organization and for various material compositions. Correspondingly, this circumstance strongly points out to the advisability of constructing physical concepts and theories that from the very start are oriented toward reflecting and depicting this unity.

In his report *"A conception of the universality of Huygens's resonance synchronization principle, a model of structural peculiarities of molecules of living systems, and a new interpretation of superconductivity"*, Gareev discusses a correlation, discovered by him, between some conditions of quantization for superconductivity and the so-called 'electron's wavelength' in the hydrogen atom. In this connection one should noted that Gryziński's atomic physics has not only unveiled the physical essence of de Broglie's wave of the electron but also, taking into account that an electron has a magnetic dipole moment, has materialized the electron's "wavefield" by showing that the electron's wavefield is the electromagnetic field of a precessing magnetic dipole. Therefore a consideration of relations discovered by Gareev from the viewpoint of Gryziński's atomic physics is of unquestionable interest.

It remains to note that the interconnections discovered by the authors of the wave-related concepts discussed above will probably play a role in further applications and developments of Shelaev's ideas of irreversible electrodynamics.

3. Main task of the Conference STP-2000

Now then, in the preceding Sections we have briefly reviewed the main conceptions discussed at our Conferences. In so doing we have emphasized their interconnections and their obvious conceptual coherence. All of them not only "explain the known" but also open new perspectives for the development of many areas of physics by revealing and predicting basically new properties of systems and phenomena of micro-, macro-, and megaworld. All this testifies to their actual adequacy to the physical reality.

At our Third Conference, we are beginning to consider one more direction in theoretical physics that is now undergoing an intense development: the algebraic investigations of the mathematical laws of the space-time reflecting fundamental

physical properties of the reality. This direction is presented in V. V. Varlamovs's review *"Clifford algebras and discrete transformations of the space-time"*. The author will speak about an algebraic description of basic discrete symmetries (space reversal P, time reversal T and their combination PT). In his report discrete subgroups of orthogonal groups of multidimensional spaces over the fields of real and complex numbers are considered in terms of fundamental automorphisms of Clifford algebras. In accordance with a division rings structure, a complete classification of automorphism groups is established for the Clifford algebras over the field of real numbers. The correspondence between eight double coverings (Dąbrowski groups) of the orthogonal group and eight types of the real Clifford algebras is defined on the basis of isomorphisms between the automorphism groups and finite groups. Over the field of complex numbers there is a correspondence between two non–isomorphic double coverings of the complex orthogonal group and two types of complex Clifford algebras. It is shown that these correspondences are associated with the well–known Atiyah–Bott–Shapiro periodicity. Generalized Brauer–Wall groups are introduced on the extended sets of the Clifford algebras. The structure of the inequality between the two Clifford–Lipschitz groups with mutually opposite signatures is elucidated. The physically important case of the two different double coverings of the Lorentz group is considered in detail. Dąbrowski quotient groups obtained as a result of homomorphic mapping of Clifford algebra with odd dimension onto its subalgebra with even dimension are introduced for the case of a complex field.

From the viewpoint of physics, discrete transformations of complex spaces are of especial interest, because Pauli's and Dirac's algebras, which are the best known Clifford's algebras in physics, are algebras of the second and fourth rank, respectively, over a field of complex numbers. Moreover, Pauli's algebra is isomorphic relative to the subalgebra of the even elements of the space-time algebra, and the set of the invertible elements of this algebra forms the Clifford–Lipschitz group that is isomorphic relative to the proper Lorentz group. It turns out that, under a homomorphic mapping of a complex algebra of the third rank on the Pauli's algebra, the automorphism, corresponding to the spatial reflection P, is not carried over. Thus, the set of automorphisms of the Pauli quotient algebra does not form a finite group; a certain "violation of symmetry" of a discrete group occurs. There is an analog of such a situation in physics: the *evenness violation* in the theory of weak interactions. As is known, there exist only left neutrinos and right antineutrinos in the Nature, but not right neutrinos and left antineutrinos, i. e., the P operation for the neutrino field is not defined. For the purpose of continuing the analogy, the neutrino field is described in the review by the Dirac–Hestenes spinor field, which is completely defined in the framework of Pauli's algebra. Further, the massless Dirac–Hestenes equation is introduced, in which the wave function—the spinor is an element of Pauli's quotient algebra, and in virtue of this the set of discrete transforms of this spinor does not contain the P operation.

The mathematical investigations of the fundamental properties of the space-time initiated and directed by the Academician A. D. Aleksandrov, that were mentioned above, are represented in A. K. Guts's report *"Chronogeometry: interaction of the past of parallel universes"*. The aim of the author of this report is to show that the past of the absolute World of events has a complex geometric structure that cannot be described unambiguously. In the spirit of the Kaluza and Klein theory, asserting the existence of a five-dimensional Hyperspace, in which our Universe is merely one of the layers of a smooth foliation of codimension 1, a model is proposed in Guts's report (see also [56, 57]) in which parallel universes, i. e., layers, "have common macroscopic past" in the sense that sufficiently large "pieces" of the space of the past parallel universes are a part of the Hyperspace domain. The geometry and topology of these pieces "foam", i. e., undergo spontaneous fluctuations lasting extremely short intervals of time. The author suggests to interpret the obtained result as an indication of objective impossibility to reconstruct images of the past in the history of nature and society, because "somebody else's past" is always admixed to "our

past". In support of his interpretation the author cites the history of Russia [57], although it would be advisable first to critically reconsider the adequacy of the Riemannian geometry which was used, especially after the analysis of GRT that was performed by the originators of RTG.

Undoubtedly, this report will arouse intense discussions because the author, in particular, defends a "purely statistical approach" toward historical processes, such is used by A. T. Fomenko and V. G. Nosovski and which was criticized at our Second Conference in a report by I. V. Nikolaev and T. A. Voronina *"On the investigations of the temporal structure of historical events"* [9, pp. 183–199]. Fundamental questions associated with investigations of mathematical relationships in historical events were discussed in detail in this report. It was pointed out in the report that mathematical methods used for a retrospective analysis of historical events should be adequate to the phenomena under investigation, in particular: the history of separate ethnoses and civilizations should be treated as a certain particular process in the global development of the Earth's biosphere with its inherent peculiarities of the temporal structure. In Nikolaev and Voronina's work, general objective principles of an integral approach to the investigations of historical factual material are formulated, and the efficiency of their application is demonstrated by concrete factual material. On the other hand, the report by A. K. Guts, who works in the Riemannian space-time, is interesting from the viewpoint of an illustration of the adequacy of RTG to the physical reality.

Finally, V. A. Leus will present in his report methodological considerations and arguments pertaining to physics and astronomy and will present critical reflections about some familiar physical experiments and concepts. As is known, the Pound and Rebka experiment has revealed the gravitational red shift of spectral lines, and there is a widespread belief that the photon moving vertically upward loses its energy. However, the quantitative result of the Pound and Rebka experiment can be fully explained as a consequence of the shift of the material energy levels due to the local value of the gravitational potential (this interpretation has been suggested by L. B. Okun', K. G. Selivanov, and V. L. Telegdi). In other words, the observed red shift of light is actually only a blue shift of energy levels of atoms and nuclei with no contribution from the photon energy variation. On the other hand, as Kh. M. Beshtoev has pointed out, the latter interpretation, which implies that light does not experience gravitational attraction, conflicts with the phenomenon of the deflection of light rays in a spherically symmetric gravitational field. V. A. Leus offers a resolution of this conflict on the basis of O. Heaviside's and O. D. Jefimenko's ideas and on the basis of V. A. Ugarov's notion of the tensor nature of the inertial mass. He then develops a concept of the "kinetic nature" of every rest mass. In general, the author presents his report in a polemic manner in order to encourage discussions of various methodological issues pertaining to the entire field of physics including discussions of the status of mathematics and of the role of mathematical comprehension in natural sciences.

The main goal of our Third Conference is to show that the criterion of the adequacy to the physical reality is decisive in estimating the value of conceptual physical theories (mathematical models) and to suggest to the physics of the XXIst century a system of conceptually co-ordinated and interconnected theories (mathematical models) that are adequate to the physical reality. It is exactly the adequacy of the proposed theories and concepts that explains their effectiveness in an integral interpretation of the factual material without any use of the so-called adjustable parameters of any kind. All these theories broaden the scope of physical research, unlock basically new laws of the existence of natural systems of micro-, macro-, and megaworld and predict yet unknown phenomena and relationships.

While keeping in mind the requirement of the adequacy of the mathematical models that are being used, theorists should always be ready to face the experimental facts and to be able to look critically at their models, to be able to assess without bias the advantages and capabilities of some other, *more adequate*, approach. Our

mutual reward will be a more adequate and hence a *more effective* scientific picture of the world, which is so necessary for the mankind now and in the future.

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