I. L. GERLOVIN

TO LIVE WITHOUT DISASTERS

St. PETERSBURG, 1992

The monograph is the first to give the theory of all kinds of interactions in matter: strong, electromagnetic, weak and gravitational, i.e. it presents the Unified Theory of Fundamental Field (TFF) which is based upon a new paradigm called the Paradigm for Viable and Developing Systems (PVDS). The book is the result of the fifty year long work of a small group of scientists who were not afraid of new ideas.

The results obtained on the basis of TFF and PVDS are discussed in the book. These results, when developed and used, should help the Mankind to live in peace with Nature and avoid environmental disasters.

The book is addressed to a great many scientists and engineers.

The book is published at the author's expense

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PREFACE TO THE AMERICAN EDITION

Adversity has mothered many children and here in Russia all free-thinking persons are challenged by her stern ways. For over fifty years while the tides of war, environmental destruction, social disruption, and political repression swept across my country, a small group of scientists struggled in isolation to realize Albert Einstein's dream of a Unified Theory of Field.

The realization of Great Physicist's dream gives birth to the unlimited possibilities that Einstein foresaw as he toiled virtually alone for thirty years defending the reality and necessity of a unified picture of the universe. This monograph takes the reader into that interesting journey and to its ultimate conclusion. The theory of the unity of Nature revealed in these writings holds immense significance for our time as it opens the doorway to new, unlimited possibilities for scientific progress without violent destruction of Nature.

Before the publication in Russian of this monograph in the USSR in December of 1990, the obstacles had been put for over 50 years in my way to publishing and even discussing the results of my research. Over this half century a rich body of materials has been amassed, unread and unwanted. Therefore, in the book we have chosen to unfold this theory in a journal-like style to describe in a more complete way the accumulated results of so long a period of research. The reader is therefore challenged to read carefully, word by word. A sentence skipped may mean an idea lost. As each author's ideas tend to progress from the preceding writings, the reader can trace the development of this theory over the decades.

"TO LIVE WITHOUT DISASTERS (Principles of unified theory of all interactions in matter)" provides both the theoretical and experimental basis of all physical interactions in matter: strong, weak, electromagnetic and gravitational. The Unified Theory of Fundamental Field (TFF) is based upon a new paradigm called the Paradigm for Viable and Developing Systems (PVDS). While a great many mathematical calculations are included to support the material, any reader may get general ideas of the theory. And many readers can use the obtained results in their practical activity. This book as a whole is intended for those who are interested in concrete suggestions towards directing both science and technology in harmony with Nature to prevent further destruction of our fragile planet. Physicists will take professional interest in the entire book, and many sections should be of particular interest to other specialists as listed below. It is my hope, however, that all readers will venture beyond the sections intended for their own specialty to fully appreciate the results presented in the book:

— **mathematicians:** *sections 1.8, 1.9, 2, 3, 15, 17, 28, and appendices 1, 2, 4;*

— **philosophers:** *preface, introduction, summary, sections 2, 3, 29, 30 and appendices 5, 7, 9 and 10;*

— ***biologists:*** *sections 2, 23, 25, 26, 27, 28, 29, 30 and appendices 7 and 10;*

— ***economists and sociologists:*** *sections 2, 3, 21—30 and appendices 8, 9, 10;*

— ***chemists:*** *sections 2, 3, 23, 28 and appendices 3, 4, 7 and 8;*

— ***engineers,*** *applying results of the above-mentioned sciences: sections 2, 3, 11, 12, 21—30, and appendices 3, 4 and 8.*

Finally, I would like to take this opportunity to express my heartiest thanks to V. N. Suntsov, the editor of the English version of this book, for his great efforts in translating and perfecting the text, and to Michael Mitchell with his assistants for their noble help in the work of the author and his colleagues as well as in the publication of the English version of this book.

The Author

People, I loved you:
Be watchful.

J. Fuchik

WHAT IS THIS BOOK ABOUT?

This book presents a reasoned, practical methodology for mankind to sustain a world-wide well-being within the constraints of the ecological viability and health.

Scientific circles are fraught with doomsayers. Questions of mankind's survivability abound. And the support of these arguments have their point if mankind continues to attempt to bring three or four billion people in developing nations into modern economies with modern society's level of consumerism utilizing today's technologies. It is clear that if we stay bound within the existing physical, chemical, and biological methodologies, long-term survivability is indeed a global concern.

This book offers a pathway out. The author and his colleagues are convinced through their own varied research that the answers to such global problems lay in the new scientific direction, where all fields of science can be unified and specified under the regularities following from the new Paradigm for Viable and Developing Systems (PVDS), presented in the book.

The idea that all fields of science, natural (physics, chemistry, biology) as well as social (psychological, economic, political, and sociological), could be unified under a general "Systems Theory" has been widely discussed but naturally did not become the principal methodology in the scientific community. There are many reasons for this situation. The most obvious has been the scientific community's own shortcomings in unifying attempts. Scientists have been paradigm-bound. Some have begun with dialectical materialism, while others choose dialectics in its general form only, or others began from theological principles, and some have chosen to generalize from the laws of some particular system, such as the theory of dynamic systems, to a general theory. This enumeration could be endless, but each attempt falls short of its intended goals.

Vernadsky and Chardin first introduced the concept of a global system, the noosphere, under which laws ruling animate and inanimate matter alike would be unified. But while they postulated the existence of universal laws, it was never demonstrated. There was no foundation — the new paradigm. The author, while keeping the general concept of a noosphere, first managed to realize the elaboration of a methodological and mathematical paradigm upon which a unified system theory, such as the noosphere theory, could be constructed. The Paradigm for Viable and Developing Systems which is described in the present work, lays out the methodological and mathematical requirements that a system must obey to survive and evolve. PVDS was first formulated as far back as 1946, but the author chose then not to publicize his work. Before 1989, despite the innovative ideas put into practice by Mr. Gorbachev, any attempt to defend PVDS was considered an "heresy" in my country and would have utterly deprived the author of the possibility of pursuing his work. This precaution proved its value, allowing the author to pursue his work without repression.

Although PVDS has applications in many scientific fields, during these past fifty years the author was primarily concerned with the elaboration of a Unified Theory of Field. In present work the Theory of the Fundamental Field is substantially discussed. It illustrates the use of PVDS in the elaboration of physics theory.

After 1985, the participation of scientists from a variety of fields allowed PVDS to be applied to fields of science outside the scope of physics which is shown in the book. The present work also brings insights into the practical application of PVDS, notably in technologies and in environmental preservation.

When Albert Einstein first formulated the requirements for a Unified Theory of Field, he noted that it should describe the four types of interaction of all matter (strong, or nuclear; weak, or radioactive decay; electromagnetic and gravitational) as different manifestations of the same fundamental field. The unification of the first three forms of interactions is now commonly referred to as "Grand Unification" while a theory encompassing all four forms of interaction is called "Super Unification". Some even use the term "theory of everything", hinting at the possibility that science could stumble upon some form of immutable truth. The author is firmly convinced, and hopes he can convince the reader as well, that the concept of a "theory of everything" is only symptomatic of those scientists' presumptuous and naive belief that they can become masters of the absolute truth. The great majority of the laws of nature are still quite beyond our reach.

The author is firmly convinced that Nature is not only substantially richer than our concept of it, but more critically, it is permanently developing. We have no reason to believe that the rate of Nature's development is slower than our rate of the Nature cognition. The immutable truth may in fact be a receding goal.

The author does not recognize the erroneous ideas of the existence of the immutable truth. Mankind needs no priests of science, but dedicated toilers able to elucidate a clear and faithful path for universal and sustainable progress. Based upon the results obtained by the author and his colleagues, a certain step has been taken.

The following material will speak for itself. However, the results offered for your judgement would have been substantially diminished without the active support of numerous colleagues, friends and simply genuine toilers of science, who assisted the author.

In this manner, the author addresses his gratitude to the bright memory of his colleagues M. M. Protodyakonov, V. A. Krat, S. V. Ismailov, I. Ya. Pomeranchuk, B. M. Kedrov, F. Iu. Zigel, V. I. Menzhinsky, A. R. Regel, I. A. Rapoport, B. P. Peregud, and is grateful to V. V. Nazarov, R. R. Zapatrin, V. P. Perov, Iu. K. Balenko, N. S. Lidorenko, A. P. Kazantzev, A. A. Denisov, D. D. Ivanenko, Ia. P. Terletzky, O. B. Firsov, E. V. Gnilovskoy, I. A. Ivanov, V. Ia. Kreynovich, V. A. Pinsker, A. M. Protodyakonov, M. S. Gnedieschev.

The author is grateful to the members of the Leningrad Polytechnic Institute's interdepartmental seminar on "Development and Use of a Paradigm for Viable and Developing Systems and a Unified Theory of Fundamental Field" for their active part in the discussion and for their criticism and recommendations on materials included in this work. Discussions at that seminar greatly influenced the contents and quality of the work offered for the reader's consideration.

Many physicists are working on creation of the great picture unifying everything in an extra-super model. This play is wonderful but now players in no way agree between themselves on what this great picture is like.

R. Feynman

THE AUTHOR'S CLAIMS

The Unified Theory of the Fundamental Field is the unified theory of all interactions in matter. TFF unifies all known interactions in matter — strong, weak, electromagnetic and gravitational — considering them as different manifestations of the same fundamental field. TFF is constructed on the basis of a new paradigm for viable and developing systems.

On the basis of TFF, the periodical law of elementary particles is discovered. Found within the bounds of this law is the system of formulae for computing the masses, charges, spins, magnetic moments, lifetimes and other quantum numbers of all known experimental elementary particles as well as still unknown. The coincidence of theoretical and experimental data within the bounds of accuracy of the theory and experiment is complete.

In TFF first have been:

- found the physical phenomena responsible for quantum and relativistic properties and the boundaries of the domain over which these properties prevail;
- discovered the unified approach to describing the bosons and fermions which is more wide than supersymmetric found later and being intensely developed now;
- determined the structure of physical vacuum (PV) regarded as a structural material form, formulated and calculated the physical vacuum properties;
- proposed and investigated the string model of particles, though the very term "string" has not been earlier proposed in TFF. The above-mentioned string model of particles is more deep and essentially more rich than the string and superstring models being widely developed now;
- revealed the physical nature of quarks, tachyons, virtual states and some other postulated objects of modern microphysics;
- predicted a series of new phenomena, including those with important applied value. Most significant is the direct use of physical vacuum energy and high temperature superconductors.

TFF does not contradict known physical theories, but gives an underlying reason to their postulates and reveals the boundaries of use of these postulates. Thus TFF, far from being an alternative to generally accepted principles, simply develops and deepens the perceptions of these theories in full agreement with the correspondence principle.

TFF has a peculiarity which is important to underline here. In the book it is shown how all types of interactions are obtained and how the constants of these interactions are calculated from one system of equations representing the Triunity Law discovered in the theory. It is demonstrated that the proper constant of "strong gravitation" predicted by A. Salam, but still unfound, corresponds to each constant of interaction by means of the Unified Fundamental Field and follows the same equations.

There is an opinion often expressed that the fifth significant digit contains modern physics. It follows from TFF that the tenth significant digit contains the physics of matter.

Since it is assumed that the reader possesses some knowledge concerning the principles of modern physics and mathematics, no explanations are given when the terms, concepts and symbols adopted in modern physics and mathematical literature are used.

As a rule, the natural system of units in which $\hbar = c = 1$ or $G = \hbar = c = 1$ (the Plank system) is not used because the principal attention in the book is paid to physical significance. Exceptions are made mainly in formulae generally known or in referencies to equations taken from the works of other authors. These exceptions are evident and have no comments attached. For this reason, the SI system of units adopted in technical sciences is not utilized, but the physical one has been selected throughout the work.

So the Paradigm for Viable and Developing Systems is elaborated and the mathematical method of its use in different sciences is described. Additionally, the author demonstrates that PVDS may be applied to solve a series of problems not limited to physics, but in other natural and social sciences, as well. For a more thorough understanding of PVDS, the unified physical theory (TFF) is given in detail in this book as an example of what can be constructed in other spheres on the basis of PVDS.

The first problem to be discussed is the construction of the unified theory of field. From here the book shall begin.

INTRODUCTORY INFORMATION

NEW, NON-STANDARD, AND OFTEN USED IN MONOGRAPH CONCEPTS, DEFINITIONS, AND NOTATIONS

PVDS is the Paradigm for Viable and Developing Systems — the methodological and mathematical base of the future unified law for living and inanimate matter.

UTF is the unified theory of field which unifies all kinds of interactions in matter. In literature one can meet the following names of UTF: "Extra-Super Unification", "Super Unification". The theory unifying strong, electromagnetic, and weak interactions is called "Grand Unification".

TFF is the theory of fundamental field (a UTF version) developed on the PVDS basis and describing all kinds of interactions in matter. TFF gives a unified description of the field, and the geometric construction of its sources-charges. It is also a theory which explains relativistic and quantum phenomena.

FF is the fundamental field in TFF. The fundamental charge is the FF charge. It differs from that of the electromagnetic field, because the force field originating in the whole subspace due to the fundamental charge has the source placed in the structure symmetry center and not at the location of the charge.

Matter is the material object possessing mass considered as the measure of inertia. The mass may be positive, negative, imaginary or even equal to zero (when the positive and the negative masses constituting the investigated object are equal), yet such an object should possess the inertia mass.

PV is the physical vacuum considered as the peculiar kind of matter. It is responsible for quantum and relativistic properties of all material bodies.

EPs are the elementary particles. In TFF these are quark structures observable in the laboratory subspace.

EPVs are the elementary particles of vacuum representing fermion-antifermion pairs of virtual "bare" elementary particles, particle-antiparticle pairs, supersymmetric partners of elementary particles of a special sort.

BEPs are the "bare" elementary particles (fermions) not possessing the quark structure and being neither EPs nor quarks. In a free state they are not observable in the laboratory subspace.

VPs are the virtual particles. They are the elementary particles observable in the second and third subspaces and unobservable in the first (laboratory) subspace.

ESM is the enclosing space of the material world (macro- and microcosm). It is a sum of subspaces in which a complete description of the Universe and its principal constituents, i. e. EPs and EPVs, is necessary and sufficient.

FB is the fiber bundle, a mathematical notion widely used in modern mathematics. It represents a system of subspaces (the term "subspace" is the synonym of the terms "fiber" or "base"), where the space including all the elements of construction is called an enclosing space (ES) and subspaces embedded in it are divided into the base and the fibers. The base and the fiber have only one common point.

SM is the spatial metamorphosis. A new notion introduced in the theory discussed, SM determines different geometrical forms of the same object realized in the subspaces of the whole enclosing space in FB. The existence of SM puts a set of strict requirements on the character and essence of mappings between subspaces.

Just the realization of these requirements provides the conditions for the viability of an object and its ability to develop.

0SS is the Null subspace, a fundamental subspace considered as the foundation of the macro- and microcosm unity in the world of matter, the subspace in which a scalar component of the fundamental field is revealed completely and directly.

VSS is the physical vacuum subspace, the subspace in which quantum and relativistic properties of matter originate. Only the interactions of the physical object with PV which occur in VSS determine the presence or absence of its quantum and relativistic properties, their character and features.

1SS is the first subspace, the base of the fiber bundle in the enclosing tardyon space (v never exceeds c), the subspace in which EP and EPV are directly revealed as a unit. In 1SS the structures of EP and EPV do occur under the Schwarzschild sphere of a black microhole and may be revealed only as the mapping of the processes going on in the subspaces of a deeper level (for example in 2SS and 3SS).

2SS is the second subspace, the subspace of the microcosm in which the interactions of the FF vectorial component and the EP and EPV structure are directly revealed. The processes going on in 2SS are responsible for originating the observable masses, spins, magnetic moments, and some quantum numbers of EPs and EPVs. These parameters are observed in 1SS as the mappings of the particle parameters in 2SS and may be theoretically calculated on the basis of the physical mapping discovered in TFF and the consideration of the EPVs influence upon these parameters.

3SS is the third subspace, the deepest subspace in ESM. It is the subspace where the structure of the main particle of matter — the fundamenton — is revealed. According to the rate of fundamenton excitation its parameters are observable under the mapping onto 2SS and 1SS as different BEPs and EPVs. 3SS is the base of the fiber bundle in an enclosing tachyon space where greater velocities than that of light are adopted.

$\zeta = 0, V, 1, 2, 3$ are the indices of the Null, physical vacuum, first, second, and third subspaces, respectively. They are bracketed when they may be taken for a tensor index or for a sign of another mathematical origin.

ES1 is the enclosing space number one enveloping 0SS, VSS and 3SS.

ES2 is the enclosing space number two enveloping 2SS and 3SS.

ES3 is the enclosing space number three enveloping 1SS and 2SS.

Fundamenton is the elementary particle of matter which is represented in 3SS as the principal (fundamental) dipole of the FF charges. In other subspaces it is revealed either as EP or as the virtual state of EP or EPV. It represents in TFF the development of the concept of "maximon" (M. Plank), "friedmon" (M. A. Markov), "plankeon" (K. P. Staniukovich)

CSS is the calculation subspace (a functional-geometric subspace). It is the model used to determine all the physical and geometric parameters mapped from one subspace onto another, for example, SS $(3 \to 2)$, SS $(3 \to 1)$, SS $(2 \to 1)$.

CF is the coordinate frame.

NCF is the natural coordinate frame in which kinematical description of an object in basic geometry and its dynamical description in pseudo-Euclidian or pseudo-Riemannian geometry may be correlated between each other.

PLM is the Periodic Law of Microparticles (elementary particles) found on the TFF basis.

TL is the Triunity Law, the principal TFF law unifying space-time-matter and requiring the relation between them not only in the case of gravitational interactions (as in GR) but under all kinds of interactions in matter.

VTG is the vacuum theory of gravitation developed on the TFF basis by I. L. Gerlovin and V. A. Krat.

Relativism is the fundamental property of EPs and EPVs which means the invariability of the equations describing these particles under transformations following from the Triunity Law, in particular this is the invariability under the Lorentz transformations required by SR.

Magnetic charge is the charge of the fundamental field responsible for the magnetic properties of FF and revealed directly only in 3SS and not revealed in 1SS and 2SS.

String is the linear domain of the FF manifestation along which the FF properties are localized.

Quantum properties of matter are the fundamental properties of EPs, EPVs, the particles generated by them (nuclei, for example), and the systems of particles (for example, atoms and molecules).

Quantum properties of the microcosm are due to the multiplicity of space-time dimensions and fibration of the enclosing space of the Universe as well as to the dominating part of PV in the EP and EPV properties formation in 1SS. Because of it the classical and quantum properties of EPs and EPVs are revealed in different subspaces and are indispensable of all EPs, EPVs, and the structures created by them. Quantum and classical properties of microcosm particles are the two sides of their unified description within the TFF bounds. In this description, besides the common classical and quantum properties, there are also "unified properties" which are neither quantum nor classical ones, first introduced in the TFF description of the microcosm.

PART I

THE INITIAL PARADIGM. MATHEMATICAL AND PHYSICAL FUNDAMENTALS OF THE THEORY

> The absence of due recognition by other physicists was painful but explicable.
>
> *J. Schwinger.*

> In the science sphere the authority of a thousand is not worth the simplest reasons of one.
>
> *Galileo.*

1 THE STATEMENT OF THE PROBLEM. SUBSTANTIATION OF THE INITIAL PRINCIPLES, ANALYSIS AND DEFINITION OF THE PRINCIPAL CONCEPTS

In this section a brief discussion is given of the initial principles and mathematical construction laid down into the basis of TFF (subsection 1.1) and a detailed analysis is given of the statement of the problem of UTF construction (subsections 1.2––1.9).

1.1. The transition from the scale of ranks of quantum objects in modern physics to the system of discrete structures of matter in TFF

The most solid basis of the modern conception of the microcosm physics is a notion of the scale of ranks of quantum objects [1]. In a great degree this notion correlates with the ideology of standard model being developed now [2].

The scale of ranks of quantum objects as the basis of methodological approach of modern physics of microcosm is shown in Table 1.1.

Table 1.1

Quantum ranks	Transition energy, ΔE, eV	Typical size, c
Molecular-crystalline	< 1	$10^{-4} \div 10^{-6}$
Atomic	1	10^{-8}
Nuclear	10^{+6}	10^{-12}
Subnuclear	10^{+9}	10^{-13}

Each rank represents a separate branch of modern physics. The ranks are sharply characterized by the features of the material structures discussed in the corresponding branch (molecules and crystals, atoms, nuclei, elementary particles). The term "rank" is used in this notion to stress the discrete gap of properties under transition from one kind of structure to another. So, the boundaries of transition energy and the typical scales of length are sharply defined. Within any structure there is its own spectroscopy with intervals between the levels of the order of ΔE.

The virtual particles (VP) turn out to be beyond the bounds of the above-mentioned classification [3, 4]. They are postulated as particles unobservable in principle, though they are considered to have the same quantum numbers as their real analogues have. Yet, such quantum numbers do not obey the principal equation of relation between the energy E and the momentum p

$$E^2 \neq p^2c^2 + m^2c^4. \tag{1.1}$$

The structural elements of PV, which is considered as material form, are also beyond the bounds of this classification [5—7]. Though an opinion is widely spread that PV is not merely a concept of the lowest level of elementary particles state but also represents a structural material form, this opinion is not generally accepted.

The hierarchy of the above-mentioned scale does not include objects of the Universe (stars, star-clusters, planets) as well as the physical fields. TFF is considered as the basis of the theory of matter and claims to broaden the concept of the scale of ranks of quantum objects in such a way that all matter but not a part of it is included.

In TFF the matter is defined as a material form possessing mass as the measure of inertia. The mass may be positive, negative or even imaginary but it has to be a quantum number characterizing any structural element of matter.

All the above-mentioned material structures are matter.

Nowadays physicists do not know any structures which are devoid of mass. The objects whose masses are equal to zero in some coordinate frame (for example, photon) are not devoid of mass, it reveals in other coordinate frames. Besides, if the mass value equals zero it may correspond to the point of transition from positive to negative mass. Nevertheless, there is no reason to consider that all material structures existing in nature possess mass. Moreover, there are philosophical and intuitive reasons to consider that nature uses (and it seems that this use is especially wide in living structures) material forms which are devoid of mass as measure of inertia. This point of view has its right to exist. If it turns out to be valid this will mean a substantial decrease of the area where the unified theory of field (UTF) is valid. UTF describes only material objects which possess mass as measure of inertia.

Questions related to the hypothesis of the existence of the material forms which are devoid of measure of inertia are discussed in the last sections of the monograph.

According to TFF, all structures of matter form a closed self-consistent system of discrete structures so that the scale of ranks of quantum objects is merely a part of such system, though this part is a very substantial one.

According to TFF, molecules, crystals, atoms, nuclei, subnuclear structures are situated in the first subspace (1SS) which is not the space enclosing the whole matter but is merely the base of one of the fiber bundles in this enclosing space. According to the definition of a fiber bundle other subspaces embedded in a general fiber bundle "are attached", as mathematicians call it, to the base of the fiber bundle in the only point. At the same time the principal parameters observable in 1SS (for example, mass, charge, spin, magnetic moment,etc) are formed in more deep fibers but are observed in the base of the fiber bundle. Because of this fact only, we cannot exactly calculate the values of the above-mentioned quantum numbers if we investigate processes only in the 1SS without attracting information from other elements of the enclosing space.

It is because of this fact only that we have to use the calculus of probability methods. In the first subspace we can describe the system only by means of the state vector $|\psi\rangle$ and the vector $\langle\psi|$ conjugated with it. Here we are right to speak only of the probability of particle transition from the state $|\psi_1\rangle$ to the state $|\psi_2\rangle$

$$P_{2,1} = |\langle \psi_2 | \psi_1 \rangle|^2. \tag{1.2}$$

In this case we have to interpret the measured values as the proper values of some operator A, acting upon the given state of the system.

In TFF it is shown that the uniqueness of probabilistic estimation of characteristics observable in 1SS (such uniqueness had been proved as far back as by generally known J. von Neumann theorem) is due to the fact that the principal characteristics of the physical system just only reveal in the laboratory subspace (1SS) but are formed in other subspaces — 2SS, 3SS and VSS. It is impossible in 1SS to observe this process of formation because these subspaces have the only common point. However, we are able not only to estimate the observation probability of the parameters characterizing the system in the laboratory subspace but accurately calculate their values, if we know the motion laws in any subspace and the mapping laws between the subspaces. But such calculation is possible only in those subspaces where the unknown parameter is not only observed but also formed.

According to TFF, EPs have an apparent structure in the second subspace. 2SS is the subspace of virtual states unobservable in principle in the laboratory subspace. In the second subspace the main properties of particles are formed. Under being mapped onto the laboratory subspace, these properties give the mass, charge, spin etc in it. Knowing how these properties are formed in 2SS and how they are being mapped onto 1SS, we are able to calculate exactly all characteristics of EPs under the interaction between EPs and physical vacuum. This possibility discovered in TFF is one of the principal results of the theory.

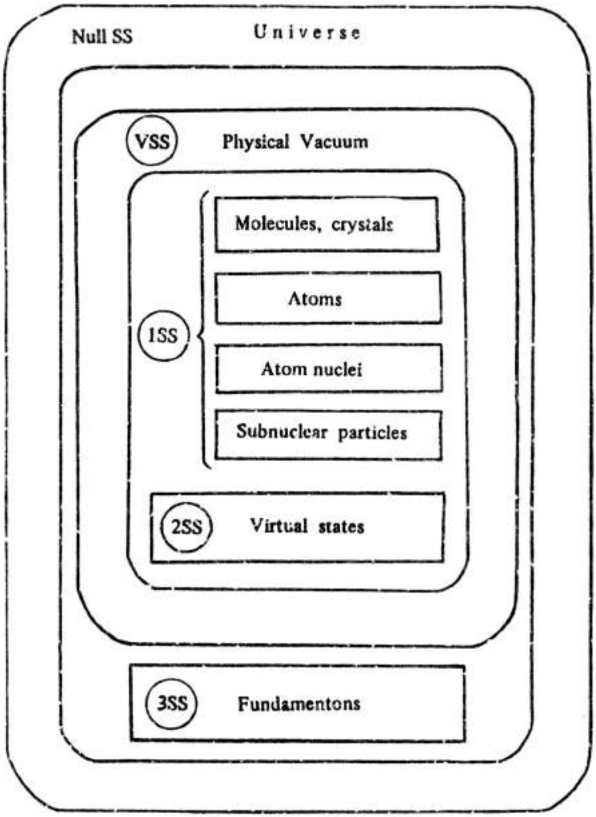

Fig. 1.1. Closed system of discrete structures.

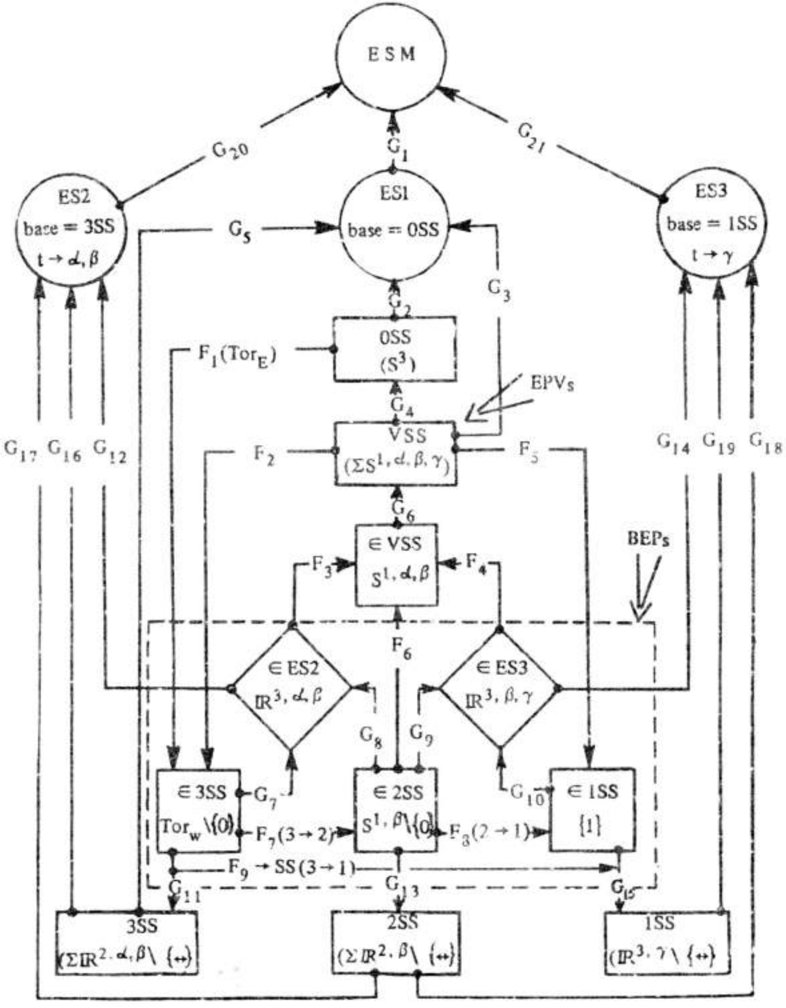

Fig. 1.2. Complete sheme of all subspaces, functional communications and mappings between them; sum of subspace elements in which BEPs are realized and a subspace element to which EPVs belong.

▭ — physical subspace; □ —physical subspace elements; ○ — enclosing space; ◇ — enclosing space elements; G — operator of embedding; F — mapping of any nature; $t \to \alpha, \beta, \gamma$ — time scale (α, or β, or γ) in the corresponding space or in its elements.

The complete set of elements of the whole enclosing space, i.e. the base of the fiber bundle and fibers, is found in TFF. These elements of the fiber bundle are also called subspaces in the papers on TFF.

Thus, in TFF the concept of the scale of ranks of quantum objects is generalized up to the closed system of discrete structures. The closed system of discrete structures (CSDS) in TFF is sketched in Fig. 1.1.

In TFF the CSDS of matter is described in the multidimensional fiber bundle [8, 9, 10, 11]. Many investigators have come to the conclusion that it is necessary to get out of the Procrustean bed of the only space in which all the objects of matter without any exception are embedded now [9—13]. However, the unified geometrical approach to all structure elements of matter is realized only in TFF [14]. It should be noted that of late these ideas were approached in modern gauge theories [15, p. 93—95].

The realization of the approach mentioned above is the main contents of this book, but here we give a qualitative description of the essence of CSDS of matter in the theory, so that the reader could better understand the forthcoming detailed discussion. We shall give a brief description of the entire CSDS of matter (Figs. 1.1 and 1.2).

By now, the structures of matter included in the scale of ranks of quantum objects turned out to be successfully described by means of modern quantum theories only because they really reveal in the only space-time common for them. In TFF, as it was mentioned above, this space (four-dimensional pseudo-Euclidian or pseudo-Riemannian one) is called the first (laboratory) subspace. Virtual states exist in another subspace-time, i.e. 2SS. In TFF the notion of virtual state has the following sense: this is the state of all elementary particles, revealing as well as not revealing directly in 1SS, and possessing geometrical-dynamical structure, directly revealed in the corresponding subspace and responsible for these elementary particle properties, directly or indirectly revealed in 1SS. The subspace of virtual states, i.e. 2SS, is a fiber in a certain enclosing fiber bundle in which 1SS is the base. The unification of the first and second subspaces is called the third encolsing space (ES3).

PV forms a special subspace, the subspace of the physical vacuum. It is also a fiber, but this fiber is embedded into another enclosing space called the first one. The first enclosing space (ES1) unifies the Null subspace, 3SS and VSS. The Null subspace is the base of this fiber bundle. 0SS is the geometrical structure of our whole Universe, the spatial part of which is the three-dimensional sphere S^3 [11].

The third subspace is of a special meaning in the described geometry. This is the subspace of the primary particles of matter which are called fundamentons in TFF.

A fundamenton is the primary and the only particle of matter which exists in 3SS and is the mapping of the 0SS cell. All EPs observed in 1SS and 2SS (virtual states) are the mappings of properties of a fundamenton, which is in some or other excited state, onto these subspaces. Thus, observing, for example, a proton or an electron in 1SS (the laboratory subspace), we fix the mapping of one or other excited state of the fundamenton onto the laboratory subspace. The same goes with all the rest of EPs and their anti-particles.

In TFF the PV is a structural material form which consists of elementary particles of vacuum. EPV is a virtual system consisting of a "bare" elementary particle (BEP) and its anti-particle. BEPs are structural forms of matter existing only in 2SS. In 1SS only some of BEPs reveal, interacting with physical vacuum in such a way that information of their existence may get into 1SS.

A photon is an excited state of EPV. The quark structures are formed by unified bare EPs and EPVs. These structures are observable in the laboratory subspace as usual EPs (subsection 5.7). Quarks, which are structural elements of particles, represent excited BEPs ans EPVs. During many years of the theory development such an approach made it possible to receive unique results mentioned in the preface and substantiated below.

To our deep conviction, it is impossible to comprehend this radically new approach in a right way without a preliminary substantial analysis of the evolution of all concepts used in this approach. This analysis is offered in subsections 1.2--1.9.

1.2. The unified theory of field

A. Einstein proposed an idea of the possibility and necessity of UTF creation as far back as in 1908--1910 and was actively working in that direction since 1920 [16].

The idea was not accepted by most physicists. Moreover, the opinion was formed that UTF creation was impossible in principle. The attempts of A. Einstein and his few associates to create UTF were condemned. Even A. F. Ioffe called Einstein's persistent strivings for UTF creation [17, p. 73] the "maniacal passion". Most theorist- physicists remained under such a delusion until 1979, when A. Salam, S. Weinberg, Sh. Glashow won the Nobel prize for the elaboration of the unified theory of electroweak interactions.

Nevertheless, the program of creation of the unified theory of field and the first results obtained on this way were openly and directly published in 1967 [18], and some initial ideas were published already in 1945 [19]. But in 1946 Lysenko phenomenon proved to work, and the author's work [19] was announced "sciology"; no doubt, the author was deprived not only of the possibility for discussion but also of the right to defend his ideas.

1.3. On the internal structure of elementary particles

Up to the end of the fifties the discussion of the internal structure of EPs was a generally accepted taboo. So, in the text-book by L. D. Landau and E. M. Lifshitz [20, p. 31] it was directly said: "The notion of elementary particles means particles which take part only as a unit in all physical phenomena, that is, to speak of their parts makes no sense". As the result, the I. L. Cerlovin's paper, in which the structure of EPs was discussed, was taken out of the Soviet Physics (JETP) Journal in 1953, though the galley-proof had been signed, and in the paper there was a reference to the work of H. Hönl [21] in which a similar approach was discussed, so the taboo turned out to work.

Only after R. Hofstadter's experiments in 1955—1958, which brought him the Nobel prize in 1961, the erroneous concept that EPs never and nowhere could reveal their internal structure was rejected. Yet, the I. L. Gerlovin's papers on the properties of EPs internal structure were not accepted to publication in JETP in 1962 and in the Letters to JETP even in 1973. The inertia of the taboo still remained, and it was in spite of the fact that L. de Broglie with his colleagues [22] had already proposed a "rotative" model of elementary particles and P. Dirac [23] had discussed an elementary particle of the finite length scale.

It is important to note that the difficulties connected with the correct description of the motion inside EP within the bounds of SR still remained. They were noted in the 5th (1967) and 6th (1973) editions of "Theory of the field" by L. D. Landau and E. M. Lifshitz, to say nothing about the periodical and monographical literature.

Thus, the recognition of the possibility to discuss the EPs internal structure in principle did not mean that the problem of correct description of this structure was solved. A contradictory approach to this problem remained. On the one hand, there was a general recognition of the reality of the constituents of hadrons consisting of quarks, partons, on the other hand, the description of the mechanism of the subparticles motion inside EPs was under prohibition, as it had been previously. Besides the difficulties of correct description of this motion within the bounds of SR, there is a firm conviction that the motion of elementary particles, all the more of their constituents, entirely lacks determinism and has only the probabilistic character, always and everywhere.

As it is shown below, in TFF there is found a non-contradictory realistic internal structure of EPs, well agreed with the experiment and immovable principles of modern physics. Yet, this structure cannot be placed on the Procrustean bed of the scale of ranks of quantum objects and demands the transition to the scale of ranks of structural objects of matter (see subsection 1.1).

1.4.
Determinism and quantum properties of EPs

The question whether determinism could be allowed under investigation of EPs and their constituents resulted in a stormy discussion in scientific literature which A. Einstein even called a "drama of ideas". In the soviet scientific literature this question was practically not discussed: everyone agreed to consider that there was no determinism and it could not be, and any opposite point of view was prohibited. At the same time this principal question of modern physics is far from being solved, and naturally its discussion continues abroad, even in special editions for wide audience [24].

It is generally known that L. de Broglie, E. Schrödinger and especially A. Einstein did not accept Copenhagen purely probabilistic interpretation of quantum mechanics. As a result of the discussion at the Solvey congress in 1927 the leading physicists adopted this interpretation and only A. Einstein continued to consider that "God does not dice". In 1952 A. Einstein presented two papers of D. Bohm [25] for publication. In those papers a question was put of the possibility of existence of the hidden parameters, returning determinism into quantum theory.

Those papers encouraged L. de Broglie to give up the decision of the Solvey congress of 1927 and return to his initial ideas of the possibility to retain determinism in quantum theory. As it is of great importance we shall give his statement on this question [26]: "Some persons may certainly accuse me of inconstancy, when they see that I had abandoned my initial attempts and during 25 years had been discussing Bohr's and Heisenberg's interpretation in all my works, and now I again have doubts as regards this and put a question to myself whether my first orientation was right in the long run... The history of science shows that the progress of science was constantly slowed down by tyrannical influence of some conceptions which turned out to be considered in the long run as dogmas. That is why we should periodically thoroughly revise the principles which had been accepted as complete and had not been discussed any more... Anyhow, it is certainly useful to attack again a difficult problem of the interpretation of wave mechanics in order to see whether the interpretation, which is now considered to be orthodox, is really the only one which we could accept".

The question of D. Bohm's hidden parameters was an object of a stormy discussion. The most exact result of this discussion was formulated by G. Lipkin [27]: "To give a strict proof that the hidden parameters do not exist, certainly is impossible". Yet, the introduction of the hidden parameters, according to D. Bohm, merely brought the complication of the mathematical apparatus but did not give the possibilities to receive any new results.

So, a search of interpretations alternative to that of Copenhagen continues.

K. Tojoky [28] has shown that the non-stationary Schrödinger equation may have an exact solution localized in space. He called these solutions "the wave complexes". He has shown that their interaction result in L. de Broglie's relation and that in the limit these complexes allow the description by means of the classical motion of material points.

Recently Cramer [29] has shown that a deterministic *exchangeable* interpretation of quantum mechanics is possible where the wave function is a real wave spreading in space but not a formal mathematical "probability amplitude". However, the given here attempts and many others to find an alternative to the probabilistic interpretation of quantum mechanics have not yielded positive results suitable for use. They only carried the conviction that the problem exists and demands solution.

It seems to be especially important to emphasize the conclusions which follow directly from the analysis of numerous attempts to find a deterministic approach to the interpretation of the fundamentals of quantum mechanics.

Firstly, the impossibility, in principle, to cognize the nature of a specific motion of quantum objects (e.g., an electron in the atom) has not been proved by anybody. Yet, this taboo continues to exist, though it is maintained only by philosophic agnosticism, a rather doubtful substantiation.

Secondly, practically all the attempts to solve the problem of the interpretation of the quantum mechanics principles were reduced to the introduction of new concepts, ideas and objects whose motion was described only in one and, as a rule, in the four-dimensional non-fibered space. Many works of the last decade are characterized by the transition to the description of micro-objects in the multi-dimensional fiber bundle. Yet, this transition did not concern the postulates of probabilistic interpretation of quantum mechanics, they were left without change.

Thirdly, in string and superstring theories where micro-objects are being discussed not as zero-dimensional points but as one-dimensional objects, the complete applicability of all generally adopted postulates of quantum mechanics is also not subjected to any doubt. At the same time many papers are published where string objects are described as classical ones, though they obviously mean micro-objects. The following internal contradiction is left without any attention: if all quantum objects, in principle, under no conditions may be described by classical or quasi-classical methods, then how can they be first described by classical equations and then those classical equations are formally quantized and it is considered to be correct? If the classical state cannot exist then what is being quantized?

There are some facts that directly contradict the probabilistic interpretation of the nature of quantum objects. According to the generally adopted interpretation, the angular distribution of the electron position in the atom has equal probabilities. The preferential localization of an electron in some atomic zones is prohibited in principle. At the same time experiments are known showing that under certain conditions an electron in the atom chooses zones of preferential localization in which it is to be found for the most part of time or always. These experimental facts are substantially analysed, for example, in the works of M. M. Protodiakonov and E. S. Makarow [30, 31]. It is noteworthy that these experimental facts can be correctly explained only on the basis of TFF, the fact is emphasized by the authors of these works.

Concluding our discussion on the interpretation of the nature of quantum phenomena we should like to emphasize that all accumulated facts, in which the quantum properties of matter reveal, are observed only in our space which we called the laboratory one. If we consider the above-mentioned laboratory space as the base of a fiber bundle, then on the basis of the presently known theoretical and experimental data nothing could be said whether the same quantum properties would or would not reveal in the fibers attached to the base in one common point. This is the fact which cannot be ignored sticking to the common taboo.

In other words, the hypothesis that micro-objects, a complete description of which is possible *only* in multi-dimensional fiber bundle, reveal quantum properties only in one of subspaces (in one fiber) and do not reveal them in other subspaces (fibers), in no way contradicts the known experimental data and well grounded principles of modern physical theories. This hypothesis is no more than a new correct approach to the interpretation of the nature of quantum phenomena.

The above-mentioned hypothesis, as it is clear from subsection 1.1 and from the detailed discussion below, plays an important role in the fundamental physical and mathematical constructions of TFF.

1.5. Physical vacuum

The formation of the primary concept of modern physics, which is the physical vacuum (PV), winds its way through many errors and delusions. Since Aristotle times up to the beginning of XX century the concept of mechanical ether as a material structure penetrating throughout the world had been the foundation of practically all physical theories.

The recognition of relativistic theories SR and GR resulted in the replacement of ether by absolute void, the curvature of which determined gravitation and, as it was assumed, other physical fields. Ether as a material medium was rejected.

In the beginning of the thirties P. A. M. Dirac in his works on quantum theory introduced a notion of some special ether, filled up with particles of microcosm having negative energy. In 1953 when he discussed "the situation with ether in physics" [32], he continued to insist on its existence. However, a complete theory of ether, according to Dirac, failed to be created. Therefore, a concept of curved void continued to dominate in physics.

The experimental discovery of corrections to the magnetic moment of an electron as well as the shear of the fine structure level in the hydrogen atom made physicists provide surrounding medium with such notion as "vacuum corrections". Yet, the materiality of PV was a taboo as before.

The concept of PV, generally accepted now, had been formed by the eighties. PV is considered to be the lowest energy state of quantum fields which nevertheless is characterized by absence of any real particles. All quantum numbers of PV are considered to be equal to zero. At the same time PV is being provided with growing numbers of properties, in no way explained, but strictly postulated. For example, it is believed that it is possible to receive real particles from empty PV by acting on it with the particle creation operator. There is no hint at the mechanism of this process. Moreover, the possibility of the existence of such an intelligible mechanism, that could be described, is subjected to doubt.

The existence of different virtual states of elementary particles in physical vacuum is postulated. It is known only that virtual particles exist and have postulated properties, but their nature is in no way explained. Any attempts to explain it are the generally accepted taboo.

Though PV is considered to be the lowest energy state of quantum fields this state is provided with the possibility of degeneration under which vacuum acquires the whole spectrum of different "zero" states. The physical nature of this correct consequence of formal calculations is still obscure.

In the paper on TFF published in 1967 [18] the following hypothesis on the nature and structure of physical vacuum was discussed for the first time. Under the annihilation of the particle-antiparticle pair these particles do not vanish, as it is believed now, but they are combined into a system which is called the elementary particle of vacuum. In our laboratory space in the non-excited state EPV has all quantum numbers equal to zero. These are the primary virtual particles which the entire PV consists of. As we can see below such a concept of PV corresponds to all experimental data and unquestionable theoretical concepts. In 1976 Sudarshan and his colleagues [5] repeated the above-mentioned hypothesis and showed that it resulted in the concept of PV as a certain superfluid quantum liquid. The above-mentioned paper on TFF and the development of the idea of such physical vacuum in papers of 1969, 1973, 1975 [33, 34, 7] were not known to Sudarshan's group, so the latter did not refer to them.

In 1978 Sudarshan with his colleagues [35] repeated also the second idea, which was contained in the papers on TFF — the idea on the possibility of UTF construction by means of the above-mentioned concept of PV. Yet, at the same time they left without any change other concepts not compatible with this hypothesis. That is why up to now they did not manage to develop UTF, though they continue to work in this direction very actively [6] (the last paper in collaboration with Vigier).

1.6. Tachyons

Since the moment of general recognition of SR, that was about 1910—1915, up to the beginning of the sixties it had been a common opinion of physicists that there were no particles in nature with velocities exceeding the speed of light. Some papers where the possibility of such motion was mentioned did not influence this unanimous opinion, though not a few outstanding scientists were the authors of the papers [36]. In the sixties this taboo was subjected to doubt. And a term tachyon was introduced into physics. It was applied to the particles moving faster than light. By 1986 more than 700 papers had been already published on the problem of tachyons. Most of them recognized the possibility of the existence of such particles and a great possibility was foreseen of their important part in future theories. A major contribution to the tachyon theory development was made by Recami group (see, for example, [37, 40]) *) and the pioneer papers by Ya. P. Terletzky [41, 42].

Thus, the years-long taboo on the superluminal particles was shaken, but up to now it is far from being broken. The principal argument of the taboo supporters comes to the following. If it is assumed that in our world the particles moving at a speed below the speed of light, i.e. "tardions" exist alongside with particles moving at a speed above the speed of light, i.e. "tachyons" then the causality principle is violated [43]. Such difficulty exists. All numerous attempts to get over this difficulty have yielded no result. In TFF it has been surmounted.

So, we may formulate the following conclusion. Tachyons and tardions cannot exist and reveal in the same space because it would violate the causality principle. The causality principle will not be violated if tardion motion is allowed in one fiber of a certain enclosing space and tachyon motion is allowed in another fiber, which is a complementary subspace to the former fiber.

Thus, the remaining difficulties as to the construction of the realistic tachyon theory can be surmounted, provided that tardions and tachyons exist only in different fibers of the same enclosing space, that is what TFF realizes.

1.7. Black holes in mega- and microcosm

While finding a solution of GR equations in a domain with the radius equal to or lower than the gravitational radius $r_G = 2mG/c^2$ (numerical coefficient on the right hand side can be equal to 1 or 1/2) certain difficulties arose [44], so this domain was announced to be "non-physical" and was excluded from the consideration. Up to the fifties this one more taboo still remained, until a corresponding redefinition of coordinates was stated, which allowed the consideration of the processes occurring in this "forbidden domain". So the notion of a "black hole" (BH) appeared together with GR. The BH theory is being actively elaborated [45, 46].

Though the taboo was abolished as to the consideration of macroscopic BH, many investigators retained it in respect of the possible BH existence in microcosm [47]. Now there are many interesting mathematical treatises in BH theory (especially see the paper [46]). Yet, these treatises leave the question of physical nature of BH open.

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*) Here and further on references are given only to the most bright papers according to the author's opinion. In subsequent references the words "see, for example" are omitted but should be kept in mind.

Thus by now, there were no sufficient reasons to affirm whether BHs really exist in nature and where they should be observed — in macro- or microcosm, or may be in both.

In our opinion, the vacuum theory of gravitation (VTG) [48—52], developed on the basis of TFF, has shown convincingly what is the physical nature of BHs origin and that they are the objects of microcosm but not megacosm. TFF shows the rightfulness and validity of the predictions which the papers by M. A. Markov [53—55] and K. P. Staniukovich [56—57] contain. There is the affirmation in these papers that the black micro-hole with the Plank radius plays the most fundamental role in the elementary particles formation. The last papers on UTF showed again the actuality of such approach. The development of this problem will be a subject of discussion in one of the sections of this book.

1.8. Triunity: space–time–matter

In the main equation of GR

$$R_{ik} - \frac{1}{2} g_{ik} (R - 2\Lambda) = \frac{8\pi G}{c^4} T_{ik} \tag{1.3}$$

A. Einstein was the first to have stated relation between the three fundamental concepts of physics: space-time-matter. It was this triunity that stimulated the idea of the possibility of UTF creation. Yet, on the right hand side of this equation there is the energy-momentum tensor T_{ik} associated with the investigated matter and the interaction constant G related only to gravitation. Neither Hilbert, nor Weil, nor Eddington, nor Einstein [58, 59], nor their numerous followers [10] could manage to unify gravitational and electromagnetic interactions within the bounds of the principal equation of GR, the left hand side of which was interpreted as an empty space with curvature.

A. Salam proposed the most interesting idea that the relation between the space-time and the matter which had been found by A. Einstein could hold for other kinds of interactions, if the strong gravitation took place with another constant of the relation, which is by many orders greater than G. Many attempts to realize this A. Salam idea are known (see [60, 61]). Yet, until now, they have not had any success. The difficulty consists in the fact that such gravitation was not managed to be realized within the bounds of GR. Besides, the second difficulty appears connected with the solution of the triunity problem: if the dependence (1.3) is interpreted as the field equation then the energy-momentum tensor T_{ik} of this field is identical with zero. The transition to the strong gravitation gives the same result.

A. A. Logunov with his colleagues [62—65] convincingly showed that the difficulty related to the equality of the energy-momentum tensor to zero was not surmounted, in principle. They came to the conclusion that GR was not complete and that it was necessary to develop a new theory of gravitation — the relativistic theory of gravitation (RTG). In RTG T_{ik} is not equal to zero. Yet, it does not allow to restrict the equation to the type of (1.3). Now it is premature to judge what contribution to the complete theory of gravitation would be made by RTG. It is the problem of the future. Yet, the transition from GR to RTG does not remove the difficulties connected with the solution of the problem of developing the triunity for different material forms and interactions, that was put forward by A. Einstein, but he did not manage to solve it. This is mainly connected with the fact that GR is supposed to generalize the laws discovered in it over other interactions (for example, strong gravitation of A. Salam), while RTG sharply restricts the theory within the bounds of gravitation.

The problem of the complete formulation of the Triunity Law for all types of matter (of course not substance generally) is one of the principal problems in TFF and due attention will be paid to it below.

1.9. On multidimensional spaces and fiber bundles

Principal physical theories, namely classical mechanics of Newton, SR, GR, non-relativistic and relativistic quantum mechanics, electromagnetic theory of the field, quantum electrodynamics, were constructed in one real space [66]. The processes which occurred in the imaginary space were considered "non-physical". Meanwhile, substantial results were accumulated which cast doubt on the rightfulness of this taboo. Among such results we should mention papers of H. Weil [67], T. Kaluza [68] and of course the result obtained by all the authors investigating black holes [12]. According to that result we turn out to be in the imaginary domain when crossing the Schwarzschild sphere.

There is another taboo logically inseparable from the one mentioned above. In all theories,the mentioned above processes are considered either in the three-dimentional Euclidian space, or pseudo-Euclidian Minkowski space, or pseudo-Riemannian one, introduced by A. Einstein under the formulation of GR. Spaces with a greater number of dimensions (multi-dimensional), all the more fiber bundles, were not practically considered in physics up to the recent time. Their use in realistic theories was also a taboo.

For a long time theoretical works using multi-dimensional spaces and/or fiber bundles were considered as the approaches using sophisticated, formal-mathematical methods, having nothing to do with real processes occurring in nature. There was nothing said of heuristic value of modern mathematics achievements. The papers on supersymmetry [69, 70], as well as on strings and superstrings [71—73], made physicists think it over for the first time whether surrounding nature realized the multi-dimensional spaces and fiber bundles. This possibility to lift another taboo filled many physicists with enthusiasm and papers on supersymmetry, supergravitation, strings and superstrings began to take more and more volume in the publications of the recent years.

It is easy to see that the question about the reality of the processes occurring in multi-dimensional spaces and fiber bundles is directly connected with the reality of the processes occurring in imaginary domains, because the mathematical structure of multi-dimensional spaces and fiber bundles is sure to contain such domains. Elegance, logical completeness, productivity of works on supersymmetry [74—77], strings and superstrings [78—82] inspired a hope for a great prospect of such works.

However, more and more difficulties related to the physical interpretation of the obtained results began to accumulate. In the basis of these difficulties there is the following problem: in our world, called as previously the laboratory space, the processes are observed either in the three-dimensional Euclidian space, or in the four-dimensional time-space. To realize the transition from the multi-dimensional space and fiber bundle to the four-dimensional time-space we have to make the redundant spaces and coordinates in some way compact. To make things clear it is important not only to find a formal mathematical solution of this problem but to clear up its reasonable physical interpretation. Though many a hundred of qualified investigators are taking part in these works the problem remains unsolved and, moreover, the difficulties in its solution continue to accumulate.

In the very beginning of the development of TFF [7, 14, 18, 19, 33, 34, 48—52, 84—87] the paradigm was laid down into its basis which contained necessary and sufficient requirements for existence of viable and developing systems (see section 2). In this paradigm and its realization in the above-mentioned papers on TFF there was a solution of the problem of physical fundamentals of lawfulness of the physical objects description in multi-dimensional spaces and fiber bundles. Unfortunately, this mathematical basis of the discovered physical regularities had not been quite understood up to the recent years. In this connection, in the works on TFF there were attempts to use the new mathematical apparatus called at first *dicomplex formalism* [34], and later on *discrete-continual geometry* [7]. However, only in the beginning of the eighties it became quite clear that the paradigm and TFF deal with a new interpretation concerning the already known (in the main part) formalism of modern mathematical theories. It allowed to describe many results obtained in the works on TFF by using the language of those mathematical theories. This deepened and broadened the theory itself, made it more clear and brightened the deep correlation between the works on TFF and many of the latest investigations connected with the attempts to construct UTF.

Besides, it became possible to recognize deeper the heuristic value of many divisions of modern mathematics [9, 88—94]. In the book the above-mentioned questions are discussed in detail.

Résumé

Concluding the brief analysis and definition of the principal concepts and initial principles of TFF it seems necessary to remind the reader of some historical facts which have substantial methodical value for the understanding of lawfulness of some new approaches used in TFF.

1. After the Yukawa's prediction of the existence of the meson responsible for nuclear forces the muon was discovered. For 12—15 years all physicists of the world believed that nature realized meson nuclear forces by means of the muon. This error was corrected after the pion discovery and it was clear from the experiment that the muon was a certain special type of a heavy electron. It has been agreed not to mention this general delusion.

2. For about twenty years it was believed that the field equations were generally not perspective in the theory of elementary particles. It was considered that s-matrix and group approaches were sufficient and unique. Especially vividly this point of view was discussed in the paper [90] published no more than 9 years before the Nobel prize was given to the author of the development of the field theory of electroweak interactions. They try to bury in oblivion this period of general delusion.

3. For many years most physicists were considering the method proposed by Regge [65] and known in physical circles as "reggistics" to be cardinal in the process of constructing the elementary particles theory. Their hopes did not come true. "Reggistics" turned out to be a rather specific feature. This general delusion is also not practically mentioned.

4. There was an especially dramatic downfall of the general belief in the fact that the law of space even parity conservation is universal. The violation of this law for weak interactions, which was predicted in 1956 and experimentally confirmed in 1957, was quite a surprise for most physicists.

5. A list of other ideas and principles, which got through a bright boom and afterwards were forgotten and rejected, can be easily continued, but here it is not necessary. The birth and death of some or other ideas, the perspectiveness of which was overestimated, are natural for the development of any science. Yet, it resulted and continues to result in the artificial slowing down of science, if in any given moment of the rise of some or other concepts they were considered the immovable truth, and the contradictory suggestions were rejected. And just because of this approach, which is difficult to call a scientific one, the works on TFF suffered and continue to suffer. It was always possible to contrapose them some or other, popular at the time, direction and then to taboo them.

Seven taboo once put on the results obtained in TFF, were rejected a long time ago, but the label of "sciology" given to the theory by the supporters of the Lysenko phenomenon continues to exist.

6. This book is addressed to those scientists who consider that: firstly, the Lysenko phenomenon has no right to exist;

secondly, the point of view adopted by the majority of specialists in some or other sphere of physics cannot be considered as the immovable truth, and the works which contradict this "truth" cannot be tabooed;

thirdly, there are no priests in science and therefore, the specialists working in the direction of the unified theory of field which, according to their own opinion, has not been constructed yet, are not the specialists in this future theory but they are merely the specialists in certain methods of developing UTF. That is why they cannot be the only judges in the question what direction in the construction of UTF would be promising in the long run. All the more, of course these scientists cannot decide the fate of the already existing unified theory of field, let them use their right to construct another theory, if TFF as the unified theory of all known interactions, does not suit them.

In the mass, modern situation can be considered as the threshold of the rise to a new higher stage of cognition, to a new paradigm of physics of the XX century, next to relativity and quantum mechanics.

L. A. Shelepin.

2 PARADIGM FOR THE INVESTIGATION OF VIABLE AND DEVELOPING SYSTEMS IS THE METHODOLOGICAL AND MATHEMATICAL BASIS FOR CONSTRUCTION OF TFF AND A NUMBER OF OTHER THEORIES

2.1. Formulation of the problem

As far back as in the beginning of our century academician V. I. Vernadsky proposed and developed an idea that the Humanity on the Globe and surrounding it living and inanimate nature make some unity, existing according to the general laws of Nature. He called this unity the noosphere.

The ideas of V. I. Vernadsky and some other our scientists (N. F. Fedorov, V. N. Sukachev, N. V. Timofeev—Resovsky, A. A. Bogdanov) were substantially developed by academician N. N. Moiseev [96, 97]. He showed that the discovered by Darvin triad — heredity, variability and selection has to play an important role in the evolution of all the elements of noosphere. A great contribution to this global question was made by works of I. R. Prigogine [98, 99] and some other foreign scientists, especially of P. T. de Chardin [100].

Yet, the theory of noosphere still does not exist, it is being developed. The first step in the development of this theory, evidently the most important one for the fate of civilization on the Globe, could be the methodological, philosophical and mathematical basis, i.e. the paradigm on the basis of which such a theory could be developed. We shall call this basis the Paradigm for Viable and Developing Systems.

2.2. Papers and facts which can be laid down in the basis of the paradigm

PVDS was formulated as far back as in 1946 as the basis of TFF construction. The paradigm itself was not published because the possibility of its use in politics, economics and other sciences were discovered at once. In the stagnation years such publication was impossible and even might deprive a small collective of its supporters of the possibility to work at all (as it happened to

N. I. Vavilov and other pioneers in science). Only in 1969—1970 the author of PVDS dared to publish certain ideas of the paradigm. He did it in the form of "science fiction" under a pen-name [101]. The first scientific publication of PVDS took place only in 1988 [102].

The absence of the paradigm as the fundamental support slows down practical use of the theory of systems in many spheres of science. We see it by the example of modern theoretical physics.

By now the necessity to form a new paradigm in theoretical physics has become completely mature. From the thirties the paradigm named "classical physics" began to be substituted by the paradigm based on the relativity theories (SR and GR) and quantum physics. Intuitively the essence of this paradigm is clear. Yet, it has not been formulated up to now. Moreover, now works on so-called "quantum logic" are intensely developing to form such paradigm.

The stormy development of modern physics during recent years showed that the "quantum-relativistic" paradigm became old before it was born. A. Einstein was the first who felt it. He did not accept the "quantum logic" as the basis of modern physics up to his last day. L. de Broglie formulated his opinion on these questions rather definitely (see section 1). P. A. M. Dirac was of the similar opinion.

In a number of papers published in the International Journal of Fusion Energy [103] in 1985 basing on the analysis of the results of recent experiments in the sphere of quantum radiophysics it is directly said of the necessity of the "...belated revision of axiomatic concepts of modern physics". A list of such examples can be continued. Yet, the necessity of such a radical reconstruction of modern physics is far from being generally accepted.

We showed the necessity of PVDS development. Yet, to construct PVDS, it was necessary to answer such questions as: what is the essence of the general law of nature, providing viability of all mentioned above systems, and by means of what mathematical apparatus can this law be described and used to construct a future theory?

Since 1946 many works have been published which gave the possibility to describe PVDS fundamentals in modern language because these works directly approached PVDS. By now PVDS is approached by the works on the systems which are far from equilibrium [95—99], on string and superstring theories [78—82], within the bounds of which many physicists now try to solve the problem of constructing the theory unifying all interactions in microcosm, especially this concerns works on TFF, based on PVDS. According to our opinion, modern formulation of PVDS should be the following.

2.3. Fundamentals of the paradigm

Any theory basing on PVDS has to satisfy the following principles, which constitute the basis of the paradigm:

1. For the complete description of any viable and developing system it is necessary to consider it being situated simultaneously in different subspaces, i.e. fibers of a certain fiber bundle.

2. The space-time structure of the system in fibers (base) of the enclosing space under any (no matter how cardinal) differences obeys the unified (for all fibers) Triunity Law of space-time-matter. In other words, space metamorphosis (SM) exists in all viable systems, under which a given system has consistent but different space-time structures in different fibers (and the base) of the enclosing space. The example of the use of this principle for BEP in TFF is shown in fig. 2.1.

3. In respect to a given subspace (the base and/or the fiber) any subspace complementary to it, embedded in the complete enclosing space, is always situated in the imaginary domain. In this case the imaginary domain is not a formal-mathematical mode but a real structural feature of all viable and developing systems.

Note. The first three principles characterize the conditions of stability of a system, its viable steadfastness. To be viable in time but not only stable in a given moment the system should satisfy certain requirements of the steadfastness in the process of life and the ability not only to development but also to self-development.

The next five principles claim the requirements necessary and sufficient for a system to become self-developing. Self-development is one of the primary principles of a viable system. In the process of self-development the system can also be subjected to time metamorphosis but in contrast to space metamorphosis this type of metamorphosis can fail to hold for systems satisfying PVDS.

4. The connection between spaces (fibers) or between the base of a given fibration and the fiber is possible only along the information channel. Along this channel the information is spread not only of the processes occurring in the space, the origin of information, but also the signals controlling general processes. Thus, the information is interpreted in a broad sense.

5. In the stationary regime along the information channel there goes the signal which can bring only negative entropy into the subspace which it enters.

6. The development of a viable system is realized by a sharp increase of flow of information carrying negative entropy. This information may also contain signals which control the Darvin development triad, i.e. variability, heredity and selection.

If the flow of negative entropy dominates over the production of positive entropy then the system is capable of self-organization.

7. The penetration of the signal carrying positive entropy into the information channel or break of information channel carrying negative entropy brings disease or death to the system.

8. If the closure and/or commutativity of the mapping diagram describing all the information channels of the enclosing space is broken then the system loses viability and is sure to die.

The enumerated eight principles of PVDS substantially restrict an infinite set of solutions of the equations of the mathematical theories of dynamic systems, fiber bundles, mappings and other theories used for the investigation.

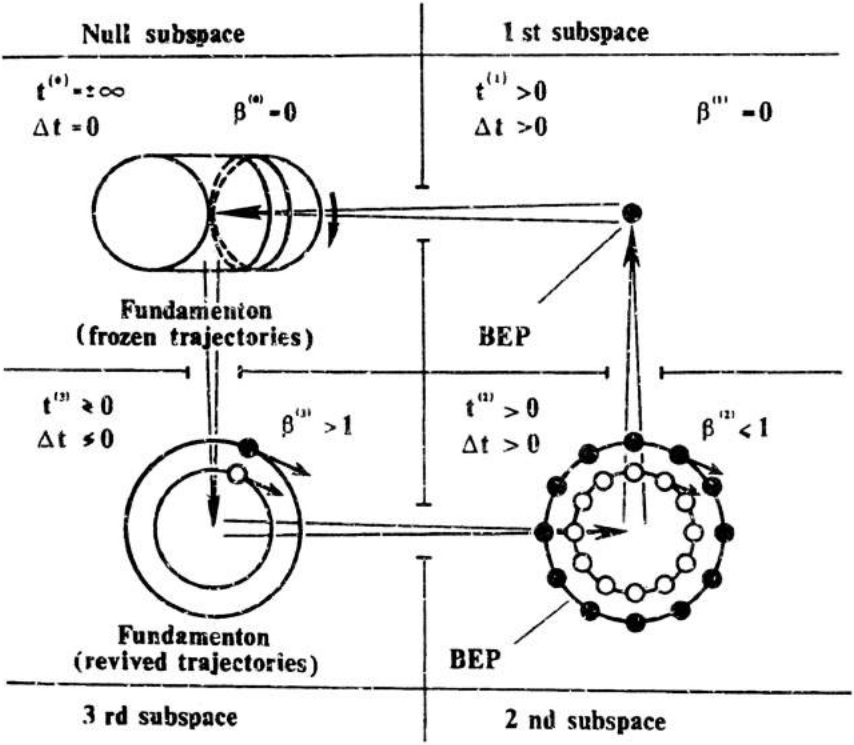


Fig. 2.1. Spatial metamorphosis of structures of a bare elementary particle.

All these principles excluding the Darvin triad were used under the development of the unified theory of fundamental field. The Darvin triad was included into the enumerated conditions under the influence of works by N. N. Moiseev.

In our opinion, the proposed paradigm can be considered as a certain step in the direction of the development of works of V. I. Vernadsky, N. N. Moiseev, I. R. Prigogine oriented on the construction of the theory of noosphere.

It is easy to see that offered to the reader's attention PVDS corresponds to the ideas of N. Wiener who considered cybernetics substantially broader than the idea which is now put into the concept "systemotechnics".

Yet, further discussion of PVDS and especially of the mathematical apparatus needed for its use, is impossible until the fundamentals of these branches of modern mathematics, which are far from being generally known, are given.

Who could guess that we would know so much and understand so little.

A. Einstein.

Many modern scientific inventings are written in a semimystical language as if specially to make the reader have a painful sensation of a certain superman presence.

K. Lanczos.

3 ON THE USE OF HEURISTIC POSSIBILITIES OF MODERN MATHEMATICS. PECULIARITIES OF MATHEMATICAL APPARATUS OF THE THEORY

3.1. The statement of the problem

The program claimed in sections 1 and 2 cannot be solved without an active use of not only the technical but also the heuristic possibilities of modern mathematics.

The development of modern mathematics resulted in the appearance of a great number of new objects and new laws and rules connected with them. They can not be considered as the result of the extrapolation by stages of direct abstractions of these or those known natural objects and phenomena.

Almost for all the discussed *internal, purely mathematical* objects, it was not managed yet to find such stages of abstractions which would be finished by a sharply recognized object of nature, by abstracting certain or all properties of which we could receive this mathematical object. To use the heuristic possibilities of mathematics it is necessary to learn to follow this way from the abstract to the real things.

3.2. Formulation of the problem

The problem resides in the necessity to develop a rather general theory of mapping of *internal mathematical* objects (let us call in such a way abstract mathematical objects created within the bounds of laws of mathematics itself) onto the objects of Nature. The first steps in this direction are made in TFF. We mean not to return to the mystical ideas of the beginning of our century of "the beyond" (with other dimensions) which influences our world. We mean that the space with other dimensions is not "the beyond" but our real space, though it is not sure to be identical to the habitual Euclidian space, or even to pseudo-Riemannian or pseudo-Euclidian which became habitual too.

Up to now the use of the internal mathematical notions for discovering natural objects corresponding to them, in fact, in most cases was of spontaneous character of mere guess-work or it dawned upon a person. In our opinion, it is quite the time to regulate this process. Principles of this regulation, as it would be seen from below, are laid down into the fundamentals of the Paradigm for Viable and Developing Systems on the base of which TFF was constructed.

3.3.
The mathematical basis of the description of the spatial metamorphosis phenomenon

The term "metamorphosis" is widely used in modern biology. It means a radical change of the structure and properties of an organism over time, for example, a caterpillar becomes a chrysalis and afterwards a butterfly. For some types of living organisms this metamorphosis over time (time metamorphosis) is an important condition of viability and development. Yet, this condition is not necessary for all living organisms. The greater part of living organisms is not subjected to time metamorphosis. Spatial metamorphosis required by PVDS has to be realized in all viable and developing systems including of course all structural elements of matter (see section 2).

For any fiber bundles the existence of at least one type of SM follows from their definition [11, 8]. Indeed, any geometrical construction existing in a fiber is realized in the base only as a point, that very point which is common for the fiber and base. In systems satisfying PVDS the type of SM in each case is determined by the composition and construction of fiber bundles in which the system is realized and by the features of mapping between all subspaces. *)

Now, in fact, there is no unified discussion of the general theory of mapping in literature. It is discussed as important fragments in very different branches of modern mathematics, upon which we rest in this section.

In modern mathematics there are substantial developments of many problems of the theory of mapping. They can be not only a guide in solving concrete technical problems but, what is especially important, they are of great heuristic significance.

In this subsection we enumerate the principal information on modern theory of mappings which is used in some or other way in the forthcoming calculations. To save the volume of the book we restrict only to the information we call the definition-résumé (DR). All DRs enumerated below have a reference number. References are given to the papers where the reader can find the discussion in detail and the proof of these results by modern mathematics. That is a part of all things laid down into the basis of the description of mapping in the theory and the description of the SM phenomenon, in particular.

---

*) Here and below, as previously, we call all the elements of fiber bundles (fibers and bases) by subspaces of a certain enclosing space. According to this, in the fiber bundle the concept of subspace is the synonym of the fiber or the base.

The first group of DRs describing spaces and their elements in the theory

DR 1. Topological space X is called the Hausdorff space if the following Hausdorff axiom is valid in it: any two different points of this space $x, y \in X$ have disjoint neighbourhoods [11, Vol.5, p.777]

$O_x \cap O_y = \varnothing$.

According to the definition, a neighbourhood of any point is an open set.

Note. Below certain additional conditions will be imposed upon the neighbourhood.

DR 2. If in the space X there is a signed point $x_0 \in X$ then such spaces (X, x_0) have substantial singularities and are called the dotted spaces [93, p.13].

DR 3. If the neighbourhood O_x of some point of the topological space has the boundary ∂O_x then the neighbourhood with the boundary forms a closed set.

The subspace consisting of points which have maximal neighbourhoods O_x with the boundary ∂O_x is not the Hausdorff one.

DR 4. A topological space is called compact if any of its open coverings contains a finite subcovering.

This means that if $\{U_s\}_{s \in S}$ is an open covering of the space X then the finite set $\{s_1, \dots s_k\} \in S$ exists, such set that $X = U_{s_1} \cup U_{s_2} \cup U_{s_3} \cup \dots \cup U_{s_k}$, where U_{s_1} is the element of covering of $\{U_s\}$, that is an open set; $\cup$ is the theoretical-set union [91, p. 196].

DR 5. The Cartesian product of the topological spaces X and Y is the space $X \times Y$ whose elements are the ordered pairs (x, y), where $x \in X$, $y \in Y$. The topology on the Cartesian product is called the Tikhonov topology [9, p. 127]. It is originated by the family of projections

$p_s : \prod_{s \in S} X_s \rightarrow X_s$.

DR 6. The bunch of two dotted spaces (X, x_0) and (Z, z_0) is the space

$(Z \times \{x_0\}) \cup (\{z_0\} \times X)$.

In detail it is given in [91, pp. 19, 127] and [93, p. 14].

The second DRs group, describing the mappings themselves and the homotopies

DR 7. The most important properties of continuous mappings, compact sets, connected sets represent the principal subject of general topology. The problem of existence or non-existence of the continuous mappings $f: X \to Y$ between two topological spaces X and Y, by methods of mapping topology in algebra, represents the subject of algebraic topology.

DR 8. To formalize the natural intuitive concept of relations of different types of mappings between two topological spaces the notion of homotopy is introduced. The homotopy F of the space X into the space Y is the continuous mapping of the Cartesian product $X \times I$ into Y: $F: X \times I \to Y$, where X, Y are the topological spaces; $I = [0, 1] \subset R^1$ is the unit cut.

For each t the homotopy F_t determines the continuous mapping $F_t: X \to Y$, given by the following formula:

$$F_t(x) = F(x, t)\ ;\ t \in I, x \in X .$$

DR 9. Mappings $f: X \to Y$ are divided into a set of disjoint homotopical classes $[X, Y]$ which have a number of regularities distinguishing them from the class of topological spaces of a general type. The principal feature is the presence of a group structure in many cases (see DR 15).

DR 10. The universal property of the mappings onto the Cartesian product consists of the following:

if $p_x: X \times Y \to X$ and $p_y: X \times Y \to Y$ are the projections of the Cartesian product $X \times Y$ on the first and second factors, respectively, then for any pair of mappings from some space Z onto X and Y, respectively, $f: Z \to X$; $g: Z \to Y$, such *unique* mapping $h: Z \to X \times Y$ exists that $p_x \circ h = f$ and $p_y \circ h = g$, where $\circ$ is the symbol of composition of mappings.

DR 11. The topology of quotient space. Let A be a closed subset of the space X.

We consider the transition to the quotient space X/A resulting from the reducing of the subset A to a point. We consider the relation:

$$\alpha = (A \times A) \cup \{(x, x), x \in X\} \subset X \times X$$

and suppose: $X/A = X/\alpha$.

Thus, the quotient space of the space X on the subset A is defined as the quotient space of the space X on the relation α [93, p. 11].

DR 12. The principal property of a bunch of spaces $(X, x_0) \vee (Z, z_0)$ is: for any continuous mappings $f: (Z, z_0) \to (W, w_0)$; $g: (X, x_0) \to (W, w_0)$ such mapping exists and is unique:

$h : (Z \vee X, *) \to (W, w_0)$, where $*$ is the common point of the bunch, that $h \mid Z = f$; $h \mid X = g$. This mapping h is denoted by (f, g).

Note. Described in DR 12 property is the analogue of DR 10 property but only for the converse direction of the mappings f and g. Such properties are called dual.

DR 13. The standard mapping of the sphere onto the bunch of two spheres $\psi : S^i \to S^i \vee S^i$ results in the fact that the equator S^{i-1} entirely turns into the common point S_0 of the bunch $S^i \vee S^i$. Such mapping in all points except the equator is: a) one-to-one correspondence; b) of the same orientation.

Algebraic structures in the general theory of mappings

DR 14. If for a given topological space a certain algebraic object $F(X)$ (group, hoop, module) is chosen for the analysis then the condition of the mapping $f : X \to Y$ is the requirement of the existence of the homomorphism

$F(f) : F(X) \to F(Y)$.

DR 15. For dotted spaces, homotopical groups $\Pi_n (Y, y_0) = [(S^n, s_0); (Y, y_0)]$ are defined.

A group operation is introduced in $\Pi_n (Y, y_0)$ in the following way [11, vol. 1, pp.1062—1063]: if $n \geq 2$, $x = [u]$, $y = [v]$, then $x \cdot y = [W]$, where the mapping $W : (I^n, I^{n-1}, J^{n-1}) \to (X, A, x_0)$ is defined as

$$W(t_1, \dots t_n) = \begin{cases} u(2t_1, t_2, \dots t_n), \text{ if } 0 \leq t_1 \leq 1/2, \\ v(2t_1 - 1, t_2, \dots t_n), \text{ if } 1/2 \leq t_2 \leq 1. \end{cases}$$

DR 16. If $n = 1$ then Π_1 is called the fundamental group.

DR 17. If $n = 0$ then $\Pi_0 (M, x_0)$ is the set of components of the linear connectivity of the space M and has no group structure in a general case, but in several impotrant particular cases $\Pi_0 (M, x_0)$ is the group. This is the case when M itself has a group structure. In the case when M is the Lie group and $x_0 = 1$, $\Pi_0 (M, x_0) = M/M_0$ is the quotient group of M group.

The same holds with the loop space $\Omega (x_0, N)$.

Note. The loop space $\Omega (x_0, N)$ is the space the elements of which are closed paths going through the signed point x_0 of the space N.

DR 18. Elements of homotopical groups are the classes of the disk $D^i \to (M^n, x_0)$ mappings in which the boundary $\partial D^i = S^{i-1}$ turns into the signed point $x_0 \in M$ under *all homotopies* (and consequently, under the mappings (see DR 8)).

Another way of the definition of the element from $\Pi_l(M,x_0)$ is to represent it as the homotopical class of the mappings of the dotted sphere $S^l \to M$ when the signed point of the sphere s_0 turns into x_0 (also under all homotopies). The mentioned above group elements are the components of the connectivity of the space of the mappings $S_l \to M$ under which $s_0 \to x_0$.

Differential-geometrical constructions in the general theory of mappings

DR 19. The fiber bundle is the quaternion (B, P, E, F), where E is the enclosing (total) space; B is the base; F is the fiber; $P : E \to B$ is the projection.

The following requirement should also be satisfied: there is an open covering of the base $\{U_\alpha (e_\alpha)\}_{\alpha \in A}$, i.e.

$$\begin{cases} \bigcup\limits_{\alpha \in A} U_\alpha = B, \\ \operatorname{diam} U_\alpha = e_\alpha \end{cases}$$

and the homeomorphisms $\Phi_\alpha : U_\alpha \times F \to p^{-1}(U_\alpha)$, which results in $P_\alpha \Phi_\alpha = PU_\alpha : U_\alpha \times \times F \to U_\alpha$. This requirement is called local triviality condition. It is important in a number of physical applications.

DR 20. The fibration (B, P, E, F) is called principal if its fiber F is isomorphic to the structural group.

We consider the simplest examples of the principal fibrations:

1) $\mathbb{R}P^3 = SO(3) \xrightarrow{P} S^2$; $F = SO(2) \equiv S^1$;

2) The Hopf bundle

$S^3 = SU(2) \xrightarrow{P} S^2$; $F = S^1$;

3) The general Hopf bundle

$S^{2n+1} \xrightarrow{P} \mathbb{C}\ P^n$; $F = S^1$.

DR 21. Those bundles are called trivial which are isomorphic to the direct product $E = B \times F$, where E is the enclosing space; B is the base; F is the fiber.

In particular, the unitary group may be represented as a trivial bundle:

$U(n) = S^1 \times SU(n)$.

DR 22. A particular case of the bundle is the covering $X^1 \xrightarrow{P} X$.

In this case the fiber F is discrete and coincides with the fundamental group.

DR 23. A vector field is the section of the tangent bundle J upon the manifold M. A single closed orientable two-dimensional surface, allowing a non-degenerated in any point vector field, is the torus T^2 [104, p.615].

DR 24. The non-degenerated singular points of the vector field on the plane may be only as the following:

center ($\lambda_1 \in Im, \lambda_2 \in Im$) ;

node ($\lambda_1 , \lambda_2 \in R, \lambda_1 \cdot \lambda_2 > 0$) ;

focus ($\lambda_1 = \lambda_2$) ;

saddle ($\lambda_1 , \lambda_2 \in R, \lambda_1 \cdot \lambda_2 < 0$) ,

where λ_1 , λ_2 are roots of the characteristic equation.

DR 25. If the neighbourhood of each point of the space has the following properties: the maximality (see DR 3); ∂O_{x_0} is the boundary between real and imaginary domains; the point x_0 itself belongs to the real and imaginary domains, then the construction has a structure of a fiber bundle. Its base is the neighbourhood O_x ; its fiber is $X \setminus (O_x \cup \partial O_x)$; numeral values of the elements of the base and the fiber (i. e. the intervals in the spaces $O_x = B$ and F) differ by the factor i. It means that if the base is considered to be real then the fiber is imaginary. Therefore, the concepts of a real space and an imaginary one are relative here.

Classificational spaces in the general theory of mappings

DR 26. Classes of the isomorphic vector fiber bundles over the cellular space X with the structural group $G(n)$ have corresponding homotopical classes of mapping $f: X \rightarrow B \cdot G(n)$, where $B \cdot G(n)$ is the classifying space.

DR 27. Different fiber bundles have the corresponding different homotopical classes: the Chern classes correspond to $U(n)$; the Pontriagyn ones correspond to $S_p(n)$; the Stieffel-Whithey ones correspond to $O(n)$.

For the Hopf fiber bundle the Chern class is defined as

$$ch(\gamma) = e^y = \sum \frac{y^k}{k!} .$$

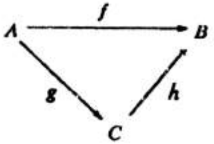
DR 28. If M is the compact one-connective symmetrical space with sectional curvature, everywhere being not greater than α, then the volume of any non-trivial k-dimensional cycle is not less than that of the k-dimensional standard sphere with the curvature α [102].

DR 29. In $k(x)$ group the operation of the tensor product of fiber bundles induces a ring structure.

The Definitions-Résumé given here are certainly far from exhausting the basic information taken from modern mathematics when working out PVDS and TFF. But they give an idea of this information and in many cases they allow better understanding of the initial premises in the calculations below. In the last case if the use of the corresponding DR is not evident the reference to it is given.

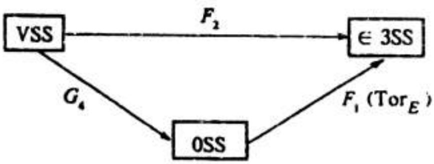
4 CONSTRUCTION OF THE DIAGRAM CHARACTERIZING ALL SPACES DESCRIBING THE MATTER IN TFF*)

The main principle, in accordance with which the construction is made, is the following: from the inside to the outside or otherwise, from the elements to the subspaces and further on to the enclosing spaces. According to this principle, elements of the diagram (see Fig. 1.2) are picked up and laws of mappings between them are determined. The leading principle, which makes the laws of mapping concrete, is satisfying all the requirements of commutativity of the diagram arrows. The accurate formulation of the commutativity condition is the following: if there are three arbitrary taken elements of the diagram connected in the following way:



then the mapping f has always to be equal to the composition of the mappings g and h: $f = g \circ h$.

4.1. The first chain of commutativity at the level of OSS, VSS and 3SS



We now begin from the mapping F_1. It represents the mapping of S^3 onto the spatial part of Tor$_W$.**) The topology of the spatial part of Tor$_W$ represents the Cartesian product of two

*) R. R. Zapatrin took part in writing this section.

**) The description of the fundamenton geometry (Tor$_W$) is considered in section 14.

circumferences $S^1 \times S^1$. Therefore, it is homeomorphic but not isometric to the Euclidian torus Tor_E. In fact, Tor_W allows embedding into R^3 but

$$\mathrm{Tor}_E = \{x, y, z, z_1 \mid x^2 + y^2 = a^2, z^2 + z_1^2 = b^2\} \subset R^4 \neq R^3 . \tag{4.1}$$

Yet, it is impossible to consider Tor_E as a subset of the Euclidian space R^3. Therefore, the mapping $F_1 : S^3 \to \mathrm{Tor}_W$ is constructed in the following way. In S^3 a subset is picked up which is homeomorphic to Tor_E and afterwards it is mapped by coordinates onto Tor_W. We give the computation corresponding to the F_1 construction.

S^3 is the subset of R^4 given by the equation

$$x^2 + y^2 + z^2 + z_1^2 = R_s^2 ,$$

where x, y, z, z_1 are the Cartesian coordinates in R^4, R_s = const (length dimension) is the radius of S^3. These coordinates are connected with angular coordinates on S^3 in the following way:

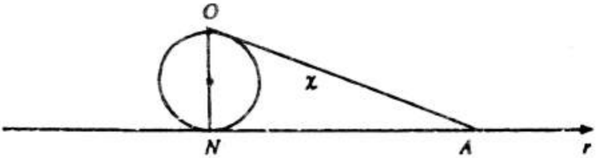
$$\begin{cases} x = R_s \cos\chi \cos\theta \cos\varphi , \\ y = R_s \cos\chi \cos\theta \sin\varphi , \\ z = R_s \cos\chi \sin\theta , \\ z_1 = R_s \sin\chi , \end{cases} \tag{4.2}$$

where χ, θ, φ are the standard angular spherical coordinates (see table 4.1).

S^3 is stereographically projected on R^3 so that χ turns into the radial coordinate r in R^3, $r = r(\chi)$, while φ and θ become conventional polar angular coordinates in R^3. Therefore, if in R^3 we pass to the Cartesian coordinates x', y', z' (which have primes in contrast to analogous coordinates in R^4), then there is a usual relation:

$$\begin{cases} x' = r(\chi) \cos\theta \cos\varphi , \\ y' = r(\chi) \cos\theta \sin\varphi , \\ z' = r(\chi) \sin\theta . \end{cases} \tag{4.3}$$

It remains to calculate the dependence $r(\chi)$. We make an auxiliary construction



where O is the pole of the stereographic projection; N is the tangent point of S^3 and R^3; A is an arbitrary point in R^3; $AN = r(\chi)$; $ON = 2R_s$ is the diameter of S^3.

We now consider the triangle NOA. It is rectanguiar, and therefore

$$\frac{AN}{ON} = \mathrm{tg}\,\widehat{NOA} \Rightarrow \frac{r(\chi)}{2R_s} = \mathrm{tg}\,\widehat{NOA} \Rightarrow r(\chi) = 2R_s\,\mathrm{tg}\,\widehat{NOA}.$$

Yet, the angle $\widehat{NOA}$ is an inscribed one and it is equal to a half of the arc tightening it. The length of this arc is equal to χ, then $\widehat{NOA} = \chi/2$; in this case

$$r(\chi) = 2R_s\,\mathrm{tg}\,\frac{\chi}{2}, \tag{4.4}$$

and then $F_1(\chi, \theta, \varphi) = (x', y', z')$, where

$$\begin{cases} x' = 2R_s\,\mathrm{tg}\,\frac{\chi}{2}\cos\theta\,\cos\varphi\,; \\ y' = 2R_s\,\mathrm{tg}\,\frac{\chi}{2}\cos\theta\,\sin\varphi\,; \\ z' = 2R_s\,\mathrm{tg}\,\frac{\chi}{2}\sin\theta\,. \end{cases} \tag{4.5}$$

The formulae (4.5) map S^3 onto R^3, and Tor $_W$ is the subset of R^3; therefore, (4.5) covers Tor_W as well. It covers Tor_W in the sense that there is the theoretical-set inclusion $\mathrm{Tor}_E \subset S^3$ which is given by formula (4.1). Its functional type is given by formula (4.5). So we have found the unknown mapping F_1.

We now pass to G_4. This is the embedding of the bunch of spheres S^1 with different time scales into S^3. It is the result of fixation of any two of the three spherical coordinates of S^3. This embedding is determined unambiguously since the remaining coordinate has to be within the domain $(0, 2\pi)$ and it may be only the coordinate φ, because there is no time on S^3, the time coordinate "is pressed" into zero point, therefore

$$G_4(\varphi, t^{\alpha}, t^{\beta}, t^{\gamma}) = (\chi_0, \theta_0, \varphi, 0, 0, 0)\,. \tag{4.6}$$

Table 4.1

Diagram terms (Fig. 1.2)	Topological type	Dimension system		Domain of change	
		rectangular	oblique-angled	spatial coordinates	time coordinates
ES1	$\Sigma(\mathbb{R}^2\times S^3)^{\alpha,\beta,\gamma}\setminus\{\infty\}$	8	6	$x, y\,(-\infty,+\infty)$ $\chi, \theta\,(0, \pi)$ $\varphi\,(0, 2\pi)$	$t^\alpha(-\infty,+\infty)$ $t^\beta(-\infty,+\infty)$ $t^\gamma(-\infty,+\infty)$
0SS	S^3	3	—	$\chi, \theta\,(0, \pi)$ $\varphi\,(0, 2\pi)$	—
VSS	$\Sigma S^{1,\alpha,\beta,\gamma}$	4	2	$\varphi\,(0, 2\pi)$	$t^\alpha, t^\beta, t^\gamma(-\infty,+\infty)$
ESM	$\Sigma(\mathbb{R}^2\times S^3\times\mathbb{R}^5)^{\alpha,\beta,\gamma}\setminus\{\infty\}$	13	11	$x^{(1)}, y^{(1)}, z^{(1)}(-\infty,+\infty)$ $x^{(2)}, y^{(2)}, x^{(3)}, y^{(3)}(-\infty,+\infty)$ $\chi, \theta\,(0, \pi), \varphi\,(0, 2\pi)$	$t^\alpha, t^\beta, t^\gamma(-\infty,+\infty)$
$\in$ VSS	$S^{1,\alpha,\beta}$	3	2	$\varphi(0, 2\pi)$	$t^\alpha, t^\beta(-\infty,+\infty)$
$\in$ ES2	$\mathbb{R}^{3,\alpha,\beta}$	5	4	$x, y, z(-\infty,+\infty)$	$t^\alpha, t^\beta(-\infty,+\infty)$
$\in$ ES3	$\mathbb{R}^{3,\beta,\gamma}$	5	4	$x, y, z(-\infty,+\infty)$	$t^\beta, t^\gamma(-\infty,+\infty)$
$\in$ 3SS	$\mathrm{Tor}_w\setminus\{0\}$	3	—	$x'y'(-R,R),\ R=const$ $z'(-b,b),\ b=const$	—
$\in$ 2SS	$S^{1,\beta}\setminus\{0\}$	2	—	$\varphi\,(0, 2\pi)$	$t^\beta(-\infty,+\infty)$
$\in$ 1SS	{1}	0	—	One-element set corresponding to zero point (0,0,0)	$t=0$
2SS	$\Sigma\,\mathbb{R}^{2,\beta}\setminus\{\infty\}$	3	—	$x, y\,(-\infty,+\infty)$	$t^\beta(-\infty,+\infty)$
1SS	$\mathbb{R}^{3,\gamma}\setminus\{\infty\}$	4	—	$x, y, z\,(-\infty,+\infty)$	$t^\gamma(-\infty,+\infty)$
ES2	$\Sigma\,\mathbb{R}^{4,\alpha,\beta}\setminus\{\infty\}$	6	5	$x^{(2)}, y^{(2)}, x^{(3)}, y^{(3)}(-\infty,+\infty)$	$t^\alpha, t^\beta(-\infty,+\infty)$
ES3	$\Sigma\,\mathbb{R}^{5,\beta,\gamma}\setminus\{\infty\}$	7	6	$x^{(1)}, y^{(1)}, z^{(1)}(-\infty,+\infty)$ $x^{(2)}, y^{(2)}(-\infty,+\infty)$	$t^\beta, t^\gamma(-\infty,+\infty)$
3SS	$\Sigma\,\mathbb{R}^{2,\alpha,\beta}\setminus\{\infty\}$	4	3	$x^{(3)}, y^{(3)}(-\infty,+\infty)$	$t^\alpha, t^\beta(-\infty,+\infty)$

It remains to examine F_2. The commutativity condition fixes it strictly:

$$F_2(\varphi, t^\alpha, t^\beta, t^\gamma) = F_1(G_4(\varphi, t^\alpha, t^\beta, t^\gamma)) = F_1(\chi_0, \theta_0, \varphi, 0, 0, 0) = (x', y', z'), \tag{4.7}$$

where x', y', z' are determined from formula (4.5). Finally, we have

$$F_2(\varphi, t^\alpha, t^\beta, t^\gamma) = (x', y', z'); \tag{4.8}$$

$$\begin{cases} x' = 2R_s \operatorname{tg}\frac{\chi_0}{2}\cos\theta_0\cos\varphi; \\ y' = 2R_s \operatorname{tg}\frac{\chi_0}{2}\cos\theta_0\sin\varphi; \\ z' = 2R_s \operatorname{tg}\frac{\chi_0}{2}\sin\theta_0, \end{cases} \tag{4.9}$$

where $\chi_0 = \text{const}$, $\theta_0 = \text{const}$.

We now determine θ_0 from the condition of mapping S^1 onto the diameter. This means that $z=0$, consequently, $\theta_0=0$ *).

We determine χ_0 from the condition when the torus radius is either internal or external, i.e. it is equal to $a \pm b$. This follows from

$$2R \operatorname{tg}\frac{\chi_0}{2} = a \pm b \Rightarrow \operatorname{tg}\frac{\chi_0}{2} = \frac{a \pm b}{2R} \Rightarrow \frac{\chi_0}{2} = \operatorname{arctg}\frac{a \pm b}{2R} \Rightarrow \chi_0 = 2\operatorname{arctg}\frac{a \pm b}{2R}. \tag{4.10}$$

Here $R \neq R_s$; R is the radius of S^1; a, b are the parameters of Tor_W which have length dimension. And so

$$\theta_0 = 0: \ \chi_0 = 2\operatorname{arctg}\frac{a \pm b}{2R}. \tag{4.11}$$

Consequently, $F_2(\varphi) = (x', y', 0)$, where

$$x' = 2R \operatorname{tg}\frac{\chi_0}{2}\cos\varphi;$$
$$y' = 2R \operatorname{tg}\frac{\chi_0}{2}\sin\varphi;$$
$$z' = 0.$$

---

*) We can not take $\chi_0 = 0$ because in this case the whole mapping F_2 would degenerate into one-point mapping.

4.2. The chain of embeddings G_7 and G_8 and the mapping F_7

Here the commutativity condition must be satisfied

$$G_7 = F_7 \circ G_8 . \tag{4.12}$$

At first we examine G_7. The image of the mapping F_2 is characterized by the fact that the coordinate z' is equal to zero. Therefore, we map the remaining coordinates x', y' onto $\in$ ES2:

$$G_7 (x', y') = (x, y) ; \tag{4.13}$$

$$\begin{cases} x = x' , \\ y = y' . \end{cases}$$

In this case two time scales corresponding to different values of the constant χ in the formula (4.9) turn into t^{α} and t^{β} in ES2. This transition is determined as follows: since $a \neq b$, then $\chi_{0\alpha} \neq \chi_{0\beta}$ and the time scales t^{α} and t^{β} are different:

$$\begin{cases} \chi_{0\alpha} = 2 \operatorname{arctg} \frac{a - b}{2R} \mapsto t^{\alpha} , \\ \chi_{0\beta} = 2 \operatorname{arctg} \frac{a + b}{2R} \mapsto t^{\beta} . \end{cases} \tag{4.14}$$

Thus,

$$G_7 (x', y') = (x', y') = id . \tag{4.15}$$

We now examine G_8 :

$$G_8 : S^{1,\beta} \setminus \{0\} \to \mathbb{R}^{3,\alpha,\beta} ,$$

here S^1 is standardly turned into the Cartesian coordinates in $\mathbb{R}^3$; z' must be equal to zero because in $\in$ 3SS $z' = 0$. Therefore,

$$\begin{cases} x = R \cos\varphi , \\ y = R \sin\varphi . \end{cases} \tag{4.16}$$

There are two time coordinates in $\in$ ES2 and one in $\in$ 2SS, therefore $t^{\beta} \mapsto t^{\alpha}$; $t^{\beta} \mapsto t^{\beta}$. This demands the coincidence of angular velocities, that is $\omega_1^{(2)}$ has to be equal to $\omega_2^{(2)}$, i.e.

$$\omega_1^{(2)} = \omega_2^{(2)} \Rightarrow \frac{R_1^{(2)}}{\beta_1^{(2)}} = \frac{R_2^{(2)}}{\beta_2^{(2)}} \Rightarrow \frac{2\pi R_1^{(2)}}{\beta_1^{(2)}} = \frac{2\pi R_2^{(2)}}{\beta_2^{(2)}} , \tag{4.17}$$

and this is what gives the above-mentioned relation of the equality of angular velocities.

Thus, the mapping G_8 exists only if the relation $\omega_1^{(2)} = \omega_2^{(2)}$ is valid.

So:

$$G_8(\varphi) = (x, y) = (R\cos\varphi, R\sin\varphi),$$

where $x = R\cos\varphi$; $y = R\sin\varphi$; $R = \text{const}$ is the radius of S^1; x, y are the coordinates in $\in$ ES2, which have the dimension of length.

We now construct F_7 using the commutativity condition. It can be constructed by introducing the calculation space $(3 \to 2)$, which can be interpreted as the space of scales change. As a matter of fact, the radii of the internal and external circumferences are different (they are equal to $(a - b)$ and $(a + b)$, respectively) but S^1 has the only radius.

Therefore, it is possible to introduce the false space $\mathbb{R}^{2,(3\to2),\alpha,\beta}$. It should have different length scales but a common time scale. These scales are calculated in such a way:

$$\begin{cases} r_\alpha = A_\alpha r; \\ r_\beta = A_\beta r, \end{cases} \tag{4.18}$$

where r is the radial coordinate in $\in$ 3SS; r_α is the radial coordinate in $\mathbb{R}^{(3\to2),\alpha}$; r_β is the radial coordinate in $\mathbb{R}^{(3\to2),\beta}$. The coefficients A_α and A_β are calculated so:

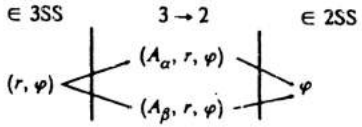
$$R = A_\alpha(a - b); \; R = A_\beta(a + b).$$

It means that

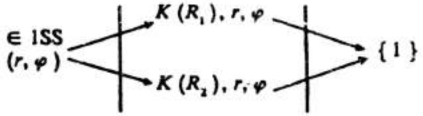
$$A_\alpha = \frac{R}{a - b}; \; A_\beta = \frac{R}{a + b}. \tag{4.19}$$

The radii of both circumferences in the components α and β are the same and equal to R. Now the formulae (4.16) can be used because R is determined unambiguously.

So, F_7 in polar coordinates has the form:



In the analogous way the mapping $F_9 : \in 3\text{SS} \to \in 1\text{SS}$ is constructed. In the same polar coordinates it has the form:



4.3. The mappings F_6, F_3 and the embedding G_8

G_8 has been already calculated in subsection 4.2. The mapping F_6 demands for its existence the same conditions as G_8 because of the same reason: in $\in$ 2SS there is the only time coordinate and in $\in$ VSS there are two. The mapping F_6 is

$$\begin{cases} \varphi \mapsto \varphi \, , \\ t^{\beta} \mapsto t^{\alpha} = t^{\beta} \end{cases} \tag{4.20}$$

to satisfy the chain commutativity condition, namely

$$F_6 = G_8 \circ F_3 \, . \tag{4.21}$$

Thus,

$$F_6 = id \big|_{S^1} \, , \text{ i. e. } F_6(\varphi) = \varphi \, , \tag{4.22}$$

where φ is the angular coordinate on S^1.

F_3 should be $F_3(\varphi) = \varphi$. Yet, in $\in$ ES2 there are the Cartesian coordinates, and therefore

$$F_3(x, y, z) = \arccos \frac{x}{\sqrt{x^2 + y^2}} \, . \tag{4.23}$$

Consequently, the commutativity (4.21) is valid because

$$\begin{aligned} & F_3(G_8(\varphi)) = F_3(R\cos\varphi, R\sin\varphi, 0) = \\ & = \arccos \frac{R\cos\varphi}{\sqrt{R^2\cos^2\varphi + R^2\sin^2\varphi}} = \arccos(\cos\varphi) = \varphi \, . \end{aligned} \tag{4.24}$$

4.4. The chains of mappings F_4, F_5 and the embedding G_9

In the spatial part G_9 is equal to G_8 and the time relations are $t^{\beta} \mapsto t^{\beta} = t^{\gamma}$.

In the same way the spatial parts of F_3 and F_4 do coincide. Finally we obtain:

$$G_9 : \begin{cases} x = R\cos\varphi\ , \\ y = R\sin\varphi\ , \\ z = 0\ , \\ t^{\beta} \mapsto t^{\beta}, t^{\gamma}\ . \end{cases}$$

Thus

$$G_9(\varphi, t^{\beta}) = (x, y, z, t^{\beta}, t^{\gamma})\ ; \tag{4.25}$$

$$F_4 : \begin{cases} \varphi = \arccos \dfrac{x}{\sqrt{x^2 + y^2}}\ ; \\ t^{\beta}, t^{\gamma} \mapsto t^{\beta}\ . \end{cases}$$

$$F_4(x, y, z) = (\varphi, t^{\beta})\ . \tag{4.26}$$

We now check whether the commutativity condition is valid:

$$F_4 = G_9 \circ F_4\ ;$$

$$F_4(G_9(\varphi)) = \arccos\left(\frac{R\cos\varphi}{\sqrt{R^2\cos^2\varphi + R^2\sin^2\varphi}}\right) = \varphi\ , \tag{4.27}$$

i.e. the same as in the formula (4.24), consequently $F_6 = \varphi$ (see the formula (4.22)).

4.5. The chain of embeddings G_9 and G_{10} and the mapping F_8

Here the commutativity condition must be satisfied:

$$G_9 = F_8 \circ G_{10}\ , \tag{4.28}$$

which has the topological structure {1}.

Yet, for the commutativity (4.28) we should "not forget" that this one-element set is the circumference, considered not as a subset but as an element. This can be done by constructing in a special way the space $(2 \to 1)$ which is a false space, merely a calculation space, through which F_8 acts.

The space $(2 \to 1)$ is the two-dimensional Euclidian space on which the equivalence relation $(x, y) \sim (x', y')$ is given only in the case when

$$x^2 + y^2 = x'^2 + y'^2\ , \tag{4.29}$$

where (x, y) and (x', y') are two equivalent points on $\mathbb{R}^2$.

The mapping F_8 acts in the following way. The circumference $\in$ 2SS is mapped onto $\mathbb{R}^2$ in the usual way:

$$\begin{cases} x = R\cos\varphi\,, \\ y = R\sin\varphi\,, \end{cases} \tag{4.30}$$

and after that $(2 \to 1)$ is considered as the quotient space (see DR 11) $R^2/\sim$. The equivalence classes (4.29) of the quotient space are the circumferences $x^2 + y^2 = \text{const}$. From these elements F_8 picks up one element {1} which corresponds to the circumference $x^2 + y^2 = R^2$ and maps it onto 1SS. The word "picks up" has the following mathematical meaning: the image of mapping F_8 is the circumference S^1 of the given radius $R = \text{const}$:

$$\text{Im}\, F_8 = S^1(R)\,.$$

We obtain $\{1\} \in$ 1SS.

Therefore, $G_{10}(\{1\})$ is S^1 with the same radius R, and the commutativity (4.28) is satisfied.

From the results of subsections 4.2—4.5 it follows that all circumferences in $\in$ 3SS, $\in$ ES2, $\in$ 2SS, $\in$ ES3, $\in$ 1SS turn into circumferencs. Consequently, their centers turn into the centers (since there were no inversions among the mappings discussed). Yet, on the one hand, the zero point of the coordinate frame is their center, on the other hand, the signed point {0} is their

center. It means that all these elements belonging to BEP have the common zero point which is the signed point {0}.

4.6. The embeddings of elements

We now examine the embeddings G_6, G_{11}, G_{13}, G_{15} and the mapping F_5 onto the element.

Since these embeddings are those of the elements, they represent the restrictions of the identical mapping *id* onto the element in question, therefore,

$$G_6 : S^{1,\alpha,\beta} \to S^{1,\alpha,\beta,\gamma} \Rightarrow G_6(\varphi, t^\alpha, t^\beta) = (\varphi, t^\alpha, t^\beta)\,; \tag{4.31}$$

$$G_{11} : \text{Tor}_W\Big|_{z=0} \to R^{2,\alpha,\beta} \setminus \{\leftrightarrow\} \Rightarrow G_{11}(x, y, t^\alpha, t^\beta) = (x, y, t)\,, \tag{4.32}$$

and consequently, $G_{11} = id\,(R^{2,\alpha})$ and t on the right hand side of (4.32) can mean t^α or t^β in respect of what coordinate frame is used in 3SS (rectangular or oblique-angular). The space-time (ST) in 3SS remains the same and different frames of ST coordinates single out different time axes in it.

In the mappings G_{13} and G_{15} no problem of this kind exists and both the former and the latter have one time axis only:

$$G_{13} : S^{1,\beta} \setminus \{0\} \to R^{2,\beta} \setminus \{\leftrightarrow\} \Rightarrow G_{13}(\varphi) = (R\cos\varphi, R\sin\varphi)\,, \tag{4.33}$$

where $R = \text{const}$ is the radius of S^1,

$$G_{15} : \{1\} \to R^{3,\gamma} \setminus \{\leftrightarrow\} \Rightarrow G_{15}(\{1\}) = G_{15}(S^1) = (0, 0, 0) . \quad (4.34)$$

The mapping F_5 has the one-element set $\{1\}$ as an image, therefore, for any $\varphi \in S^1$ we have:

$$F_5(\varphi) = 1 . \quad (4.35)$$

4.7. Construction of ES2

Here two commutativity conditions are used simultaneously:

$$G_{11} \circ G_{16} = G_7 \circ G_{12} , \quad (4.36)$$

$$G_{13} \circ G_{17} = G_8 \circ G_{12} . \quad (4.37)$$

ES2 is enclosing for 3SS and 2SS and therefore, it has the following structure:

$$\begin{aligned} \text{ES2} &= (\Sigma R^{2,\alpha,\beta} \setminus \{\leftrightarrow\}) \times (\Sigma R^{2,\beta} \setminus \{\leftrightarrow\}) = \\ &= (\Sigma R^{2,\alpha,\beta} \times \Sigma R^{2,\beta}) \setminus \{\leftrightarrow\} = \Sigma (R^2 \times R^2)^{\alpha,\beta} \setminus \{\leftrightarrow\} = \Sigma R^{4,\alpha,\beta} \setminus \{\leftrightarrow\}. \end{aligned} \quad (4.38)$$

We denote the coordinates corresponding to 3SS by index (3), and those corresponding to 2SS by index (2). Then the embeddings G_{16} and G_{17} take the form:

$$G_{16}(x, y) = (x^{(3)}, y^{(3)}, 0, 0) ; \quad (4.39)$$

$$G_{17}(x, y) = (0, 0, x^{(2)}, y^{(2)}) . \quad (4.40)$$

It remains to obtain G_{12} from the conditions (4.36) — (4.37) because the remaining part of the embeddings has been already calculated. We make it in the following way: G_8 gives the Cartesian coordinates in $\in$ ES2: $x = r\cos\varphi$, $y = R\sin\varphi$. They have been already agreed with ES2, and therefore:

$$\begin{cases} G_{12}(x, y) = (0, 0, x^{(2)}, y^{(2)}) \text{ when } t = t^{\beta} ; \\ G_{12}(x, y) = (x^{(3)}, y^{(3)}, 0, 0) \text{ when } t = t^{\alpha} . \end{cases} \quad (4.41)$$

4.8. Construction of ES3

In the most part this construction is analogous to the one performed in subsection 4.7.

Two commutativity conditions are

$$G_{13} \circ G_{18} = G_9 \circ G_{14} ; \quad (4.42)$$

$$G_{15} \circ G_{19} = G_{10} \circ G_{14} . \quad (4.43)$$

ES3 is enclosing for 2SS and 1SS and therefore, it has the following structure:

$$
\begin{aligned}
ES3 &= (\Sigma \mathbb{R}^{2,\beta} \setminus \{\leftrightarrow\}) \times (\Sigma \mathbb{R}^{3,\gamma} \setminus \{\leftrightarrow\}) = \\
&= (\Sigma \mathbb{R}^{2,\beta} \times \Sigma \mathbb{R}^{3,\gamma}) \setminus \{\leftrightarrow\} = \Sigma (\mathbb{R}^2 \times \mathbb{R}^3)^{\beta,\gamma} \setminus \{\leftrightarrow\} = \qquad (4.44) \\
&= \Sigma \mathbb{R}^{5,\beta,\gamma} \setminus \{\leftrightarrow\}.
\end{aligned}
$$

We denote the coordinates corresponding to 2SS by index (2) and those corresponding to 1SS by index (1). Then the embeddings G_{18} and G_{19} take the form:

$$G_{18}(x, y) = (x^{(2)}, y^{(2)}, 0, 0, 0); \qquad (4.45)$$

$$G_{19}(x, y, z) = (0, 0, x^{(1)}, y^{(1)}, z^{(1)}). \qquad (4.46)$$

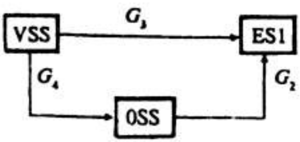
It remains to obtain G_{14} from the conditions (4.42) — (4.43) because the remaining part of the embeddings has been already calculated. We make it in the following way:
G_9 gives

$\begin{cases} x = R\cos\varphi \\ y = R\sin\varphi \end{cases} \Rightarrow$ in $\in$ ES3 there are the Cartesian coordinates already agreed with ES3, and therefore:

$$
\begin{cases}
G_{14}(x, y, z) = (0, 0, x^{(1)}, y^{(1)}, z^{(1)}), \\
G_{14}(t^{\beta}) = t^{\beta}, \\
G_{14}(t^{\gamma}) = t^{\gamma}.
\end{cases} \qquad (4.47)
$$

Note: In this place there is some difference from that given in (4.7) because here the times with indices β and γ are agreed.

4.9. Construction of ES1 and the chain of mappings



ES1 is enclosing for 3SS, 0SS and VSS, therefore:

$$ES1 = (\Sigma \mathbb{R}^{2,\alpha,\beta} \setminus \{\leftrightarrow\}) \times S^3 \times (\Sigma S^{1,\alpha,\beta,\gamma}). \qquad (4.48)$$

Yet, it is necessary to take into account that VSS is embedded by its spatial part into 0SS (this is G_4) and therefore, in the product (4.48)

$$S^3 \times (\Sigma S^{1,\alpha,\beta,\gamma}) = S^{3,\alpha,\beta,\gamma}. \tag{4.49}$$

And then:

$$\text{ES1} = (\Sigma \mathbb{R}^{2,\alpha,\beta} \setminus \{\leftrightarrow\}) \times S^{3,\alpha,\beta,\gamma} = \Sigma (\mathbb{R}^2 \times S^3)^{\alpha,\beta,\gamma} \setminus \{\leftrightarrow\}. \tag{4.50}$$

In ES1 it is most convenient to use the mixed Cartesian and polar coordinates, i.e. in ES1 $(x, y, \chi, \theta, \varphi)$, taking the values:

$$\begin{cases} -\infty \le x, y \le +\infty, \\ 0 \le \chi, \theta \le \pi, \\ 0 \le \varphi \le 2\pi. \end{cases} \tag{4.51}$$

Then the embedding G_5 takes the form:

$$G_5(x, y) = (x, y, 0, 0, 0); \tag{4.52}$$

and

$$G_2 : G_2(\chi, \theta, \varphi) = (0, 0, \chi, \theta, \varphi). \tag{4.53}$$

In this case G_3 can be calculated as the following composition to satisfy the commutativity condition

$$G_3 = G_4 \circ G_2. \tag{4.54}$$

G_4 was calculated in subsection 4.1, by the formula (4.6). Then

$$G_3(\varphi, t^\alpha, t^\beta, t^\gamma) = G_2(G_4(\varphi, t^\alpha, t^\beta, t^\gamma)) =$$

$$= G_2(\chi_0, \theta_0, \varphi, 0, 0, 0) = (0, 0, \chi_0, \theta_0, \varphi).$$

Thus,

$$\begin{cases} G_3(\varphi, t^\alpha, t^\beta, t^\gamma) = (0, 0, \chi_0, \theta_0, \varphi), \\ t^\alpha \mapsto t^\alpha, \\ t^\beta \mapsto t^\beta, \\ t^\gamma \mapsto t^\gamma \quad \text{(see formula (4.11))}, \end{cases} \tag{4.55}$$

i.e.

$$G_3(\varphi, t^\alpha, t^\beta, t^\gamma) = (0, 0, \chi_0, \theta_0, \varphi, t^\alpha, t^\beta, t^\gamma).$$

4.10. Construction of ESM and the corresponding embeddings

ESM is enclosing for ES1, ES2 and ES3:

$$
\begin{aligned}
\mathrm{ESM} &= [\Sigma(\mathbb{R}^2 \times S^3)^{\alpha,\beta,\gamma} \backslash \{\leftrightarrow\}] \times [\Sigma\, \mathbb{R}^{4,\alpha,\beta} \backslash \{\leftrightarrow\}] \times \\
&\times [\Sigma\, \mathbb{R}^{5,\beta,\gamma} \backslash \{\leftrightarrow\}] = (\Sigma(\mathbb{R}^2 \times S^3)^{\alpha,\beta,\gamma} \times (\Sigma\, \mathbb{R}^{4,\alpha,\beta}) \times \\
&\times (\Sigma\, \mathbb{R}^{5,\beta,\gamma})) \backslash \{\leftrightarrow\} .
\end{aligned}
\tag{4.56}
$$

Yet, 3SS $-\mathbb{R}^{2,\alpha,\beta}$ is embedded into ES1 as well as into ES2, therefore, it is a common factor. In an analogous way 2SS $-\mathbb{R}^{2,\beta}$ is embedded into ES2 and ES3. As a result of this, the second factor turned out to enter by parts into the first and the third ones and therefore:

$$
\begin{aligned}
\mathrm{ESM} &= \Sigma(\mathbb{R}^2 \times S^3)^{\alpha,\beta,\gamma} \times \Sigma\, \mathbb{R}^{5,\beta,\gamma} \backslash \{\leftrightarrow\} = \\
&= \Sigma(\mathbb{R}^2 \times S^3 \times \mathbb{R}^5)^{\alpha,\beta,\gamma} \backslash \{\leftrightarrow\} .
\end{aligned}
\tag{4.57}
$$

In ESM there are the following coordinates (it is suitable to index them by the numbers of corresponding SS):

$$
(x^{(3)}, y^{(3)}, \chi^{(0)}, \theta^{(0)}, \varphi^{(0)}, x^{(2)}, y^{(2)}, x^{(1)}, y^{(1)}, z^{(1)}) . \tag{4.58}
$$

It remains to describe the proper embeddings:

$$
G_1 (x, y, \chi, \theta, \varphi) = (x^{(3)}, y^{(3)}, \chi^{(0)}, \theta^{(0)}, \varphi^{(0)}, 0, 0, 0, 0, 0) ; \tag{4.59}
$$

$$
G_{20} (x^{(3)}, y^{(3)}, x^{(2)}, y^{(2)}) = (x^{(3)}, y^{(3)}, 0, 0, 0, x^{(2)}, y^{(2)}, 0, 0, 0) ; \tag{4.60}
$$

$$
G_{21} (x^{(2)}, y^{(2)}, x^{(1)}, y^{(1)}, z^{(1)}) = (0, 0, 0, 0, 0, x^{(2)}, y^{(2)}, x^{(1)}, y^{(1)}, z^{(1)}) . \tag{4.61}
$$

Information on all mappings discussed in section 4 is reduced to tables 4.1 and 4.2.

Table 4.2

Nos	Mappings (Embeddings)	Specific coordinate expression
F_1	$0SS \to \in 3SS$	$F_1(\chi,\theta,\varphi) = (x', y', z')$ $\begin{cases} x' = 2R \operatorname{tg}\frac{\chi}{2}\cos\theta\cos\varphi \\ y' = 2R \operatorname{tg}\frac{\chi}{2}\cos\theta\sin\varphi \\ z' = 2R \operatorname{tg}\frac{\chi}{2}\sin\theta;\ R = \mathrm{const} \end{cases}$
F_2	$VSS \to \in 3SS$	$F_2(\varphi) = (x', y', z')$ $\begin{cases} x' = 2R \operatorname{tg}\frac{\chi_0}{2}\cos\varphi;\ R = \mathrm{const} \\ y' = 2R \operatorname{tg}\frac{\chi_0}{2}\sin\varphi;\ \chi_0 = 2\operatorname{arctg}\frac{a \pm b}{2} = \mathrm{const} \\ z' = 0 \end{cases}$
F_3	$\in ES2 \to \in VSS$	$F_3(x, y, z) = \arccos\frac{x}{\sqrt{x^2+y^2}}$
F_4	$\in ES3 \to \in VSS$	$F_4(x, y, z) = \arccos\frac{x}{\sqrt{x^2+y^2}}$; $t^\beta, t^\gamma \to t^\beta$
F_5	$VSS \to \in 1SS$	$F_5(\varphi) \equiv 1$ is the one-point mapping
F_6	$\in 2SS \to \in VSS$	$F_6 = id$, i.e. $F_6(\varphi) = \varphi$
F_7	$\in 3SS \overset{(3 \to 2)}{\to} \in 2SS$	$F_7(\tau,\varphi) = \mu_{\alpha,\tau,\varphi} / \mu_{\beta,\tau,\varphi} = \varphi$; $\mu_\alpha = \frac{R}{a-b} = \mathrm{const}$; $\mu_\beta = \frac{R}{a+b} = \mathrm{const}$
F_8	$\in 2SS \to \in 1SS$	$F_8(S^1) = \{1\}$ — formal record deciphering in text
F_9	$\in 3SS \overset{(3 \to 1)}{\to} \in 1SS$	deciphering in text
G_1	$ES1 \to ESM$	$G_1(x, y, \chi, \theta, \varphi) = (x^{(3)}, y^{(3)}, \chi^{(0)}, \theta^{(0)}, \varphi^{(0)}, 0, 0, 0, 0, 0)$
G_2	$0SS \to ES1$	$G_2(\chi, \theta, \varphi) = (0, 0, \chi, \theta, \varphi)$
G_3	$VSS \to ES1$	$G_3(\varphi, t^\alpha, t^\beta, t^\gamma) = (0, 0, \chi_0, \theta_0, \varphi)$; $t^{\alpha,\beta,\gamma} \to t^{\alpha,\beta,\gamma}$ $\chi_0 = \mathrm{const}$, $\theta_0 = \mathrm{const}$
G_4	$VSS \to 0SS$	$G_4(\varphi, t^\alpha, t^\beta, t^\gamma) = (\chi_0, \theta_0, \varphi, 0, 0, 0)$; $\chi_0 = \mathrm{const}$, $\theta_0 = \mathrm{const}$

Nos	Mappings (embeddings)	Specific coordinate expression
G_6	$\in$ VSS → VSS	$G_6 = id\,|_{S^1} \Rightarrow G_6(\varphi, t^\alpha, t^\beta) = (\varphi, t^\alpha, t^\beta)$
G_7	$\in$ 3SS → $\in$ ES2	$G_7(x', y') = (x, y); x = x', y = y'$
G_8	$\in$ 2SS → $\in$ ES2	$G_8(\varphi) = (x, y); x = R\cos\varphi, y = R\sin\varphi$
G_9	$\in$ 2SS → $\in$ ES3	$G_9(\varphi) = (x, y, z); x = R\cos\varphi, y = R\sin\varphi, z = 0; t^A \mapsto t^\beta, t^\gamma$
G_{10}	$\in$ 1SS → $\in$ ES3	$G_{10}(\{1\}) \sim S^1$ (incomplete record, introduction of SS(2 → 1) is necessary)
G_{11}	$\in$ 3SS → $\in$ 3SS	$G_{11}(x, y, t^\alpha, t^\beta) = (x, y, t)$
G_{12}	$\in$ ES2 → ES2	$G_{12}(x, y) = \begin{cases}(0, 0, x^{(2)}, y^{(2)}) \text{ when } t \mapsto t^\beta \\ (x^{(3)}, y^{(3)}, 0, 0) \text{ when } t \mapsto t^\alpha\end{cases}$
G_{13}	$\in$ 2SS → 2SS	$G_{13}(\varphi) = (R\cos\varphi, R\sin\varphi); R = \text{const}$
G_{14}	$\in$ ES3 → ES3	$G_{14}(x, y, z) = (0, 0, x^{(1)}, y^{(1)}, z^{(1)}); G_{14}(t^\beta, t^\gamma) = (t^\beta, t^\gamma)$
G_{15}	$\in$ 1SS → 1SS	$G_{15}(1) = (0, 0, 0)$
G_{16}	3SS → ES2	$G_{16}(x, y) = (x^{(3)}, y^{(3)}, 0, 0)$
G_{17}	2SS → ES2	$G_{17}(x, y) = (0, 0, x^{(2)}, y^{(2)})$
G_{18}	2SS → ES3	$G_{18}(x, y) = (x^{(2)}, y^{(2)}, 0, 0, 0)$
G_{19}	1SS → ES3	$G_{19}(x, y, z) = (0, 0, x^{(1)}, y^{(1)}, z^{(1)})$
G_{20}	ES2 → ESM	$G_{20}(x^{(3)}, y^{(3)}, x^{(2)}, y^{(2)}) = (x^{(3)}, y^{(3)}, 0, 0, 0, x^{(2)}, y^{(2)}, 0, 0, 0)$
G_{21}	ES3 → ESM	$G_{21}(x^{(2)}, y^{(2)}, x^{(1)}, y^{(1)}, z^{(1)}) = (0, 0, 0, 0, 0, x^{(2)}, y^{(2)}, x^{(1)}, y^{(1)}, z^{(1)})$

5 TRANSITION FROM THE SPACE-TIME TO STRUCTURAL ELEMENTS OF MATERIAL FORMS (TO THE MATTER)

5.1. General formulation of the problem and the principal ideas

Nowadays we know a lot of structural forms in which matter reveals: the entire Universe, star-clusters, stars, planets, molecules, atoms, crystalls, elementary particles including photons, all of them are the known structural elements of matter. To clear up the nature of these structural forms and interactions between them just a unified theory of field is required. In numerous theories of the field which are being developed now a great number of still not observed structural elements of matter are postulated: quarks, partons, gluons, creons, supersymmetrical doubles of elementary particles and many others.

In TFF such a volitional postulation of still unknown elements of matter is forbidden: they have to appear as a result of mapping abstract internal mathematical objects onto the concrete geometrical constructions which are liable if not to immediate observation then at least to description in interaction with each other. PVDS and the results of section 4 give enough reasons for transition to the structural elements of matter.

During centuries in the existing system of knowledge we mainly just guessed the essence of the structures created by Nature or simply took them from the experience. The theory developed here allows to do it on the basis of rather peculiar but subsequent and understandable mathematical approaches and to obtain everything "step-by-step" in the forms of unambiguous solutions found by nature for the immense time of its evolutional development. We begin with the description of the mathematical construction of the principal "bricks" of matter. Part of this description rests upon the problems already discussed in the previous sections, part of it is an abstract of things which would be proved below but it is necessary for understanding the material discussed. So, we describe the principal mathematical constructions which Nature has used to construct all fundamental forms of matter.

The scheme of these mathematical constructions based on PVDS and laid down into TFF (see Figs 1.1 and 1.2) is the following. The Universe is the three-dimensional sphere S^3. Any point inside this sphere, as it is known, is its center. (Transition from S^3 to the spatial part of the Einstein Universe with pseudo-Riemannian geometry will be given below). The most natural object originated as the mapping of S^3 onto any of these centers turns out to be the torus. Consequently, the first "elementary" structures in such Universe have to be tori. The solution of the corresponding Plateou problem [105] with taking into accout the requirements of the Triunity Law (see subsection 5.4) shows that these tori are of finite dimensions. Consequently, their number in the Universe with finite dimensions and their concentration in all finite parts of the Universe are also finite. In TFF these elementary essences of matter are called "fundamentons". The whole world of matter and all its structural manifestations are the mappings of different states of the fundamenton. Consequently, the most elementary essence of matter is the only particle, i.e. the fundamenton.

The calculation shows that under mapping the fundamenton properties from the fiber S^3 onto the base (which is the "laboratory" subspace) the fundamenton should be considered as the "Plank particle" [14]. The enclosing space in the given fiber bundle (see DR 19) is complex. In the real subspace (the tardion base) only those properties of the fibers are observed (by means of the proper mappings) which are possible to be observed in this base. Besides, in the base the result of the process occurring in the fibers but not the course of the process itself can be observed.

With respect to the real part of the base, the space S^3 and its mappings in the form of tori are placed in an imaginary domain. Because of it in the real part of the laboratory subspace the fundamenton is not directly observed. In the long run the elementary particles are the mappings of the fundamenton properties onto the real part of the base. Two stable states of the fundamenton have corresponding mappings in the laboratory subspace in the form of elementary particles whose parameters coincide with those of the proton and electron and because of it these states are identified with the proton and electron. The metastable states of the fundamenton have corresponding instable (shortliving) elementary particles, certainly including resonances (see DR 25).

The fiber in which toroidal objects as the mappings of the entire S^3 onto the centers of the Universe are directly observed has no time course, the time is "frozen". Time reveals only in the "dynamic" fibers of our enclosing space which form the geometrical constructions with the pseudo-Riemannian geometry. In this case S^3 turns into the Einstein Universe and the immovable tori turn into a pair of point charges of the fundamental field moving along the geodetics of the pseudo-Riemannian geometry on the torus surface.

In TFF the mappings of the processes, occurring upon the torus surface, onto other fibers of the fiber bundle lead to the whole manifold of geometrical structures of FF charges. Moreover, in TFF it turned out to be possible to understand why the principal unified fundamental field has the nature of the two-charges field. Really, the force lines of the field go "from the charge" to the center (each point of the space can be a center), where they begin to return and go back "to the charge". The change of the charge sign follows from the following trivial property of integrals:

$$\int_0^R \rho \, dv = - \int_R^0 \rho \, dv \,. \tag{5.1}$$

The symmetry of these two types of interaction when the force lines are closed within the bounds of the Universe is so great that positive and negative charges of the fundamenton, speaking strictly, are equal to each other and the total charge is equal to zero. Therefore, strong and superstrong interactions between the structural forms nearest to the fundamenton have a dipole or multipole character under quasiclassical description. The electric field connected with the finite charge originates as a result of the break of this charge symmetry of FF in the space.

In TFF further examination of structural elements shows that the simplest "bare" elementary particles originate only from the stable particles of FF. It is from these simplest BEPs and anti-BEPs that principal particles of matter, called elementary particles of the physical vacuum (EPVs), are formed. They consist of BEPs and are superpartners of the elementary particles. Their spin is 1 or 0.

Yet, PV and its EPVs make a fiber which is not observed and consequently, EPVs can be observed only in the excited state in the form of photons of ordinary light. EPV is the union of BEP and anti-BEP. When there is a surplus of BEPs, which do form the observed EPs and the structures of matter made of them, BEPs cannot remain in the original form. They are sure to unite with EPVs forming quark structures, the latter are just elementary particles (in detail see section 5.7).

Within the bounds of this qualitative description the gravitational interaction has also a clear origin. As it was shown in the papers [48—52], in TFF gravitation is the result of screening the force lines of FF by the elements of the EPs structure. Only the force lines "to EP" go through EP, the lines "from EP" do not influence it. If in the structure of EP all elements had been transparent for the lines "to EP" then gravity forces would not have originated. Yet, the screen exists and there are forces.

5.2. The first step. Realization of the idea of interpretation of the Null space. Deduction of the equation for the scalar component of the fundamental field

In this section we consider that in TFF the Null subspace is homeomorphic to the three-dimensional sphere, i.e. to a set of points

$$S^3 = \{(x_1, x_2, x_3, x_4) \subset R^4 \mid x_1^2 + x_2^2 + x_3^2 + x_4^2 = 1\}. \quad (5.2)$$

Further on we examine how in the Null subspace the cell and group structures are given and how the time coordinate is introduced. In the Null subspace it is necessary to give a certain map

$$\xi_x : R^3 \to S^3 , \quad (5.3)$$

the closing of the image of which would coincide with the whole sphere S^3.

The following mapping may be taken as such a map:

$$\xi_x : R^3 \to S^3 \; ; \; \xi_x : r = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} \to \begin{pmatrix} \frac{4x_1}{4+r^2} \\ \frac{4x_2}{4+r^2} \\ \frac{4x_3}{4+r^2} \\ \frac{4-r^2}{4+r^2} \end{pmatrix} \in R^4 \, . \tag{5.4}$$

It is easy to see that the mapping (5.4) really works in S^3 because the sum of matrix elements squares in (5.4) identically equals a unit. It is not difficult to be convinced that (5.4) is one-to-one mapping onto the whole sphere S^3 without the point (0, 0, 0, — 1), i.e. it is a map whose closing coincides with the entire sphere S^3.

We now examine in detail the topological structure of the Null subspace in TFF. It follows from the definition that S^3 is the closed topological manifold (i.e. it is compact and has no edge). Besides, it is evident that any point of S^3 is its center. Now we show that in the Null subspace it is possible to introduce a structure of the finite cellular space. For this we give the definition of a finite cellular space: the finite cellular space X is called the Hausdorff topological space provided with the finite cellular partition cW which means the following representation of the space X in the form of the unification of the finite number of the disjoint subsets:

$$X = \bigcup_{i=1}^{N} x_i \, , \tag{5.5}$$

on the elements of which the integer non-negative function is defined:

$$d\,(x_i) \in \mathbf{Z} \; ; \; d\,(x_i) \geq 0 \, , \tag{5.6}$$

where $d\,(x_1)$ is the dimension of the cell x_1. In this case the continuous mappings have to exist:

$$f_i : D^{d(x_1)} \to x_i \tag{5.7}$$

(D^d is the ball of the d dimension) under which

$$f_i : \text{Int } D^{d(x_1)} \to x_i \text{ is the homeomorphism;} \tag{5.8}$$

$$f_i\,(\partial D^{d(x_1)}) = \{\text{unification of cells of smaller dimension}\}. \tag{5.9}$$

We construct a cellular partition of the space S^3. For this we introduce the mapping:

$$h : D^3 \to R^3 \; ; \; h\,(\bar{r}) = \frac{\bar{r}}{\sqrt{1-\bar{r}^2}} \, . \tag{5.10}$$

It is not difficult to see that it is one-to-one mapping of the interior of the ball D^3 onto the whole R^3

Now we introduce the following notations:

$$x_1 = S^3 \setminus \{0, 0, 0, -1\} ; \; f_1 = \xi \circ h , \tag{5.11}$$

where ξ is determined by the formula (5.4);

$$d(x_1) = 3 ; \tag{5.12}$$

$$x_2 = (0, 0, 0, -1) ; \; d(x_2) = 0 ; \tag{5.13}$$

$$f_2(\bullet) = (0, 0, 0, -1) . \tag{5.14}$$

It is not difficult to see that the partition

$$S^3 = x_1 \cup x_2 \tag{5.15}$$

together with the formulae (5.11)—(5.14) give the finite cellular partition of the Null space. Indeed, the function d takes the integer non-negative values $f_1 \; (dD^3) = x_2$. The remaining part of the requirements in the definition of the cellular partition is satisfied by its construction.

Thus, we obtained the representation of the Null space in the form of the unification of two cells with different dimension. This cellular partition can be the basis for other cellular partitions containing a great number of cells.

Further on we show that in the Null space it is possible to introduce a group structure. The following facts are necessary for it. We show that the group manifold of the group $SU(2)$ is homeomorphic to the three-dimensional sphere S^3, i.e. to the Null subspace in TFF.

Really, according to the definition, $SU(2)$ is the set of the unitary complex matrices of the dimension 2×2, the determinant of which is equal to 1, i.e.

$$SU(2) = \{A = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \in \mathbb{C}^2 \times \mathbb{C}^2 \mid A^* = A^{-1}, \det A = 1\} , \tag{5.16}$$

here

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}^* = \begin{pmatrix} \bar{a} & \bar{c} \\ \bar{b} & \bar{d} \end{pmatrix} \tag{5.17}$$

means complex conjugation. For any complex matrix $A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$, for which $\det A = 1$, the inverse matrix has the form

$$A^{-1} = \begin{pmatrix} d & -b \\ -c & a \end{pmatrix} . \tag{5.18}$$

It can be easily seen.

On the other hand, for the unitary matrices with the determinant equal to a unit we have

$$A^{-1} = A^{*} = \begin{pmatrix} \overline{a}\,\overline{c} \\ \overline{b}\,\overline{d} \end{pmatrix} = \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}, \tag{5.19}$$

from which we get:

$$\overline{a} = d,\ \overline{b} = -c\,, \tag{5.20}$$

i.e. any matrix from (5.16) has the form:

$$A = \begin{pmatrix} a & b \\ -\overline{b} & \overline{a} \end{pmatrix}. \tag{5.21}$$

In this case $\det A = |a|^2 + |b|^2 = 1$. Now we determine the mapping $\gamma : S^3 \to SU(2)$ in the following way. Let it be $(x_1, x_2, x_3, x_4) \in S^3$ (i.e. $x_1^2 + x_2^2 + x_3^2 + + x_4^2 = 1$). Suppose

$$\gamma\,(x_1, x_2, x_3, x_4) = \begin{pmatrix} x_1 + ix_2 & x_3 + ix_4 \\ -x_3 + ix_4 & x_1 - ix_2 \end{pmatrix} \in SU(2)\,. \tag{5.22}$$

It can be seen from direct calculations that the obtained matrix is unimodular (i.e. it belongs to $SU(2)$). Besides, it follows from (5.21) that the mapping $\delta : SU(2) \to S^3$, determined in the following way:

$$\begin{pmatrix} a & b \\ -\overline{b} & \overline{a} \end{pmatrix} \xrightarrow{\delta} (\mathrm{Re}\, a, \mathrm{Im}\, a, \mathrm{Re}\, b, \mathrm{Im}\, b) \in S^3\,, \tag{5.23}$$

is inverse to γ, i.e.

$$\delta \circ \gamma = Id\,;\ \gamma \circ \delta = Id\,. \tag{5.24}$$

So, we have shown that γ is a homeomorphism. Using this homeomorphism in the Null space S^3 the group structure can be introduced by supposing

$$a \times b = \gamma^{-1}\,(\gamma\,(a) * \gamma\,(b))\,, \tag{5.25}$$

where $*$ is the usual product in $SU(2)$. On S^3 the obtained group is naturally isomorphic to $SU(2)$.

All the discussed above was related to the pure spatial part of the Null subspace. To examine the space itself as well as the time in the Null subspace we embed it into a certain manifold of the dimension 4:

$$\beta : S^3 \to X\,, \tag{5.26}$$

and according to the definition, we consider that in X the metrics is given with the signature (++++) which on S^3 coincides with the natural metrics and is the Null space-time. Thus, in S^3 the coordinates x_1, x_2, x_3 are the spatial ones and x_0 is the time one. The element of an interval in the obtained space-time is calculated by the formula:

$$ds^2 = dx_0^2 + dx_1^2 + dx_2^2 + dx_3^2 . \tag{5.27}$$

We now examine in detail the question of the real but not formal mathematical time course in such space. In the theories SR and GR the notion of the light signals and the postulate on the light velocity constancy are used to determine the time interval between the events. As it is known, light is spreading in space-time along the isotropic geodetic trajectories for which

$$ds^2 = 0 . \tag{5.28}$$

In the case of the planar Minkowski world with the signature (—+++) the condition (5.28) determines the "light cone" for any point of the space-time, i.e. a certain subset of the Minkowski space on which the world lines of the light signals are placed. In the case with the metrics (5.27) the condition (5.28) always gives the only point (i.e. the light cones degenerate into the point). This may be interpreted so that the light signal does not spread at all in space with the metrics (5.27). (As we see further, under the consideration of complexification of the Null space-time, it spreads in the complementary subspace). Because of it we cannot determine (informally) the time intervals between the events in the Null space-time, i.e. the time is "frozen" in it.

The problem that faces us now is to pass from the general understanding of the nature of the Null subspace, its space-time structure, to the principal bricks of the world of matter, i.e. to the structural elements of matter.

In 0SS, as it was noted above, there is a structure of the cellular space. Since 0SS is S^3 then it is evident that the center of each cell is simultaneously the center of the entire Universe because in S^3 each point may be its center. Then it is evident that these centers of cells are the very signed points for 0SS as well as for the cell. 0SS as well as its cells are the Hausdorff spaces (see DR 1 and DR 2). Therefore, the signed points should have the neighbourhoods. Thus, we conclude that cells are signed points with the neighbourhoods. This is according to geometry. But since the entire closed Universe is mapped in each cell it is natural to consider these cells to be micro-universes described by the same equations of relation between space-time-matter. Naturally, the scale relations of units, determining the time, the space, the matter in the Universe and micro-universe should be evidently different.

In this case the use of the equation of the Triunity Law (equation 5.53) for the Universe and micro-universe means the scale invariancy of the laws controlling the matter. Thus, for different subspaces the Triunity Law, which is further on considered in detail, means the scale invariancy for the units determining space-time-matter. This very invariancy was discovered by Einstein by means of his equation, yet, he had no time to clear up its geometrical and physical nature.

Since the cells in OSS are micro-universes and at the same time the signed points with the neighbourhoods,then boundaries of these neighbourhoods are the very Schwarzschild spheres and the cells are black microholes.

Denoting the radius from the signed point to the Schwarzschild sphere in this black microhole by R, and carrying out further calculation in the spheric coordinates, in which the radius-vector $\vec{r}$ originates in the signed point-center of the Schwarzschild sphere, we have to conclude that the coordinates outside the sphere, i.e. under $r > R$ and inside it have to be different. The difference which would simultaneously satisfy the equation of TL, the principles of PVDS and the geometry of fiber bundles in TFF may be only the following: if the space outside the sphere is real then inside it the space is imaginary and vice versa. It is important to find the relation between these coordinates. This relation is sure to exist, since both coordinates describe the same object but in different subspaces. As far back as in the paper [84] it was noted that the coordinates inside the sphere and outside it had to satisfy the condition of the *mirror reflection* from the sphere, yet, it was not mentioned there, that these coordinates belong to different subspaces. That is why the relation between them may be not simply algebraic but should be given through mappings.

So, if we consider that the radius-vector $\vec{r}$ outside the sphere is a real value, then such relation between the corresponding imaginary coordinate ir inside the sphere and its analytical continuation has to be given by the mapping:

$$f : ir \to \frac{R^2}{r} . \tag{5.29}$$

The obtained result allows to determine the scalar component of the fundamental field. Really, a rather general equation for the scalar field potential is the Klein—Gordon—Fock equation

$$\Delta \varphi (r) (\overline{+}) R^{-2} \varphi (r) = 0 . \tag{5.30}$$

Here $R = \hbar / mc$. The solution of this equation is the Yukawa potential

$$\varphi = q \frac{e^{-r/R}}{r} , \tag{5.31}$$

if there is a negative sign before the second term in (5.30), and is the potential

$$\varphi = q \frac{e^{-ir/R}}{r} , \tag{5.32}$$

if there is a positive sign before the second term in (5.30).

It is easy to see that the last equation has no apparent physical sense since there are real and imaginary coordinates in it. Yet, if we interpret it as a potential in mixed coordinates and reduce it to the description in one space only using the relation (5.29) then we obtain the potential

$$\varphi = q\frac{e^{-R/r}}{r}. \qquad (5.33)$$

It is easy to see that this potential is not the solution of (5.30). Yet, it is the solution of a more general equation

$$\Delta\varphi(r)\,(\overset{+}{-})\,R^{-2}\varphi(r) = F(r), \qquad (5.34)$$

where $F(r) = q\frac{e^{-R/r}}{r^3}\left(\frac{R^2}{r^2} - 2\frac{R}{r} + \frac{r^2}{R^2}\right)$. This is the very equation for the scalar component of FF, and the potential (5.33) is the potential of the scalar component of FF (Fig 5.1).

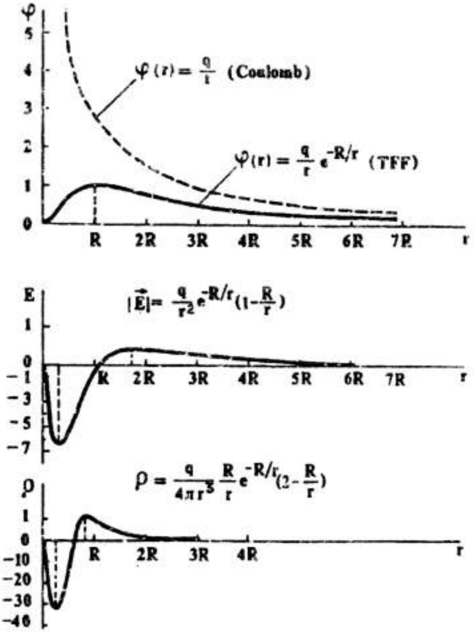


Fig. 5.1 Changes of potential, intensity and charge density of fundamental field scalar component along radius-vector

The potential of the scalar component of FF has no divergences in any point. The same goes with the intensity of the field and the density of the charge in any point of the field if they are determined respectively:

$$\vec{E} = -\operatorname{grad}\varphi = q\,\frac{e^{-R/r}}{r^2}\left(1-\frac{R}{r}\right)\frac{\vec{r}}{r}, \tag{5.35}$$

$$\rho = \frac{1}{4\pi}\operatorname{div}\vec{E} = \frac{q}{4\pi}\,\frac{R\,e^{-R/r}}{r^4}\left(2-\frac{R}{r}\right). \tag{5.36}$$

Fig 5.1 shows these relations in the form of a diagram. It is of a special interest that

$$Q = 4\pi\int_0^\infty \rho\,d\upsilon = q\,e^{-R/r}\left(1-\frac{R}{r}\right) = q\,, \tag{5.37}$$

where υ is the volume. This means that the constant q with the dimension of the charge is numerically equal to the integral of the total density of the charge over the whole infinite Euclidian space. The physical sense of this result is not changed in spite of the fact that the Universe is S^3 and not the Euclidian space, because, firstly, S^3 is embedded into the enclosing space $\mathbb{R}^{3,1}$ the spatial part of which is Euclidian, secondly, the similar result can be obtained in non-Euclidian space as well.

Since the potential of FF leads to the calculated charge which is not only finite but also numerically equal to the constant in the formula for the potential, we have to state a deep internal self-consistency of this potential, which no potential known in modern physics had ever before. Besides, from (5.37) it follows directly that the charge related to the center of the black microhole structure, i.e. to the signed point, is the mapping of the charge of the whole Universe onto it.

5.3. The second step. Complexification as a transition from the processes occurring in the fiber and the base to the processes observable in the enclosing space

In TFF for a complete description of particles the concept of the fiber bundle is used:

$$p : B \times U_\zeta \to B\,, \tag{5.38}$$

where B is the base of the fiber bundle; U_ζ is the fiber (or its group) corresponding to the subspace with index ζ, which under such consideration turns out to be complementaty to the space B. The fiber placed over the point $b \in B$ is attached to the base in the only point. Consequently, the whole structure existing in the base cannot be directly observed in the fiber and vice versa.

We show that the similar description of the complementary subspaces may be obtained under the consideration of the broadened (complexificated) base space $\tilde{B}$ and the disposition of the subspace U_ζ in the imaginary domain of the space $\tilde{B}$. Different methods may be used allowing to map the structures given in the fiber onto the base and vice versa. We consider the Null subspace of FF discussed in the subsection 5.2 as the base B.

We now consider a pure spatial case. Naturally, in this case the space B is embedded into the broadened (complexificated) base space $\tilde{B}$. In local polar coordinates this embedding can be given in the following way:

$$B \ni \begin{pmatrix} r \\ \theta \\ \varphi \end{pmatrix} \xrightarrow{\xi_0} \begin{pmatrix} r + i\,0 \\ \theta + i\,0 \\ \varphi + i\,0 \end{pmatrix} \in \tilde{B}\,. \tag{5.39}$$

Spaces U_ζ complementary to B can be considered as embedded into the imaginary domain $\tilde{B}$. This embedding is supposed to be given in the following form:

$$U_\zeta \ni \begin{pmatrix} r_\zeta \\ \theta_\zeta \\ \varphi_\zeta \end{pmatrix} \xrightarrow{\xi_0} \begin{pmatrix} 0 + i\,r_\zeta \\ 0 + i\,\theta_\zeta \\ 0 + i\,\varphi_\zeta \end{pmatrix} \in \tilde{B}\,. \tag{5.40}$$

We show that in the broadened space $\tilde{B}$ spaces B and U_ζ embedded in it are complementary to each other. namely, they cross strictly in one point. Indeed, if we suppose that

$$\begin{pmatrix} r_x \\ \theta_x \\ \varphi_x \end{pmatrix} \in B \cap U_\zeta\,,$$

then considering (5.39) we have:

$$\mathrm{Im}\,(r_x) = \mathrm{Im}\,(\theta_x) = \mathrm{Im}\,(\varphi_x) = 0\,, \tag{5.41}$$

where Im is the imaginary part of the complex number, and considering (5.40) we have:

$$\mathrm{Re}\,(r_x) = \mathrm{Re}\,(\theta_x) = \mathrm{Re}\,(\varphi_x) = 0\,, \tag{5.42}$$

where Re is the real part of the complex number. But the only point in B which can satisfy the conditions (5.41) and (5.42) is (0, 0, 0). Thus, we have shown that the description of the complementary subspaces by means of the broadened (complexificated) space satisfied the requirements of the fiber bundles.

Now we consider how the potential of FF originated in 0SS and its cells would be mapped onto other subspaces. For this aim we use the formalism given in section 5.2. We clear up what the potential of FF turns into, if it is given in $\tilde{B}$. With this aim we extend the definition of the potential of FF over the entire space $\widetilde{B}$ by means of the embedding (5.39) and the analytical continuation. In local coordinates we have:

$$\widetilde{\varphi} : \mathbb{C}^3 \to \mathbb{C} ; \; \widetilde{\varphi}(r) = \frac{q e^{-R/r}}{r} . \tag{5.43}$$

We see that $\widetilde{\varphi}$ is given on $\widetilde{B}$ by the same formula as on B:

$$\xi_\zeta : U_\zeta \to \widetilde{B} . \tag{5.44}$$

By taking the superposition $\widetilde{\varphi} \circ \xi_\zeta$ we have:

$$\widetilde{\varphi} \circ \xi_\zeta : U_\zeta \to \mathbb{C} . \tag{5.45}$$

To give a certain potential on the subspace U_ζ it is necessary to give the function $\tau : \mathbb{C} \to R$. This superposition $\tau \circ \varphi \circ \xi_\zeta$ does give the potential on the subspace U_ζ:

$$\varphi_\zeta = \tau \circ \widetilde{\varphi} \circ \xi_\zeta : U_\zeta \to \mathbb{R}. \tag{5.46}$$

We consider this potential as the mapping of the potential from the space B onto the space U_ζ in the fiber bundle of FF. As a function $\tau : \mathbb{C} \to R$ we take the function

$$\tau(c) = |c| \in \mathbb{R}. \tag{5.47}$$

This function (the modulus of the complex number) is suitable by the fact that it takes the zero value only in the zero point.

We rewrite the formula (5.46) in detail and clear up into what the potential of FF turns under such mapping. We have:

$$\begin{aligned} \varphi_\zeta(r, \theta, \varphi) &= \tau(\widetilde{\varphi}(\xi_\zeta(r, \theta, \varphi))) = \tau(\widetilde{\varphi}(ir, i\theta, i\varphi)) = \\ &= \left| q \frac{e^{-R/ir}}{ir} \right| = \left| \frac{1}{i} \right| \cdot \left| \frac{q e^{iR/r}}{r} \right| = \frac{q}{r} \end{aligned} \tag{5.48}$$

(since $\left| e^{-iR/r} \right| = 1$ for all $R, r \in \mathbb{R}$), i.e.

$$\varphi_\zeta(r, \theta, \varphi) = q/r . \tag{5.49}$$

Thus, we see that the potential of FF, given in the Null subspace, turns into the Coulomb potential under the mapping onto the complementaty subspace. Besides, it means that under such mapping the nonlinear part of the scalar potential of FF is lost.

We consider the question how the information from the base can be transferred into the fiber and vice versa. We begin with the mapping of the metrics from the Null space-time onto the complementary spaces. In this case the four-dimensional Null space-time (5.27) is considered as

B. The four-dimensional complex space is considered as $\bar{B}$. B is embedded in the real part of $\bar{B}$. In local coordinates this embedding can be represented in the following way:

$$\begin{pmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{pmatrix} \to \begin{pmatrix} x_0 + 0i \\ x_1 + 0i \\ x_2 + 0i \\ x_3 + 0i \end{pmatrix} . \qquad (5.50)$$

The formula for the metrics (5.27) is spread over $\bar{B}$ by means of the analytical continuation. The type of the formula (5.27) is not changed in this case. The space-time B is embedded into $\bar{B}$ so that the spatial parts of B and U_ζ are complementary to each other:

$$U_\zeta \ni \begin{pmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{pmatrix} \xrightarrow{\eta} \begin{pmatrix} x_0 \\ i\,x_1 \\ i\,x_2 \\ i\,x_3 \end{pmatrix} \in \bar{B} .$$

Consider the superposition $ds \circ \eta$ for the space U_ζ. We have:

$$ds^2 = d\,(\eta\,(x_0))^2 + d\,(\eta\,(x_1))^2 + \dots + d\,(\eta\,(x_3))^2 = dx_0^2 - dx_1^2 - dx_2^2 - dx_3^2 . \qquad (5.51)$$

Thus, we see that, firstly, ds^2 is real, secondly, the invariable-sign metrics turns into an ordinary type of metrics of the Minkowski space. Ordinary light cones appear and we can determine the flowing time, it "revives" in the complementary subspace. The above-mentioned procedure is inverse: in the same way (by means of the complexification and the embeddings) it is possible to pass from metrics (5.51) to metrics (5.27). In particular, in this way (as the motion in the complementary subspace) it is possible to interpret in TFF the instanton-like solutions of the field equations obtained in [106] for the metrics (5.27).

So, we can see in what way the charges of FF distributed in space and frozen over time are "pressed" into the points at the boundary of the neighbourhood. The time "revives". The charges begin to move. The scalar potential of FF turns into the Coulomb potential.

Besides, what is also of importance, we showed that the fiber could (and should) be considered as the space situated in the imaginary domain of the complexificated base.

5.4.
The third step. Unification of both the space-time and matter properties in the Triunity Law

The fundamentals of the mathematical formulation of TL were discovered by Einstein and were laid down into the basis of GR. When formulating GR Einstein wrote down the principal equation of the theory so:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} (R - 2\Lambda) = \frac{8\pi G}{c^4} T_{\mu\nu}, \tag{5.52}$$

interpreting it as the equation of the gravitation field. Further on [12] GR was interpreted as the gravity theory and the term "GR" was considered old-fashioned, though there were some bright exceptions to this rule [41, 42, 110, 123]. In recent years especially in works of A. A. Logunov's group [62—65] the question is being seriously discussed whether the equation (5.52) as such is the equation of the field. Thus, for 70 years that passed after GR formulation its fundamentals are still being discussed.

All it means that the equation (5.52) *is neither* the equation of the gravity field, *nor* the equation of the physical field at all. Therefore, in TFF it is considered that the following interpretation of the law discovered by Einstein corresponds to the totality of all known theoretical and experimental data. This is the space-time-matter Triunity Law. And that is all. This law is valid for all types of physical fields including naturally the gravitational field as well, but this law is not the equation of the field. A. A. Logunov and his collegues [62—65] affirming the fact that the "field theory of gravity" is required and that (5.52) is not the field equation, are undoubtedly right from the point of view of the theory discussed here. What this field should be like is a special problem but (5.52) is not the equation of the gravitational field.

In TFF the law found by Einstein is generalized and for the principal objects of TFF it is written in the form:

$$R^{(\zeta)}_{\mu\nu} - \frac{1}{2} g^{(\zeta)}_{\mu\nu} (R_\zeta - 2\Lambda_\zeta) = \frac{8\pi\gamma_\zeta}{c^4} T^{(\zeta)}_{\mu\nu}, \tag{5.53}$$

where $\zeta = 0, 1, 2, 3, V$ is the index of the subspace (fiber and base, it is discussed in detail in [14]). In the non-fibrated space the solutions of (5.53) coincide with the known from GR solutions of (5.52).

Under the consideration of the solutions of (5.53) in all subspaces sufficient for the EPs description, the situation substantially changes. We consider it by such an example. As it is known, in GR there is some difference between the coordinates used under the solution of (5.52) and the real coordinates of the physical object to which these solutions refer *).

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*) L. Brillouin [123] indignant at the ambiguity of the values obtained in GR called it "science fiction". As it is shown here, there are no fantastic things, simply in GR there was an incompleteness of physical objects description.

So, for example, in the Fridman space for a maximal "physical" coordinate we have [107, p. 52]:

$$r_p = \int_0^{\pi} r_0 \, dr = \int_0^{\infty} r_0 \frac{d\tilde{r}}{1+\frac{\tilde{r}^2}{2}} = \pi r_0 \,, \tag{5.54}$$

where r_0 is the curvature radius of the closed "universe"; r_p is the radial coordinate in the sphe rical coordinate frame.

At the same time the volume of this closed universe is determined not by r_p but by r_0:

$$V_U = 4\pi r_0^3 \int_0^{\infty} \frac{\tilde{r}^2 \, d\tilde{r}}{\left(1+\frac{\tilde{r}^2}{4}\right)^3} = 2\pi^2 r_0^3 \,. \tag{5.55}$$

If we take other examples then we can obtain quite different relations between the radial coordinates and "physical" ones.

All the above-mentioned concerns the solution of (5.52) in GR. Under the solution of (5.53) in TFF there is no such problem. Different coordinates are obtained due to one reason only: in GR the object is unlawfully considered in one non-fibrated space, it is the origin of all difficulties. The physical coordinate in (5.54) is the coordinate in the space where the distances are determined along the circumference and the volume of the closed universe is determined by the geometry of subspace, where the curvature radius r_0 is determined. If $\Lambda \neq 0$ then in OSS for the closed macro- or micro-universe with the radius r_U by taking into account (5.53) we obtain:

$$r_U = \Lambda^{-1/2} \;{}^{*)} \tag{5.56}$$

and

$$\Lambda = \frac{4\pi\gamma\rho}{c^2}, \tag{5.57}$$

where ρ is the density of the mass. For the mass of the entire Universe we have:

$$m = \frac{\sqrt{\pi}\, c^3}{4\sqrt{\gamma^3 \rho}}. \tag{5.58}$$

If γ is measured in the units q^2 / m^2, q — in the units $\sqrt{\hbar c}$, r — in the units $\hbar / mc$, then:

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*) We have omitted index ξ.

$$\gamma = A_\gamma \frac{q^2}{m^2}\,;\; q^2 = A_q \hbar c\,;\; r = A_r \frac{\hbar}{mc}\,, \tag{5.59}$$

where A_γ, A_q, A_r are the dimensionless coefficients. And for ρ we have:

$$\rho = \frac{m}{4\pi r_U^3} \cdot \frac{A_r}{A_q A_\gamma}\,. \tag{5.60}$$

Besides, for the average value of density the equality

$$\rho = \frac{m}{2\pi^2 r_U^3} \tag{5.61}$$

is valid. And then for dimensionless coefficients we find the first equation:

$$\frac{A_r}{A_q A_\gamma} = \frac{2}{\pi}\,. \tag{5.62}$$

It is of interest to note that in the case of the Euclidian space we have the equality

$$\frac{A_r}{A_q A_\gamma} = 3\,.$$

The solutions of (5.53) for different subspaces show that they differ by numerical values of A_γ, A_q and A_r for the elementary structures corresponding to these subspaces. So, for 3SS $A_\gamma = A_q = A_r = 1$. Therefore, for the fundamenton:

$$\gamma_f = \frac{q_f^2}{m_f^2}\,;\; q_f^2 = \hbar c\,;\; r_f = \frac{\hbar}{m_f c}\,. \tag{5.63}$$

We have considered the solution of TL equation when the cosmological term Λ was not equal to zero. If we consider the equation under $\Lambda = 0$ then the solutions will be of different form. Though GR exists over 70 years the physical significance of this term remains unclear and therefore, in most solutions it is taken equal to zero. To clear up the physical significance and the value of Λ-term in TL we consider the two important solutions of (5.53) under Λ-term equal to zero.

For the following below it is important to consider the solution of TL equation for a family of black holes. In the simplest case it is a self-consistent problem for two masses which have charges as well. This problem was substantially considered by S. Chandrasekhar [46] and further on we shall use his results.

As in GR the space-time is considered as the four-dimensional differentiable manifold provided with metrics of the Lorentz signature which is equal to $\pm\,(n-2)$, where n is the space dimension, the sign is chosen by consent. In our case $n = 4$, the sign is "+" and the metrics in the case of the motion of two masses m_1 and m_2 in self-consistent gravitational field of these masses has the following form [46]:

$$ds^2 = (c\,dt)^2/u^2 - u^2\,[(dr_1)^2 + r_1^2(d\theta_1)^2 + (r_1^2\sin^2\theta_1)\,(d\varphi)^2]\,, \qquad (5.64)$$

where m_1, m_2 are the point masses; a is the distance between them; r, φ, θ_1 are the spheric coordinates.

The signature is equal to -2 $(+\,-\,-\,-)$,

$$u = 1 + \frac{m_1}{r_1}\frac{G}{c^2} + \frac{m_2}{(r_1^2 + a^2 - 2ar_1\sin\theta_1)^{1/2}}\frac{G}{c^2}\,. \qquad (5.65)$$

We denote the space-time by E. Then we introduce the fibration. E with the given metrics can be represented as a direct sum of the two disjoint subspaces E_+ and E_- with dimensions 1 and 3, respectively:

$$\begin{cases} E = E_+ \oplus E_-\,, \\ \dim E_+ = 1\,, \\ \dim E_- = 3\,. \end{cases} \qquad (5.66)$$

We find a common point of the two subspaces E_+ and E_-. The subspace E_+ has one coordinate t in the space E and is given by the system of equations

$$\begin{cases} r_1 = 0\,, \\ \theta_1 = 0\,, \\ \varphi = 0\,. \end{cases} \qquad \text{a)}$$

This is the subspace of the points of the form $(0, 0, 0, t)$ in the space E. The subspace E_- has three coordinates: r, φ, θ_1 and is given by the equation

$$t = 0\,. \qquad \text{b)}$$

This is the subspace of the points of the form $(r, \varphi, \theta, 0)$ in the four-dimensional space E. A common point of the subspaces E_+ and E_- has to satisfy simultaneously the conditions (a) and (b). Consequently, this point has coordinates $(0, 0, 0, 0)$, i.e. a common point of the subspaces E_+ and E_- is the zero point $(0, 0, 0, 0)$.

On these subspaces the metrics are introduced in a natural way:

E_+ is the subspace with positively determined metrics:

$$ds_+^2 = (c\,dt)^2 / u^2 ; \tag{5.67}$$

E_- is the subspace with negatively determined metrics:

$$ds_-^2 = -u^2 \left[(dr_1)^2 + r_1^2 (d\theta_1)^2 + (r_1^2 \sin^2\theta_1)(d\varphi)^2\right]. \tag{5.68}$$

Then the metrics (5.64) of the space E is the sum of metrics (5.67) and (5.68):

$$ds^2 = ds_+^2 + ds_-^2 . \tag{5.69}$$

These subspaces E_+ and E_- can be interpreted in different ways. For example, they can be interpreted as numeral subspaces without metrics, just as the space of complex numbers can be considered as the two-dimensional numeral real-valued space. Yet, for the solution of our problem they should be considered as real and imaginary subspaces of the space E : the coordinates of the former (better to say a coordinate) are the real numbers, the coordinates of the latter are purely imaginary. We now clear up what these spaces are like. The structures of these spaces are different but the points inside any of them have the same structure. We consider the limit cases: $u = \infty$ and $u = 0$.

1) $u = \infty$, then

$(c\,dt)^2 / u^2 = 0$ and

$$ds^2 = -u^2 \left[(dr_1)^2 + r_1 (d\theta_1)^2 + (r_1^2 \sin^2\theta_1)(d\varphi)^2\right] = ds_-^2 .$$

We solve the equation (5.65) for $u = \infty$:

$$u = 1 + \frac{m_1}{r_1}\frac{G}{c^2} + \frac{m_2}{(r_1^2 + a^2 - 2ar_1 \sin\theta_1)^{1/2}}\frac{G}{c^2} .$$

After some easy calculations we obtain the equation:

$$\infty = 1 + \frac{m_1}{r_1}\frac{G}{c^2} + \frac{m_2}{|r_1 - a|}\frac{G}{c^2} ,$$

which has two roots: $r_1 = 0$ and $r_1 = a$.

We substitute these values into the original equation and obtain:

$$\infty = 1 + \frac{m_1}{r_1}\frac{G}{c^2} + \frac{m_2}{(r_1^2 + a^2 - 2ar_1 \sin\theta_1)^{1/2}}\frac{G}{c^2} .$$

Under $r_1 = 0$

$\infty = 1 + \infty + \infty$, i.e. the equation is valid.

Under $r_1 = a$

$$\infty = 1 + \frac{m_1}{a}\frac{G}{c^2} + \frac{m_2}{(2a^2 - 2a^2\sin\theta_1)^{1/2}}\frac{G}{c^2}.$$

This equality holds only for $\theta_1 = \frac{\pi}{2}$ and shows that the condition corresponds to the motion with $\theta_1 = \frac{\pi}{2}$.

Thus, we have cleared up that E_- is the subspace of the space E, in which $u = \infty$, $r_1 = 0$, $\theta_1 = \frac{\pi}{2}$. As it was proved by S. Chandrasekhar [46], under the events horizon radius $r_1 = 0$ the surface area of the events horizon is equal not to zero but to the finite value of $4\pi m_1^2$. But this value is reached in the imaginary subspace E_- with the negatively determined metrics (5.68).

It is easy to see what it means: in the real subspace $r_1 = 0$ and the surface area of the events horizon is equal to zero as well. But in the imaginary domain $S > 0$, and in this case $r_1 \neq 0$, but this radius is imaginary. Indeed, the area of the sphere is:

$$S = 4\pi r_1^2 \Rightarrow r_1^2 = \frac{S}{4\pi};$$

$$r_1 = \left(\frac{S}{4\pi}\right)^{1/2}; S = 4\pi m_1^2 \Rightarrow r_1 = \left(\frac{4\pi m_1^2}{4\pi}\right)^{1/2} = m_1 \neq 0; ir_1 = im_1.$$

This radius is imaginary, in the real space the zero radius corresponds to it.

2) $u = 0$.

We now solve (5.65) for $u = 0$:

$$0 = 1 + \frac{m_1}{r_1}\frac{G}{c^2} + \frac{m_2}{(r_1^2 + a^2 - 2ar_1\sin\theta_1)^{1/2}}\frac{G}{c^2}. \quad (5.70)$$

For this aim we put the following requirements for the equation:

1) $m_1 < 0$, $m_2 > 0$;

2) $R_1 > R_2$; $\frac{R_1}{R_2} = k_R$, where R_1 and R_2 correspond to r_1 and r_2;

3) $a = R_1 - R_2$;

4) R_1; R_2; m_1; m_2 are situated in the same plane;

5) the angle θ_1 is known;

6) c and G are known;

7) $\frac{|m_2|}{|m_1|} = k_m$;

8) $R_1 = \frac{\hbar}{m_1 c} k_h$.

We find the relation of m_1, m_2, R_1, a from G, c, k_R, k_m, $\hbar$, k_h. From condition 3 we find R_2:

$R_2 = R_1 - a$. From condition 2 we find a by substitution R_2 into the formula

$\frac{R_1}{R_2} = k_R$:

$$\frac{R_1}{R_1 - a} = k_R;$$

$$R_1 = k_R (R_1 - a);$$

$$R_1 - k_R R_1 = -k_R a;$$

$$a = \frac{R_1 (k_R - 1)}{k_R}. \quad (5.71)$$

We express m_1 through R_1:

$$m_1 = \frac{\hbar}{R_1 c} k_h. \quad (5.72)$$

We find m_2:

$$|m_2| = k_m |m_1| = \frac{\hbar}{R_1 c} |k_h| k_m.$$

Since $m_1 < 0$, then $k_h < 0$ and $|k_h| = -k_h$, thus,

$$m_2 = \frac{-\hbar}{R_1 c} k_h k_m > 0. \quad (5.73)$$

The values θ_1, c and G are known. By substituting the values a, m_1, m_2 from the formulae (5.71), (5.72), (5.73) respectively, into the equation (5.70) we find R_1 for the equation (5.70) in the form:

$$R_1 = \left(\frac{\hbar k_h G}{c^3} \left[\frac{k_m}{\left(1 + \left(\frac{k_R - 1}{k_R} \right)^2 - \frac{2 (k_R - 1) \sin\theta_1}{k_R} \right)^{1/2}} - 1 \right] \right)^{1/2} \tag{5.74}$$

We insert the obtained value of R_1 into the formulae (5.71), (5.72), (5.73) and obtain a, m_1, m_2 versus $G, c, k_R, k_m, \hbar, k_h$:

$$a = \frac{k_R - 1}{c k_R} \left(\frac{\hbar k_h G}{c} \left[\frac{k_m}{\left(1 + \left(\frac{k_R - 1}{k_R} \right)^2 - \frac{2 (k_R - 1) \sin\theta_1}{k_R} \right)^{1/2}} - 1 \right] \right)^{1/2} , \tag{5.75}$$

$$m_1 = \frac{\hbar k_h c}{c} \left(\frac{c}{\hbar k_h G} \cdot \frac{[k_R^2 + (k_R - 1)^2 - 2 k_R (k_R - 1) \sin \theta_1]^{1/2}}{k_m k_R - [k_R^2 + (k_R - 1)^2 - 2 k_R (k_R - 1) \sin \theta_1]^{1/2}} \right)^{1/2} =$$

$$= \left(\frac{\hbar k_h c}{G} \cdot \frac{[k_R^2 (2 - 2 \sin \theta_1) - k_R (2 - 2 \sin \theta_1) + 1]^{1/2}}{k_m k_R - [k_R^2 (2 - 2 \sin \theta_1) - k_R (2 - 2 \sin \theta_1) + 1]^{1/2}} \right)^{1/2} , \tag{5.76}$$

$$m_2 = - k_m \left(\frac{\hbar k_h c}{G} \cdot \frac{[k_R^2 (2 - 2 \sin \theta_1) - k_R (2 - 2 \sin \theta_1) + 1]^{1/2}}{k_m k_R - [k_R^2 (2 - 2 \sin \theta_1) - k_R (2 - 2 \sin \theta_1) + 1]^{1/2}} \right)^{1/2} . \tag{5.77}$$

The values R_1, a, m_1, m_2 from the formulae (5.74), (5.75), (5.76), (5.77) are the solutions of the equation (5.70) under the given conditions.

The metrics (5.64) under $u = 0$ has the form:

$$ds^2 = (c\, dt)^2 / u^2 = ds_+^2 .$$

Thus, the subspace E_+ with the metrics ds_+ is the subspace of the space E, where $u = 0$ and R_1 takes the value of (5.74).

The space-time E can be provided with the fibration structure because according to (5.66), it is expanded into the direct sum of the subspaces E_+ and E_-. E_+ can be considered as the base and E_- can be considered as the fiber in the enclosing space E. The equations of the zero sections of the fibration E are the functions of mapping from E onto E_+ and E_-. The section of the fibration E is such mapping: $\psi : E_+ \to E$, which in the point $x \in E_+$ takes the value in the fiber over the point x. We choose the zero section because it is isomorphic to the base. Really, the zero section puts zero in correspondence with each point $b \in E_+$. And the isomorphism between the zero section and the base has the form:

$$E_+ \times \{0\} \leftrightarrow E_+$$
$$(b, 0) \mapsto b$$
$$(b, 0) \leftarrow b\,,\ b \in E_+\,.$$

The equation for the base is obtained in the following way: $\dim E_+ = 1$, consequently to pick out E_+ in the four-dimensional space E it is necessary to give the system of three equations (since $1 = 4 - 3$). As those are the equations of the zero sections, they have a simple form:

$$\begin{cases} r_1 = 0\,, \\ \theta_1 = 0\,, \\ \varphi = 0\,. \end{cases} \tag{5.78}$$

Since $\dim E_- = 3$ it is sufficient to give one equation (because $3 = 4 - 1$) to pick out E_- in the four-dimensional space:

$$t = 0\,, \tag{5.79}$$

which is also the equation of the zero section. It is not the unique mode of the subspace setting, the latter can also be set by fixing basic vectors or a normal vector.

Thus, the unknown functions of mapping are given by the system of equations (5.78) (for mapping from E onto E_+) and by the equation (5.79) (for mapping from E onto E_-).

By considering this concrete example we have shown what great cognition capacity characterizes the approach demanded by PVDS, i.e. the need to use fiber bundles to describe any structure if we suppose this structure to belong to an object viable and able to develop. Really, by considering the similar problem in GR, S. Chandrasekhar obtained the paradoxical result explained neither by him nor by any other scientists: a black hole with the radius of the Schwarzschild sphere equal to zero has the surface area not equal to zero. Under our approach the paradox vanishes. It turns out to appear because they unlawfully consider the space as nonfibrated, while in reality it is, without fail, a fiber bundle.

In the fiber bundle all things take their own places. In the base of the fiber bundle, which is the real space, the zero Schwarzchild sphere surface does correspond to the zero Schwarzshild sphere radius. In the fiber, which is in the imaginary domain with respect to the base, the radius of the sphere is not equal to zero and naturally, it corresponds to the Schwarzschild sphere surface unequal to zero.

This is a bright example of the space metamorphosis realization. The same object in one subspace has a black hole dimension equal to zero and in another subspace the black hole dimension of this very object turns out to be finite and unequal to zero.

Now we have approached the possibility to clear up the nature of Λ-term in the Triunity equation. Under the deduction of the equation of the scalar component of FF in the subsection 5.2 we have considered the mappings of any points in two subspaces, both *outside* the sphere and *inside* it. In this case neither the mass nor the charge were localized in the finite and, moreover, in the small volume. Neither by Λ-term is the object in question constrained within the space in which it is localized, under the solution of the principal TL equation.

At the same time, when solving TL equation when $\Lambda = 0$, we consider the point charges and the point masses, though the space around them has zero density of the charge as well as the mass.

The following result obtained above is very important as it is slightly raising the veil of the mystery of Λ-term. When we considered the scalar component of FF we could see that the integral of the charge density distributed all over the space is not only convergent but *exactly* equals the charge which originated the field investigated by us. The charge is a *point one* and is situated in the center of the symmetry.

From the considerations above and the facts below the following conclusion is evident: in the TL equation the Λ-term is sure to be in the only case when the equation characterizes the distribution of the mass and charge over the entire investigated space without their localization in the finite volume. In the cases when in the object in question situated in one of the fibers of the enclosing fiber bundle there appears the mapping of the localized charge (mass) which, without fail is moving, the TL equation for this object should not include Λ-term. Thus, Λ-term characterizes distribution of mass and charge over the entire space, distribution which does not allow localization of mass and charge in the finite volume, outside which there is neither mass nor charge.

Further on we shall see that the nature of the spinor fields discovered by P. Dirac is tightly connected with this exceptional feature of the matter mapping from the structure continuously distributed over the space onto the structure consisting of the localized, as a rule point objects, which are inevitably moving.

5.5.
The fourth step. From TL to the structure of fundamental particles of matter in all mutually consistent subspaces

In the previous subsections it was shown that tori of finite dimension are embedded into the Null subspace. Since the dimensions of the tori embedded into the Null space S^3 are substantially less than the curvature radius of this sphere, it can be considered with great accuracy that the tori are embedded into the flat space R^3. In this case the tori embedded in the Null subspace are considered as the third subspace. Because of the above-mentioned "frozen" time effect in the Null subspace it is lawful to consider "frozen" trajectories on these tori. (For the transition from the frozen to the current time see the subsection 5.3).

All BEPs in the theory have a structure of one type and are considered as excited states of one "priming" particle, i.e. fundamenton.

The fundamenton is the tachyon consisting of one dipole of fundamental field charges q_1 and q_2. The mass of the dipole is determined by the energy of interaction of charges q_1 and q_2 and has different signs: the internal charge has the positive mass (m_2) and the external one has the negative mass (m_1).

The geometry of the fiber bundle results in the fact that the mappings of the tachyon dipole onto 2SS and 1SS originate quite a different structure and different properties of the particle observed in these spaces (Fig. 5.2). Thus, the structure of BEP is different in each subspace. The same goes well with the geometry and the time scale. The mapping of BEP properties from 3SS onto 2SS occurs in the way as if there existed some intermediate subspace $(3 \to 2)$, the properties of which are mapped just directly onto 2SS. Thus, the mapping

$$\Gamma_{(32)} = \Gamma''_{(32)} \circ \Gamma'_{(32)} ,$$

where

$$\Gamma'_{(32)}: G_3 \to G_{(3\to 2)} \text{ and } \Gamma''_{(32)}: G_{(3\to 2)} \to G_2 , \tag{5.80}$$

is done by means of the intermediate subspace $(3 \to 2)$. All real and intermediate structures of BEP are shown in Fig. 5.2.

We now consider the procedure of the subsequent mappings of the BEP structure from 3SS onto 1SS (see Fig. 5.2). We consider the third subspace as two tori embedded into $\mathbb{R}^3$. Torus 1 has no internal diameter and parametrically is defined as follows:

$$\begin{cases} z = R_1 \sin\theta ; \\ x = R_1 (1 + \cos\theta) \sin\varphi , \quad 0 \le \varphi < 2\pi ; \\ y = R_1 (1 + \cos\theta) \cos\varphi , \quad 0 \le \theta < 2\pi . \end{cases} \tag{5.81}$$

Torus 2 is parametrically defined in the following way:

$$\begin{cases} z = R_2 \sin\theta ; \\ x = (R_1 + R_2 \cos\theta) \sin\varphi , \quad R_1 > R_2 ; \\ y = (R_1 + R_2 \cos\theta) \cos\varphi , \end{cases} \tag{5.82}$$

where θ is the angle of the particle position on the torus surface, measured counter-clockwise; φ is the angle of the motion trajectory turn along the angle θ relatively to the symmetry axis of the torus; x, y, z are the Cartesian coordinates, the zero point of which is in the center of the external torus, and the axis z coincides with the symmetry axis of the torus, the axes x and y are situated in the plane of a great diameter section of the torus.

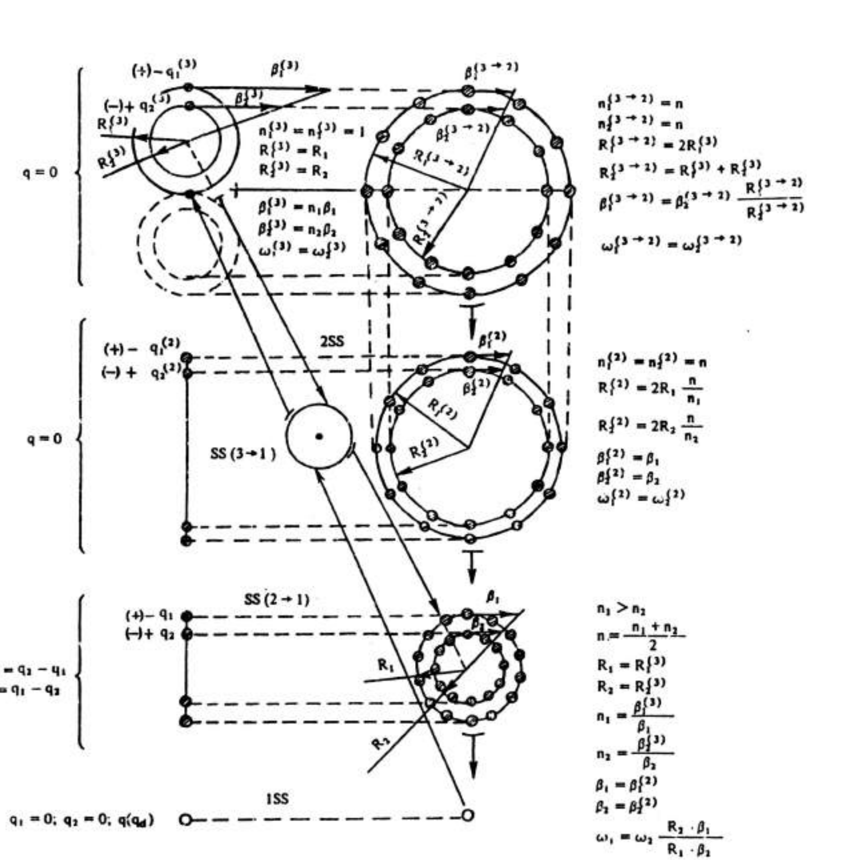

Fig.5.2 BEP structure in the following subspaces: 3; (3 → 2); 2; (2 → 1) and 1. Directions of mapping channels between subspaces. Main parameter values of the given BEP observed in different subspaces.

An intermediate SS $(3 \rightarrow 2)$ and 2SS are determined in the plane $z = 0$. The intersection of this plane with tori 1 and 2 is considered as the mapping from 3SS onto SS $(3 \rightarrow 2)$. Under such mapping in SS $(3 \rightarrow 2)$ three circumferences originate: the first one has the radius $2R_1$ and is given parametrically in the following way:

$$\begin{cases} x = 2R_1 \sin\varphi , \quad 0 \le \varphi < 2\pi ; \\ y = 2R_1 \cos\varphi . \end{cases} \tag{5.83}$$

The second circumference has the radius $(R_1 + R_2)$ and the parameters:

$$\begin{cases} x = (R_1 + R_2) \sin\varphi , \\ y = (R_1 + R_2) \cos\varphi ; \end{cases} \tag{5.84}$$

and the third one has the radius $(R_1 - R_2)$ *) and the parameters:

$$\begin{cases} x = (R_1 - R_2) \sin\varphi , \\ y = (R_1 - R_2) \cos\varphi . \end{cases} \tag{5.85}$$

We now consider the features of this motion. The motion along the torus surface takes place along the coil line with the angular velocity $\omega^{\theta}_{1,2}$ and with the drift along the $(n - n_{1,2})$ - coil screw line with the angular velocity $\omega^{\varphi}_{1,2}$. There is the following relation between the integers n, n_1 and n_2:

$$n = \frac{n_1 + n_2}{2} . \tag{5.86}$$

All points of the intersection of the n-coil line and the plane $z = 0$ represent the image of the structure in SS $(3 \rightarrow 2)$. According to TL , the time scales ratio is the following. In SS $(3 \rightarrow 2)$:

$$\left(\frac{g^{(3)}_{00i}}{g^{(2)}_{00i}} \right)^{1/2} , \tag{5.87}$$

and in SS $(2 \rightarrow 1)$:

$$\left(\frac{g^{(2)}_{00i}}{g^{(1)}_{00i}} \right)^{1/2} , \tag{5.88}$$

where $i = 1, 2$ are the indices related to the first and the second tori.

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*) This radius is the width of the gravitational screen in the vacuum theory of the gravity [7, 48 — 52].

According to the equations $g_{00} = (1 - \beta^2) = \text{const}$ and $g_{00\,(j)} = (1 - \beta^2_{(j)})$, and taking into account that $\beta_i^{(2)} < 1$ and $\beta_i^{(3)} > 1$ we have:

$$g_{00i}^{(3)} = (\beta_i^{(3)})^2 - 1 = n_i^2 (\beta_i^2 - 1)\,, \tag{5.89}$$

$$g_{00i}^{(2)} = 1 - (\beta_i^{(2)})^2 = 1 - \beta_i^2\,. \tag{5.90}$$

The value $g_{00i}^{(1)}$ has to be determined in this calculation because in the first subspace there is no velocity of the structure elements.

The subspace $(2 \to 1)$ is the plane onto which the mappings p_1 and p_2 of the tori 1 and 2, respectively, are determined:

a) p_1 brings the plane point $(R_1 \sin\theta,\ R_1 \cos\theta)$ in correspondence with the torus 1 point (φ, θ);

b) p_2 brings the plane point $(R_2 \sin\theta,\ R_2 \cos\theta)$ in correspondence with the torus 2 point (φ, θ).

Consequently, in SS $(2 \to 1)$ the images of the points of intersection of the screw lines under the mappings p_1 and p_2 determine the structure.

It is significant that the information enters into SS $(2 \to 1)$ not only through 2SS but also directly from 3SS. For example, the radii R_1 and R_2 are mapped from 3SS onto SS $(2 \to 1)$ without any change. Under the mapping from SS $(3 \to 2)$ onto 2SS a number of subparticles n_1 and n_2 and the angular velocities remain without any change, and the radius is "deformed" according to the law:

$$R_1^{(2)} = 2R_1^{(3)} \frac{n}{n_1}\,;\ R_2^{(2)} = 2R_2^{(3)} \frac{n}{n_2} \text{ and } \frac{R_1}{R_2} = \frac{\beta_1 n_1}{\beta_2 n_2}\,. \tag{5.91}$$

From the above-mentioned conditions of the parameters mapping from one subspace onto another it is easy to calculate all EP parameters in all subspaces (see Fig. 5.2). In 3SS:

$$\begin{cases} n_1^{(3)} = n_2^{(3)} = 1\,;\ \omega_1^{(3)} = \omega_1^{\theta} + \omega_1^{\varphi}\,;\ \omega_2^{(3)} = \omega_2^{\theta} + \omega_2^{\varphi}\,; \\ \beta_1^{(3)} = \dfrac{\omega_1^{(3)}}{c} R_1^{(3)} = \beta_1 n_1\,;\ \beta_2^{(3)} = \dfrac{\omega_2^{(3)}}{c} R_2^{(3)} = \beta_2 n_2\,; \\ R_1^{(3)} = R_1\,;\ R_2^{(3)} = R_2\,. \end{cases} \tag{5.92}$$

In SS $(3 \to 2)$:

$$\begin{cases} n_1^{(3\to2)} = n_2^{(3\to2)} = n\,; \\ \omega_1^{(3\to2)} = \dfrac{n_1\omega_1^{\varphi}}{n(n-n_1)}\left(\dfrac{g_{001}^{(2)}}{g_{001}^{(3)}}\right)^{1/2}\,;\quad \omega_2^{(3\to2)} = \dfrac{n_2\omega_2^{\varphi}}{n(n-n_1)}\left(\dfrac{g_{002}^{(2)}}{g_{003}^{(3)}}\right)^{1/2}\,; \\ R_1^{(3\to2)} = 2R_1\,;\, R_2^{(3\to2)} = R_1 + R_2\,; \\ \beta_1^{(3\to2)} = \dfrac{\omega_1^{(3\to2)}R_1}{c}\,;\, \beta_2^{(3\to2)} = \dfrac{\omega_2^{(3\to2)}R_2}{c}\,. \end{cases} \tag{5.93}$$

In 2SS:

$$\begin{cases} n_1^{(2)} = n_1^{(3\to2)} = n\,;\, n_2^{(2)} = n_2^{(3\to2)} = n\,; \\ \omega_1^{(2)} = \omega_1^{(3\to2)} = \dfrac{n_1\omega_1^{\varphi}}{n(n-n_1)}\left(\dfrac{g_{001}^{(2)}}{g_{001}^{(3)}}\right)^{1/2}\,;\quad \omega_2^{(2)} = \omega_2^{(3\to2)} = \dfrac{n_1\omega_2^{\varphi}}{n(n-n_1)}\left(\dfrac{g_{001}^{(2)}}{g_{001}^{(3)}}\right)^{1/2}\,; \\ R_1^{(2)} = 2R_1\dfrac{n}{n_1}\,;\, R_2^{(2)} = 2R_2\dfrac{n}{n_2}\,; \\ \beta_1^{(2)} = \dfrac{2\omega_1^{\varphi}R_1}{(n-n_1)c}\left(\dfrac{g_{001}^{(2)}}{g_{001}^{(3)}}\right)^{1/2} = \beta_1\,;\, \beta_2^{(2)} = \dfrac{2\omega_2^{\varphi}R_2}{(n-n_2)c}\left(\dfrac{g_{002}^{(2)}}{g_{002}^{(3)}}\right)^{1/2} = \beta_2\,. \end{cases} \tag{5.94}$$

In SS $(2 \to 1)$:

$$\begin{cases} n_1^{(2\to1)} = n_1\,;\, n_2^{(2\to1)} = n_2\,;\, n_1 - n_2 = k_1 \neq 0\,; \\ \omega_1^{(2\to1)} = \omega_1^{(3)}\left(\dfrac{g_{001}^{(1)}}{g_{001}^{(2)}}\right)^{1/2}\,;\quad \omega_2^{(2\to1)} = \omega_2^{(3)}\left(\dfrac{g_{002}^{(1)}}{g_{002}^{(2)}}\right)^{1/2}\,; \\ R_1^{(2\to1)} = R_1\,;\, R_2^{(2\to1)} = R_2\,; \\ \beta_1^{(2\to1)} = \dfrac{\omega_1^{(2\to1)}R_1}{c}\,;\, \beta_2^{(2\to1)} = \dfrac{\omega_2^{(2\to1)}R_2}{c}\,. \end{cases} \tag{5.95}$$

1SS is the base of the fiber bundle and therefore, we have in it:

$$R_1 = R_2 = 0\,;\, n_1 = n_2 = 0\,;\, \omega_1 = \omega_2 = 0\,;\, \beta_1 = \beta_2 = 0\,.$$

But

$$g_{001}^{(2)} = \beta_1^2 - \frac{1}{n_1^2}\,;\, g_{002}^{(1)} = \beta_2^2 - \frac{1}{n_2^2}\,, \tag{5.96}$$

where $\beta_{1,2}$ and $n_{1,2}$ are in SS $(2 \to 1)$.

5.6.
The fifth step. Calculation of internal parameters of BEPs

The quantum and relativistic properties of the primary essences of matter are determined as it was mentioned above; firstly, by the fact that a space metamorphosis exists, and therefore it is impossible, in principle, to give the complete description of any object of microcosm considering it only in one, for example, laboratory space; secondly, by the fact that in the space complementary to our laboratory space the physical vacuum exists whose influence on microcosm is decisive in many respects.

Nevertheless, the enumerated conditions of the origination of quantum and relativistic properties allow to consider certain processes in which the doubles of the particles, unobservable directly in the laboratory space, take part. In certain processes their behavior can be considered as classical or quasi-classical. Though it sounds paradoxical,these classical or quasi-classical considerations do not contradict the quantum description, but moreover, they provide the basis for reasoning, without any invocations and mysticism.

Such calculation is possible for the description of the behaviour of the BEP structures in the second subspace. To have the possibility of further transition to the mapping of the properties originated in the second subspace and then mapped onto the first one we mainly make the calculation for the functional space of the mapping from 2SS to 1SS, that is, in subspace $(2 \to 1)$. The calculation given below can be considered as the reasoning for the lawful use of SS $(2 \to 1)$.

To provide the self-consistence of calculations in all subspaces it is necessary to bring the boundary conditions into the concord. It makes impossible the arbitrary choice of the zero point (the "basis" according to Fock [21]) and the orientation of this basis, i.e. the arbitrary choice of the coordinate frame. Therefore, the symmetry center is taken as the zero point and the coordinate frame is taken "attendant", i.e. such one with respect to which the particle itself (the first subspace) or its subparticles (the second and the third ones) are immobile.

For the central symmetrical field of the static or stationary problem we have the following form of the interval s in CSS [7, p. 19]:

$$ds^2 = g_{00}\, c^2\, dt^2 - g_{11}\, dr^2 - g_{22}\, d\theta^2 - g_{33}\, d\varphi^2\,. \tag{5.97}$$

Taking into account the Hamilton—Jacobi equation

$$g^{ik}\frac{\partial S}{\partial x^i}\frac{\partial S}{\partial x^k} - m^2c^2 = 0\,,$$

and considering the plane motion ($d\theta = 0$) we obtain:

$$\frac{1}{g_{00}}\left(\frac{\partial S}{c\,dt}\right)^2 - \frac{1}{g_{11}}\left(\frac{\partial S}{\partial r}\right)^2 - \frac{1}{g_{33}}\left(\frac{\partial S}{\partial \varphi}\right)^2 - m^2c^2 = 0\,. \tag{5.98}$$

In our problem we have to find the solution in the form:

$$S = -Et + M\varphi + S_r(r)\,.$$

Then

$$\frac{\partial S}{\partial t} = -E\,;\ \frac{\partial S}{\partial \varphi} = M\,;\ \frac{\partial S}{\partial r} = \frac{\partial S_r}{\partial r}\,.$$

For $(\partial S_r/\partial r)^2$ we have:

$$\left(\frac{\partial S_r}{\partial r}\right)^2 = \frac{g_{11}}{g_{00}}\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{g_{33}}\right)g_{11}\,,$$

i.e. $$S_r = \int \left[\frac{g_{11}}{g_{00}}\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{g_{33}}\right)g_{11}\right]^{1/2} dr\,. \tag{5.99}$$

We find the value of the derivative:

$$\frac{\partial S_r}{\partial M} = -\int \frac{\frac{g_{11}}{g_{33}}M\,dr}{\left[\frac{g_{11}}{g_{00}}\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{g_{33}}\right)g_{11}\right]^{1/2}}\,. \tag{5.100}$$

But $-\dfrac{\partial S_r}{\partial M} = \varphi$, and consequently,

$$\varphi = \int \frac{g_{11}}{g_{33}} \frac{M\,dr}{\left[\frac{g_{11}}{g_{00}}\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{g_{33}}\right)g_{11}\right]^{1/2}}\,. \tag{5.101}$$

And since $g_{11} = 1/g_{00}$, then

$$\varphi = \int \frac{M\,dr}{g_{33}\left[\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{g_{33}}\right)g_{00}\right]^{1/2}}.$$

But $g_{33} = r^2$, therefore,

$$\varphi = \int \frac{M\,dr}{r^2\left[\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{g_{33}}\right)g_{00}\right]^{1/2}}. \tag{5.102}$$

Since $\omega = d\varphi/dt$ we can write:

$$\omega = \frac{d\varphi}{dt} = \frac{M}{r^2\left[\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{r^2}\right)g_{00}\right]^{1/2}} \cdot \frac{dr}{dt}.$$

Since $v = \omega r$, (we denote $dr/dt = v_r$) this equation can be written in the form:

$$\omega = \frac{M}{r^2\left[\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{r^2}\right)g_{00}\right]^{1/2}} v_r$$

from which

$$\frac{M}{r\left[\frac{E^2}{c^2} - \left(m^2c^2 + \frac{M^2}{r^2}\right)g_{00}\right]^{1/2}} = \frac{v}{v_r},$$

or

$$g_{00} = \frac{\frac{E^2 r^2}{c^2} - M^2\frac{v_r^2}{v^2}}{m^2c^2r^2 + M^2}. \tag{5.103}$$

From this equation we can obtain the expression for g_{00} for certain relations between $E(m)$ and $M(m,r)$. Indeed, if

$$M^2 = \frac{m^2v^2r^2}{f^2(\beta)} \text{ and } E = \frac{mc^2}{f(\beta)},$$

then

$$g_{00} = \frac{1 - \beta_r^2}{f^2(\beta) + \beta^2}, \tag{5.104}$$

where

$$\beta_r = \frac{v_r}{c}\,;\ \beta = \frac{v}{c}\,.$$

Since in this equation there is a radial velocity v_r and a tangent velocity v the obtained solution may be considered only in the second and third subspaces and also in the model corresponding to the mapping of the second subspace onto the first one. This model is observed neither in the first subspace nor in the second one. It is in the complex space but it determines the properties and parameters of the particles observable in the first subspace in the form of indivisible structureless point subparticles.

In all three cases we consider the particle structure in the attendant coordinate frame, which in this situation is equivalent to the proper coordinate frame. Since in TFF, as well as in GR, the non-inertial motion is absolute, the linear tangent velocity v has a definite physical sense and has to be considered in the proper coordinate frame.

In TFF in the third and second subspaces the structure of EPs and EPVs situated inside the Schwarzschild sphere is described in the proper coordinate frame where v_r is numerically equal to v, and v as the relative velocity is absent but it has the significance of the linear velocity of rotation and has to determine the metrical properties of the corresponding space-time.

The above-mentioned statement needs to be explained. The object in question in one of subspaces has to be considered as the sum of orthogonally disposed oscillators, whose summary process of oscillation along the radius provides the motion along the circumference, i.e. the rotative motion in another subspace of this fibration. For the calculation of the entire object a summary motion of two oscillators along the radius is important. The velocity of this motion is equal to the rotative velocity along the circumference. Therefore, when in the above-mentioned calculation we used the notions of two velocities v_r and v, this was a tribute to the attempts to consider the whole phenomenon in one subspace. This situation is analogous to the one mentioned previously, when we tried to calculate an object (situated in the fiber bundle) in one space and obtained the paradoxical results when the radius was equal to zero and the surface with this radius was finite.

In this case if to "remember" that there is only the motion along the circumference and "forget" that it is created by two oscillatory motions in another fiber, then the unification of the notions of the motion with the velocity along the radius and along the tangent would also sound paradoxical.

From the equation (5.104) we have:

$$\begin{cases} g_{00}^{(2)} = \dfrac{1-\beta^2}{1+\beta^2}, \quad (f(\beta) = 1); \\ g_{00}^{(3)} = \dfrac{1-\beta^2}{\beta^2 + (1-\beta^2)^3}, \; (f(\beta) = (1-\beta^2)^{3/2}); \\ g_{00}^{(2\to1)} = 1 - \beta^2, \quad (f(\beta) = (1-\beta^2)^{1/2}). \end{cases} \tag{5.105}$$

In all cases of transition through Schwarzschild sphere the signature in (5.97) has to be changed. In the cases when a new value of g_{00} corresponds to the former value of g_{11}, then instead of (5.105) we have:

$$\begin{cases} g_{00}^{(2)} = 1 + \beta^2; \\ g_{00}^{(3)} = \beta^2 + (1-\beta^2)^3; \\ g_{00}^{(2\to1)} = 1. \end{cases} \tag{5.106}$$

To exhaust all the possible values of g_{00} for different conditions of motion of EPs and their structural elements in the fundamental field we consider the additional condition of the energy minimum (the stability maximum) corresponding to the given value of g_{00}, i.e. the condition $\partial E \,/\, \partial g_{00} = 0$.

From (5.99), considering that $g_{00} = 1 - \frac{r_\gamma}{r}$; $g_{33} = r^2$; $r_\gamma = \frac{2\gamma m_\alpha}{c^2}$ (m_α is the mass creating the field) we have:

$$E^2 = \left[A_m (1 - g_{00})^2 + m^2c^2 + g_{00}A_s(g_{00})\right] g_{00}\, c^2, \tag{5.107}$$

where $A_m = \frac{M^2}{r_\gamma^2}$; $A_s(g_{00}) = \left(\frac{\partial S_r}{\partial r}\right)^2$; m is the mass moving in the field created by the mass m_α. If we put the condition $\partial E / \partial g_{00} = 0$ on (5.107) we have:

$$\begin{aligned} &A_m(g_{00} - 1)(3g_{00} - 1) + m^2c^2 + \frac{dA_m(g_{00})}{dg_{00}}(1 - g_{00})^2 g_{00} + \\ &+ 2A_s(g_{00})\, g_{00} + \frac{dA_s}{dg_{00}} g_{00}^2 = 0. \end{aligned} \tag{5.108}$$

On the Schwarzschild sphere surface $r = r_\gamma$ and $g_{00} = 0$ and, taking into account that $M = \frac{m v r}{f(\beta)}$, (5.108) results in the condition:

$$r_\gamma^2 = \frac{-m_\alpha^2\, 4\gamma^2 f^2(\beta)}{c^4 \beta^2}.$$

But it has to be $r_\gamma^2 = \frac{4\gamma^2 m_\alpha^2}{c^4}$ and consequently, on the Schwarzschild sphere surface $\beta = 1; f(\beta) = 1$ and the mass m_α has an imaginary value. Thus, the stable orbit on the surface of this sphere is possible only in the second subspace ($f(\beta) = 1$). In this case under $r = r_\gamma$, $\beta = 1$. Comparing this result with the value of g_{00} given in (5.105) we see that

$$g_{00}^{(2)} = \frac{1 - \frac{r_\gamma}{r}}{1 + \frac{r_\gamma}{r}}; \; g_{00}^{(2 \to 1)} = 1 - \frac{r_\gamma}{r} = 1 - \beta^2 ,$$

where $\frac{r_\gamma}{r} = \beta^2$.

So g_{00} is determined in 2SS and SS $(2 \to 1)$. If $A_s(g_{00}) = a_M \cdot M$ (a_M is the constant factor), then (5.108) also has the following solutions:

$$g_{00} = \frac{1}{2}; \; g_{00} = 1; \; g_{00} = 0 .$$

Considering the problem *) of subparticles motion along the stable orbit and supposing that A_m = const, we derive from (5.108):

$$A_m(g_{00} - 1)(3g_{00} - 1) + m^2c^2 = 0 . \tag{5.109}$$

The solution of this equation under $g_{00} > 0$ determines the domain of the existence of the most stable orbits outside the Schwarzschild sphere. The stable orbit turns out to exist only under $g_{00} = 2/3$ (which corresponds to $r = 3r_\gamma$). Besides, the level of its stability is rather high. The mass of the body moving on this orbit decreases due to the bond energy and becomes equal to $\sqrt{8/9}\, m$. The energy mc^2 decreases respectively.

In TFF the structure of a genuine elementary particle is situated inside the Schwarzschild sphere. The motion of the given particle outside the sphere may characterize only the system of two particles, i.e. the first type of the compound elementary particles. Further on in part IV, under the consideration of the methods of particles calculation we shall see that the coefficient $\sqrt{9/8} \equiv \frac{3}{2\sqrt{2}}$ plays an important role in the calculation scheme of TFF.

Solution (5.109) can also be used for the analysis of the stable orbits inside the Schwarzschild sphere. It is necessary to take into account the fact that in this case, as well as under the motion

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*) The similar problem in GR was discussed by Kaplan [112].

along the stationary orbit on the Schwarzschild sphere itself, we have $m_\alpha^2 < 0$. What physical significance is in it? In TFF it means that the BEP structure found in a general form should be corrected in the following way. The subparticles in the second and third subspaces represent the mass-dipole (according to the apt name given by Hönl [21] who was the first to investigate the similar models). It is clear that in a centrally-symmetric field the mass-dipole consisting of the positive mass m_+ and the negative one m_- would rotate around the common inertia center carried beyond the bounds of the dipole arm in direction of the positive mass. Thus, m_+ will rotate along the internal orbit and m_- along the external one. It is clear that the difference of the mentioned above masses, i.e. $m = |m_+| - |m_-|$ would be an object moving in a given force field. This is the mass of the entire BEP if $|m_+| > |m_-|$. The question arises, which mass creates the field? It is easy to understand that the field is created by the sum of the absolute values of the masses:

$$m_\alpha = |m_+| + |m_-|.$$

If $|m_+| + |m_-| >> |m_+| - |m_-| \equiv m$, then the problem of the motion of m in the field of m_α can be considered as self-consistent and solved by means of the equations given above.

We now consider the following solution. Denoting the parameters corresponding to the orbit of the motion of m_- (the external orbit) by index 1 and the orbit of the motion of m_+ (the internal orbit) by index 2 we obtain from (5.109) for the mass-dipole:

$$M = \frac{i\,2m_\gamma(|m_+| + |m_-|)}{c(1 - g_{00})^{1/2}(3g_{00} - 1)^{1/2}}.$$

Considering that for the system of two circular currents in SS $(2 \to 1)$: $g_{00}^{(2\to1)} = (\beta_1^2 - \beta_2^2)$ and in SS $(3 \to 1)$: $g_{00}^{(3\to1)} = |\beta_1^{(3)}|^2 + |\beta_2^{(3)}|^2$, and taking into account the generally known relation between the longitudinal and the transversal masses [66]:

$(m_+^{(2)} + m_-^{(2)})^2 = -\left[\dfrac{m}{(1-\beta_1^2)}\right]^2$ (here it is taken into account that m_α is the imaginary mass), we

have for the moment of the mass-dipole $|m_+| - |m_-| \equiv m$:

$$M = 2m^2\gamma / c\left[(1 - g_{00})^{1/2}(1 - 3g_{00})^{1/2}(1 - \beta_1^2)\right]^{-1}.$$

And then

$$\gamma = (1 - \beta_1^2)(1 - g_{00})^{1/2}(1 - 3g_{00})^{1/2}\frac{Mc}{2m^2}, \tag{5.110}$$

and the energy E has a sharp minimum because $g_{00} << 1$,

$$E = mc^2 \frac{2^{1/2} g_{00}}{1 - 3g_{00}} .$$

This fact characterizes the high level of the system stability.

The equations mentioned above are necessary and sufficient for the proof of the existence of this type of stable structures within the bounds of TFF. Yet, they do not give the possibility to calculate all parameters of these structures.

However, if the conditions of non-radiation are put on the charges of the fundamental field together with the conditions obtained from the solution of TL equation (5.53), then the possibility appears to calculate all the BEP parameters and then, by taking into account the quark structures, the parameters of EPs as well (see subsection 5.7 and part IV).

Here we shall restrict ourselves to an approximate calculation because the transition to the accurate calculation (up to the tenth significant digit) is not yet ready. On this stage of the calculation we consider only the following: for two masses (positive and negative) in the tardyon space (the velocity is below that of light) the time component of the metric tensor is determined by the velocity of the linear motion of the external charge β_1 and the internal one β_2 so:

$$g_{00} = \beta_1^2 - \beta_2^2 .$$

Then from (5.110)

$$\gamma = (1 - \beta_1^2)\left[1 - (\beta_1^2 - \beta_2^2)\right]^{1/2} \left[1 - 3(\beta_1^2 - \beta_2^2)\right]^{1/2} \frac{Mc}{2m^2} .$$

It is evident that for the first subspace, where only the differences of masses and charges of the fundamental field reveal, in the limit transition to interactions observable in the Euclidian space, we should obtain the interaction which we call now electromagnetic:

$$\frac{\alpha \hbar c}{r^2} \equiv \frac{\gamma}{r^2} m^2 .$$

Strictly speaking, this relation should be universal for all the types of interactions differing by the unambiguous connection between α and γ. Yet, here under the preliminary approximate consideration we restrict ourselves only to the electromagnetic component of interaction of the fundamental field.

Thus, for the self-consistent theory the following equality should take place:

$$\alpha = \gamma \frac{m^2}{\hbar c} .$$

Substituting the obtained expression for γ and the proton numerical values (see section 19) for β_1 and β_2 we have:

$$\alpha_p = \pi\left[1 - (\beta_1^2 - \beta_2^2)\right]^{1/2}\left[1 - 3(\beta_1^2 - \beta_2^2)\right]^{1/2}(1 - \beta_1^2)\frac{\beta_1}{\beta_2} = 7.29\,730 \cdot 10^{-3},$$

i.e. it is equal to α.

Such striking coincidence of the theoretical and experimental values of the dimensionless constant α testifies to the model described here.

To make the next step in clearing up the structure of any BEP it is necessary to examine in detail the properties of EPVs and the physical vacuum created by them.

In TFF the particle of the vacuum means to be a system originated under the annihilation of the particle and antiparticle in the first subspace. Such EPV forms a system whose mass is equal to zero and which does not create any forces in space except the internal tensions in vacuum. EPVs filling the first subspace with the concentration

$$n_V = \frac{1}{8\pi^2 R_V^3}$$

are responsible for spreading the signal disturbing these particles. From the EPV structure it is clear that the signal should spread with the velocity corresponding to the speed of propagation of the transversal waves of the shear deformation in the infinite medium:

$$\upsilon_V^{(1)} = \sqrt{G/\rho},$$

where the shear modulus is

$$G = \frac{m\upsilon_1^2}{8\pi^2 R_V^3 \varepsilon_V};$$

ρ is the density of particles in vacuum.

Substituting the corresponding values we obtain:

$$\upsilon_V^{(1)} = c.$$

Thus, for EPVs the theory shows that in the vacuum originated by these particles the signal velocity ("the speed of light") and the disturbance velocity of EPVs with the mentioned structure are the same

So, in TFF the following notions acquire a clear physical meaning:

a) the negative masses considered as the manifestation of negative inertia forces of one particle from a pair of strongly interacting particles. The separation of independently existing subparticles with the negative mass *is impossible*;

b) the imaginary masses in the second subspace equal to the sum of absolute values of the positive and negative masses, which contribute essentially to the formation of the chronogeometrical properties of the space but influence the inertial properties of the system as the difference of absolute values. It is clear that the imaginary masses are not observable as such;

c) the "longitudinal" and "transversal" masses, the difference of which is connected with the existence of negative and imaginary masses. The "longitudinal" masses, as the inertia measure of EPs and EPVs and, all the more, of objects originated by them, cannot reveal in the laboratory subspace;

d) the objects moving with the velocity above that of light (tachyons), i.e. the elementary particles of the third subspace. Tachyons cannot reveal in any experiments connected with EPs and EPVs of the first and second subspaces, moreover, in the experiments with the compound objects which are situated only in the first subspace.

To be convinced of the viability of the considered structure for BEP, it is necessary to show that BEP can exist as a stable formation in a free state.

Since the sources of the fundamental field originate from the charges we have to show that they do not radiate. PV consists of EPVs which are BEPs and anti-BEPs. Therefore, according to TFF, radiation spreads through PV as the process of the signal propagation in the medium consisting of EPVs. We have just affirmed it by showing the physical meaning of the speed of light. We now consider the conditions which should be put on the subparticles structure in the second subspace to make these subparticles move along the circumferences and surely form a mechanically stable system but prevent them from radiating the energy. This requirement concerns the model of the mapping of the second subspace onto the first one, i.e. SS $(2 \rightarrow 1)$.

It is known that no combination of stationary charges can be stable. The Irnshow theorem demands it [109, 113].

D. Bohm and M. Weinstein [114] using M. A. Markov's idea [115] made an attempt to find such a system of charges which would retain stability while oscillating in a small volume with velocities substantially less than that of light. The result obtained caused the discussion which ended, according to our opinion, in a sufficiently convincing proof [116, 117] of the impossibility of the existence of such stable systems.

The only possibility left, which is not yet completely discussed, is a system of charges oscillating in a small volume with velocities near to that of light.

The behaviour of the ultrarelativistic rotator was investigated by D. D. Ivanenko and A. A. Sokolov [118] and other authors [119—121]. Yet, the possibility of the existence of the systems of charges which under these cirumstances do not radiate is not proved, according to our information, if we do not take into account the trivial case of circular currents which do not radiate.

We analyze the radiation of the ultrarelativistic rotator [118]. In this case the radiation forms the spectrum of frequencies, so it is impossible to restrict the discussion to the first or some of the first harmonics. We reconsider the results obtained in [118]. The Fourier components of the vector potential in a most general way can be expressed as:

$$A = \sum_{-\infty}^{+\infty} \frac{q\, e^{-i\,n\,(\omega t - \frac{\omega r}{c} - \varphi + \frac{\pi}{2})}}{2\pi r c} \int_{-\pi}^{\pi} \upsilon \cdot e^{i\,(n\alpha - n\beta \sin\theta \sin\alpha)}\, d\alpha\,, \tag{5.112}$$

where $\alpha = \omega t - \varphi + \frac{\pi}{2}$; n is the number of harmonic; $\beta = \upsilon / c$; θ is the angle of the radius-vector inclination with respect to the rotation axis; r is the radius-vector from the center. In the spherical coordinates for projections of the vector-potential we have:

$$A_\varphi(n) = \frac{q\,\upsilon}{2\pi r c} \int_{-\pi}^{\pi} \sin\alpha \cdot e^{i(n\alpha - n\beta \sin\theta \sin\alpha)}\, d\alpha\,; \tag{5.113}$$

$$A_\theta(n) = -\frac{q\,\upsilon}{2\pi r c} \cos\theta \int_{-\pi}^{\pi} \cos\alpha \cdot e^{i(n\alpha - n\beta \sin\theta \sin\alpha)}\, d\alpha\,. \tag{5.114}$$

Passing to the notations adopted in the cylindric functions theory and taking into consideration that according to [122]:

$$J_n(n\,\beta \sin\theta) = \frac{1}{2\pi} \int_{-\pi}^{\pi} e^{i(n\alpha - n\beta \sin\theta \sin\alpha)}\, d\alpha\,; \tag{5.115}$$

$$\frac{2}{\beta \sin\theta} J_n(n\,\beta \sin\theta) = J_{n+1}(n\,\beta \sin\theta) + J_{n-1}(n\,\beta \sin\theta)\,, \tag{5.116}$$

we obtain:

$$A_\varphi(n) = i\,\frac{q\,V}{c\,r} J'_n\,(n\,\beta \sin\theta)\,; \tag{5.117}$$

$$A_\theta(n) = -\frac{q}{r} \operatorname{ctg}\theta\, J_n\,(n\,\beta \sin\theta)\,. \tag{5.118}$$

Then for the projections of the vector of the electric and magnetic fields we have:

$$H_\theta = -E_\varphi = -\frac{1}{r} \frac{\partial(rA_\varphi)}{\partial r} = \frac{2\,q\,\beta^2}{R\,r} \sum_{n=1}^{\infty} n\, J'_n\,(n\,\beta \sin\theta) \cos n\gamma\,; \tag{5.119}$$

$$H_\varphi = E_\theta = \frac{1}{r} \frac{\partial(rA_\theta)}{\partial r} = -\frac{2\,q\,\beta}{R\,r} \operatorname{ctg}\theta \sum_{n=1}^{\infty} n\, J_n\,(n\,\beta \sin\theta) \sin n\gamma\,, \tag{5.120}$$

where $\gamma = \omega t - \frac{\omega r}{c} - \varphi + \frac{\pi}{2}$. Then the radial component of the Pointing vector is

$$\sigma_r = \frac{c}{4\pi}\left(H_\varphi^2 + H_\theta^2\right) = \sum_{n=1}^{\infty} \frac{q^2 n^2 \beta^2 c}{2\pi R^2}\left[\mathrm{ctg}^2\theta\, J_n^2(n\beta\sin\theta) + \beta^2 J_n'^2(n\beta\sin\theta)\right]. \quad (5.121)$$

The intensity of the radiation of any given harmonic has the following form:

$$G_n = \frac{q^2 n^2 \beta^2 c}{2\pi R^2}\left[\mathrm{ctg}^2\theta\, J_n^2(n\beta\sin\theta) + \beta^2 J_n'^2(n\beta\sin\theta)\right]. \quad (5.122)$$

Transition from the rotator to a series of charges uniformly moving along the circumferences is made by means of the "coherence factor" [118]:

$$S_N = (-1)^n N \frac{\sin \pi n}{\mathrm{tg}\frac{\pi n}{N}}, \quad (5.123)$$

where N is the number of the uniformly situated charges. The general intensity of radiation of N charges on the n-th harmonic is

$$G_{nN} = S_N G_n. \quad (5.124)$$

Now using the results obtained in [118] we approach the solution of our problem.

We find the serial number of the harmonic, radiating maximum under a certain angle θ with respect to the axis of the rotation. It is evident that this maximum can be found from the equation

$$\frac{dG_{nN}}{d\theta} = 0. \quad (5.125)$$

We fix n and differentiate the function with respect to θ because by the definition $J_n'(z) = \frac{d\,[J_n(z)]}{dz}$, and in our case $z = n\beta\sin\theta$ and n determines the order of the Bessel function. Substituting the value of G_{nN} from (5.124) into (5.125) and taking into account (5.122), differentiating and making the simplest transformations, we obtain:

$$\beta^2 \frac{J_n''(n\beta\sin\theta)}{J_n(n\beta\sin\theta)} = \frac{1}{n\beta\sin^3\theta}\frac{J_n(n\beta\sin\theta)}{J'_n(n\beta\sin\theta)} - \frac{\cos^2\theta}{\sin^2\theta}. \quad (5.126)$$

From (5.126) by taking into account the recurrent relations for the Bessel functions [122] we have:

$$n = \frac{\beta\sin\theta\frac{J_n'(n\beta\sin\theta)}{J_n(n\beta\sin\theta)} + \frac{1}{\beta\sin\theta}\frac{J_n(n\beta\sin\theta)}{J_n'(n\beta\sin\theta)}}{1 - \beta^2\sin^2\theta + \cos^2\theta}. \quad (5.127)$$

It is evident that this equation is valid for any number of the charges regularly situated along the circumference because they should have the same radiation maximum under the given angle θ.

Mind that in electrodynamics the radiation maximum of the first harmonic is directed under the angle of the order $(1 - \beta^2)^{1/2}$ to the rotation plane. The harmonics next in turn have smaller angles, and the critical harmonics ($n = n_\beta$) and the great ones are situated in the rotation plane.

Therefore, the harmonic giving the radiation maximum in the rotation plane, i.e. under $\cos\theta = 0$, is of interest to us. In this case:

$$n_\beta = \frac{\beta \dfrac{J_n'(n\beta)}{J_n(n\beta)} + \dfrac{1}{\beta}\dfrac{J_n(n\beta)}{J_n'(n\beta)}}{1 - \beta^2} . \tag{5.128}$$

We have obtained the information on the number of subcharges moving on the circumference but if their number is finite they would radiate all the same. Besides, it is difficult to provide the stability of the charges situated only on one circumference.

A system of charges is non-radiating and stable if the charges are situated on two concentric circumferences. Make sure of that.

Denote all the parameters of the charges situated on the external circumference by the index 1 and on the internal one by the index 2. In those cases when the relations are the same we would use the index β.

We find the conditions when the radiation of the external charges may entirely compensate the radiation of the internal ones. It is evident that in this case in any point of the space the radiation should be counterphased and have the same wave length and amplitude. It is clear that these conditions have to be satisfied on all harmonics. Since we consider the radiation in the rotation plane, only those numbers of the harmonics which are greater or equal to the number determined from (5.128) are of interest to us.

It is easy to see that the mutual compensation of the radiation of the two considered systems of the charges on the harmonics, whose radiation is out of the rotation plane, is impossible, because it is impossible to satisfy simultaneously the conditions of counterphaseness, synchronism and equidirectness. Indeed, it is known [118] that the circular current does not radiate, i.e. when $N \to \infty$ there is no radiation. But if N is finite then the harmonics, for which n/N is the integer and there is radiation on them, can always be found. Therefore, to compensate the radiation on these harmonics it is necessary to satisfy the condition of their equidirectness which for a series of harmonics of two multirotators is satisfied only when the Pointing vector of all harmonics is situated in the rotation plane. Thus, the number of the charges N has to satisfy the condition

$$N \geq n_\beta . \tag{5.129}$$

When $N = n_\beta$, the system radiates just on the harmonic minimally allowed. If $N > n_\beta$, then the radiation occurs on the harmonics divisible by n_β. Consequently, in all cases we have to provide mutual compensation of the radiation on the harmonics divisible by n_β and to provide this compensation on all harmonics the serial number of which exceeds the number of the multirotator charges.

The condition of the synchronism for the harmonics n_β in the case of mutual compensation of the radiation of two systems of the charges situated on two concentric circumferences has a very simple form:

$$\lambda_1 = \lambda_2 = \lambda , \tag{5.130}$$

or

$$\frac{2\pi R_1}{\beta_1 n_1} = \frac{2\pi R_2}{\beta_2 n_2} = \lambda , \tag{5.131}$$

from where

$$\frac{R_1}{R_2} = \frac{\beta_1 n_1}{\beta_2 n_2} . \tag{5.132}$$

Since the compensation occurs only on the harmonic n_β and those whose number is divisible by n_β, then the condition (5.130) or (5.132) is valid for all these harmonics, because the same factor appears in both parts of the equality (5.131) for other harmonics.

The condition of the counterphaseness is also the same for all harmonics:

$$R_1 - R_2 = K\lambda , \tag{5.133}$$

where K is a certain integer.

In the case when the signs of the charges on both circumferences are the same (the "one-charged" state) $K/2$ in (5.133) should be instead of K.

From the condition (5.133) taking into consideration (5.132) we obtain:

$$R_1 - R_1 \frac{n_2 \beta_2}{n_1 \beta_1} = \frac{2\pi R_1}{\beta_1 n_1} K , \tag{5.134}$$

or

$$n_1 \beta_1 - n_2 \beta_2 = 2\pi K . \tag{5.135}$$

This is the very condition for the systems not to radiate. The rotation velocities of the charges and the numbers of the "critical" harmonics of both systems of charges determined from (5.128) should satisfy this condition.

The amplitude condition entirely depends on the values of charges, therefore, it can be considered separately. It determines only the relation of q_1 and q_2.

According to (5.128),

$$n_1 = \frac{\beta_1 \frac{J'_{n_1}(n_1\beta_1)}{J_{n_1}(n_1\beta_1)} + \frac{1}{\beta_1}\frac{J_{n_1}(n_1\beta_1)}{J'_{n_1}(n_1\beta_1)}}{1-\beta_1^2}, \tag{5.136}$$

and respectively,

$$n_2 = \frac{\beta_2 \frac{J'_{n_2}(n_2\beta_2)}{J_{n_2}(n_2\beta_2)} + \frac{1}{\beta_2}\frac{J_{n_2}(n_2\beta_2)}{J'_{n_2}(n_2\beta_2)}}{1-\beta_2^2}. \tag{5.137}$$

Then (5.135) can be written as follows:

$$\frac{\beta_1^2 \frac{J'_{n_1}(n_1\beta_1)}{J_{n_1}(n_1\beta_1)} + \frac{J_{n_1}(n_1\beta_1)}{J'_{n_1}(n_1\beta_1)}}{1-\beta_1^2} - \frac{\beta_2^2 \frac{J'_{n_2}(n_2\beta_2)}{J_{n_2}(n_2\beta_2)} + \frac{J_{n_2}(n_2\beta_2)}{J'_{n_2}(n_2\beta_2)}}{1-\beta_2^2} = 2\pi K. \tag{5.138}$$

To solve the equation (5.138) in an easier way we add such an evident relation to it:

$$n_1 - n_2 = K_1, \tag{5.139}$$

where K_1 is a certain integer.

Then together with (5.138) we have a system of two equations:

$$\begin{cases} \frac{\beta_1^2}{1-\beta_1^2}\left[\frac{J'_{n_1}(n_1\beta_1)}{J_{n_1}(n_1\beta_1)} + \frac{J_{n_1}(n_1\beta_1)}{\beta_1^2 J'_{n_1}(n_1\beta_1)}\right] - \frac{\beta_2^2}{1-\beta_2^2}\left[\frac{J'_{n_2}(n_2\beta_2)}{J_{n_2}(n_2\beta_2)} + \frac{J_{n_2}(n_2\beta_2)}{\beta_2^2 J'_{n_2}(n_2\beta_2)}\right] = 2\pi K; \\ \frac{\beta_1}{1-\beta_1^2}\left[\frac{J'_{n_1}(n_1\beta_1)}{J_{n_1}(n_1\beta_1)} + \frac{J_{n_1}(n_1\beta_1)}{\beta_1^2 J'_{n_1}(n_1\beta_1)}\right] - \frac{\beta_2}{1-\beta_2^2}\left[\frac{J'_{n_2}(n_2\beta_2)}{J_{n_2}(n_2\beta_2)} + \frac{J_{n_2}(n_2\beta_2)}{\beta_2^2 J'_{n_2}(n_2\beta_2)}\right] = K_1, \end{cases} \tag{5.140}$$

or

$$\begin{cases} n_1 - n_2 = K_1, \\ n_1\beta_1 - n_2\beta_2 = 2\pi K. \end{cases} \tag{5.141}$$

To solve a system of equations (5.140) we have to use some approximation for the Bessel functions. In literature there are different representations of the Bessel functions, mainly in the form of infinite series and integrals. To use these representations for the solution of the equations (5.140) is rather difficult, even if we derive the algorithm fitting in principle for the calculation by the computer on the basis of the obtained relations.

Therefore, for the Bessel functions with the integer parameter of the kind $J_n(n\,\beta)$ under the great values of n we could not manage to use their known representations. In this connection we make an attempt to find a new representation of these functions which yielded an interesting result. In the theory of the Bessel functions there are the recurrent relations [122] which determine the exact relations between them. Therefore, we naturally tried to rest mainly upon them.

Further on we shall use the recurrent formulae:

$$2\,J'_n(z) = 2\,\frac{d}{dz}\,J_n(z) = J_{n-1}(z) - J_{n+1}(z)\,; \tag{5.142}$$

$$J_{n-1}(z) + J_{n+1}(z) = \frac{2n}{z}\,J_n(z)\,, \tag{5.143}$$

and the consequences from them:

$$\frac{d}{dz}\,J_n(z) = J_{n-1}(z) - \frac{n}{z}\,J_n(z)\,; \tag{5.144}$$

$$\frac{d}{dz}\,J_n(z) = \frac{n}{z}\,J_n(z) - J_{n+1}(z)\,; \tag{5.145}$$

$$\left(\frac{d}{z\,dz}\right)^m [z^n\,J_n(z)] = z^{n-m}\,J_{n-m}(z)\,; \tag{5.146}$$

$$J_{-n}(z) = (-1)^n\,J_n(z)\,, \tag{5.147}$$

where n is a natural number.

We should keep in mind [122] that the function $J_n(n\,\beta)$ is a series consisting of the roots of the Bessel equation:

$$J''_n(n\,\beta) = -\frac{1}{n\beta}\,J'_n(n\,\beta) - \left(1 - \frac{1}{\beta^2}\right)J_n(n\,\beta)\,. \tag{5.148}$$

From (5.144) it directly follows that:

$$\frac{J'_n(n\beta)}{J_n(n\beta)} = \frac{J_{n-1}(n\beta)}{J_n(n\beta)} - \frac{1}{\beta}\,, \tag{5.149}$$

and from the equation (5.143):

$$\frac{J_{n-1}(n\beta)}{J_n(n\beta)} + \frac{J_{n+1}(n\beta)}{J_n(n\beta)} = \frac{2}{\beta}\,. \tag{5.150}$$

Introduce the notation:

$$k_n = \frac{J_n(n\beta)}{J_{n+1}(n\beta)} : \frac{J_{n-1}(n\beta)}{J_n(n\beta)}, \tag{5.151}$$

$$\text{or } k_n = \frac{J_n^2(n\beta)}{J_{n-1}(n\beta)\,J_{n+1}(n\beta)}.$$

It is easy to see that

$$\lim_{\substack{n\to\infty \\ \beta\to 1}} k_n = 1. \tag{5.152}$$

Under very great n the value k_n is the slowly and monotonously changing function of n (or β), the value k_n being near to one.

From (5.151) it follows that

$$\frac{J_{n+1}(n\beta)}{J_n(n\beta)} = \frac{J_n(n\beta)}{k_n J_{n-1}(n\beta)}, \tag{5.153}$$

and then the equation (5.150) can be written in the form:

$$\frac{J_{n-1}(n\beta)}{J_n(n\beta)} + \frac{J_n(n\beta)}{k_n J_{n-1}(n\beta)} = \frac{2}{\beta}, \tag{5.154}$$

from where

$$\frac{J_{n-1}(n\beta)}{J_n(n\beta)} = \frac{1}{\beta}\left[1 + \left(1 - \frac{\beta^2}{k_n}\right)^{1/2}\right]. \tag{5.155}$$

From (5.155) and (5.149) we have

$$\beta\,\frac{J_n'(n\beta)}{J_n(n\beta)} = \left(1 - \frac{\beta^2}{k_n}\right)^{1/2}. \tag{5.156}$$

Consequently, if $k_n \to \frac{1}{\beta^2}$ then

$$\lim_{\substack{\beta\to 1 \\ n\to\infty}} \beta\,\frac{J_n'(n\beta)}{J_n(n\beta)} = (1 - \beta^4)^{1/2} = 0.$$

To make further calculations more suitable we represent (5.156) in the form:

$$\beta \frac{J_n'(n\beta)}{J_n(n\beta)} = m_\beta (1 - \beta^2)^{1/2} , \tag{5.157}$$

where m_β as well as k_n is a certain function of β (or n). As it is clear from (5.156) and (5.157),

$$m_\beta = \left(\frac{1 - \frac{\beta^2}{k_n}}{1 - \beta^2} \right)^{1/2} . \tag{5.158}$$

By taking into account (5.157) we can write (5.128) in the form:

$$n_\beta = \frac{m_\beta (1-\beta^2)^{1/2} + \frac{1}{m_\beta (1-\beta^2)^{1/2}}}{1-\beta^2} ,$$

or

$$n_\beta = \frac{1 + m_\beta^2 (1-\beta^2)}{m_\beta (1-\beta^2)^{3/2}} , \tag{5.159}$$

and consequently,

$$\lim_{\beta \to 1} n_\beta = \frac{1}{m_\beta (1-\beta^2)^{3/2}} \approx \frac{1}{2^{1/2} (1-\beta^2)^{3/2}} . \tag{5.160}$$

Thus, under sufficiently great β:

$$n_\beta = O \left[\frac{1}{(1-\beta^2)^{3/2}} \right] . \tag{5.161}$$

So, it is possible to get an idea of the character of the dependence of n_β on β and of the value n_β , even when we have no solution for n_β in an apparent way (the function m_β is not yet represented in an apparent way even approximately).

The number of the harmonic under which the ultrarelativistic rotator radiates the energy maximum is found in the paper of D.D. Ivanenko and A.A. Sokolov [118]. They express the number of the harmonic by the approximate formula:

$$n_k \approx \frac{3}{2(1-\beta^2)^{3/2}} . \tag{5.162}$$

As we see, the numbers n_β of the harmonics corresponding to the radiation maximum in the rotation plane and the numbers of harmonics corresponding to the radiation maximum without pointing out the direction of this optimal radiation have the same order. If we suppose that both maxima coincide exactly, then (5.159) and (5.162) have to coincide too.

D. D. Ivanenko and A. A. Sokolov in their calculations have used an approximation the error of which has not yet been determined [122]. Besides, in a series of the intermediate calculations they neglected the terms of the order $(1 - \beta^2)$. Taking into account the errors mentioned above, the coincidence of (5.160) and (5.162) should be recognized as a good one. Yet, it is left unclear whether n_β and n_k coincide exactly.

For our purposes the approximate expressions for n_β in the form of (5.160) and (5.161) are not enough. Therefore, it is necessary to find the expression for m_β (or k_n) in an apparent way.

It follows directly from (5.155) that

$$\beta \frac{J_{n-1}(n\beta)}{J_n(n\beta)} = 1 + \left(1 - \frac{\beta^2}{k_n}\right)^{1/2}. \tag{5.163}$$

Expressing in (5.163) $\frac{J_{n-1}(n\beta)}{J_n(n\beta)}$ via $\frac{J_{n+1}(n\beta)}{J_n(n\beta)}$ according to (5.153), for the function of the order $(n+1)$ we obtain the expression analogous to (5.157):

$$\beta \frac{J_{n+1}(n\beta)}{J_n(n\beta)} = 1 - m_\beta (1 - \beta^2)^{1/2}. \tag{5.164}$$

To find the unknown expession for m_β we first find the ratio of derivatives of the Bessel functions to the function itself for the functions whose order differs from n by one. From (5.144) we have:

$$J'_{n-1}(n\beta) = J_{n-2}(n\beta) - \frac{n-1}{n\beta} J_{n-1}(n\beta), \tag{5.165}$$

or

$$\frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)} = \frac{J_{n-2}(n\beta)}{J_{n-1}(n\beta)} - \frac{1}{\beta}\left(1 - \frac{1}{n}\right). \tag{5.166}$$

But from (5.143) it also follows that

$$\frac{J_{n-2}(n\beta)}{J_{n-1}(n\beta)} = \frac{2}{\beta}\left(1 - \frac{1}{n}\right) - \frac{J_n(n\beta)}{J_{n-1}(n\beta)}. \tag{5.167}$$

Then the equation (5.166) after the elementary transformation can be written as follows:

$$\frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)} = \frac{1}{\beta}\left(1 - \frac{1}{n}\right) - \frac{J_n(n\beta)}{J_{n-1}(n\beta)}. \tag{5.168}$$

We introduce the notation:

$$u = \frac{J_{n-1}(n\beta)}{J_n(n\beta)}, \tag{5.169}$$

and express all unknown values via u, β and n. Then (5.168) takes the form:

$$\frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)} = \frac{1}{\beta}\left(1 - \frac{1}{n}\right) - \frac{1}{u}. \tag{5.170}$$

We find the similar expressions for the function of the order $n + 1$ from (5.149):

$$\frac{J'_{n+1}(n\beta)}{J_{n+1}(n\beta)} = -\frac{1}{\beta}\left(1 + \frac{1}{n}\right) + \frac{J_n(n\beta)}{J_{n+1}(n\beta)}. \tag{5.171}$$

Using (5.169) we reduce (5.150) to the following form:

$$\frac{J_n(n\beta)}{J_{n+1}(n\beta)} = \frac{1}{\frac{2}{\beta} - u}. \tag{5.172}$$

Then according to (5.172), the relation (5.171) can be written as follows:

$$\frac{J'_{n+1}(n\beta)}{J_{n+1}(n\beta)} = \frac{1}{\frac{2}{\beta} - u} - \frac{1}{\beta}\left(1 + \frac{1}{n}\right). \tag{5.173}$$

Similarly for the function of the order n we have:

$$\frac{J'_n(n\beta)}{J_n(n\beta)} = u - \frac{1}{\beta}. \tag{5.174}$$

Besides, directly from (5.142) and (5.143) we have:

$$\frac{2J'_n(n\beta)}{J_n(n\beta)} = \frac{J_{n-1}(n\beta)}{J_n(n\beta)} - \frac{J_{n+1}(n\beta)}{J_n(n\beta)} \tag{5.175}$$

and

$$\frac{J_{n-1}(n\beta)}{J_n(n\beta)} + \frac{J_{n+1}(n\beta)}{J_n(n\beta)} = \frac{2}{\beta}. \tag{5.176}$$

Then from (5.175) and (5.176) we obtain:

$$\frac{J'_n(n\beta)}{J_n(n\beta)} = \frac{J_{n-1}(n\beta)}{J_n(n\beta)} - \frac{1}{\beta}, \tag{5.177}$$

and further on taking into account (5.169) and (5.157):

$$\frac{J'_n(n\beta)}{J_n(n\beta)} = u - \frac{1}{\beta} = \frac{m_\beta (1 - \beta^2)^{1/2}}{\beta}, \tag{5.178}$$

from where

$$u = \frac{1 + m_\beta(1 - \beta^2)^{1/2}}{\beta}. \tag{5.179}$$

Taking into account (5.179) it is easy to transform (5.173) and (5.170):

$$\frac{J'_{n+1}(n\beta)}{J_{n+1}(n\beta)} = \frac{m_\beta(1 - \beta^2)^{1/2}}{\beta} \cdot \frac{1 - \frac{(1 - \beta^2)^{1/2}}{m_\beta}}{1 - m_\beta(1 - \beta^2)^{1/2}} - \frac{1}{n\beta}; \tag{5.180}$$

$$\frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)} = \frac{m_\beta(1 - \beta^2)^{1/2}}{\beta} \cdot \frac{1 + \frac{(1 - \beta^2)^{1/2}}{m_\beta}}{1 + m_\beta(1 - \beta^2)^{1/2}} - \frac{1}{n\beta}. \tag{5.181}$$

For the comparison it is suitable to remind the reader that

$$\frac{J'_n(n\beta)}{J_n(n\beta)} = \frac{m_\beta(1 - \beta^2)^{1/2}}{\beta}. \tag{5.182}$$

Besides, for the functions whose order differs by one we have:

$$\frac{J'_{n+1}(n\beta)}{J_n(n\beta)} = \frac{1 - m_\beta(1 - \beta^2)}{\beta}; \tag{5.183}$$

$$\frac{J'_{n-1}(n\beta)}{J_n(n\beta)} = \frac{1 + m_\beta(1 - \beta^2)}{\beta}. \tag{5.184}$$

In these equations the Bessel functions on the argument of the order n and $n \pm 1$ are directly expressed via n, β and m_β. The latter is a certain function of β (or n).

Using (5.178) and (5.180)—(5.184) we form the sums and differences of the ratios of the derivatives to their functions: .

$$\frac{J'_{n+1}(n\beta)}{J_{n+1}(n\beta)} + \frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)} = \frac{2\,m_\beta\,\beta\,(1 - \beta^2)^{1/2}}{1 - m_\beta^2(1 - \beta^2)} - \frac{2}{n\beta}; \tag{5.185}$$

$$\frac{J'_{n+1}(n\beta)}{J_{n+1}(n\beta)} - \frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)} = \frac{2(1 - \beta^2)(m_\beta^2 - 1)}{\beta\left[1 - m_\beta^2(1 - \beta^2)\right]}; \tag{5.186}$$

$$\frac{J'_n(n\beta)}{J_n(n\beta)} - \frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)} = \frac{(1 - \beta^2)(m_\beta^2 - 1)}{\beta\left[1 + m_\beta(1 - \beta^2)^{1/2}\right]} + \frac{1}{n\beta}; \tag{5.187}$$

$$\frac{J'_{n+1}(n\beta)}{J_{n-1}(n\beta)} - \frac{J'_n(n\beta)}{J_n(n\beta)} = \frac{(1-\beta^2)(m_\beta^2-1)}{\beta\left[1-m_\beta(1-\beta^2)^{1/2}\right]} - \frac{1}{n\beta}. \qquad (5.188)$$

From the equations (5.187) and (5.188) it follows that under the great n, and β approaching the unit, when the order of the function changes by one, the ratio of the derivative to the function itself changes by the value of the order

$$\frac{J'_{n\pm1}(n\beta)}{J_{n\pm1}(n\beta)} - \frac{J'_n(n\beta)}{J_n(n\beta)} = O(1-\beta^2),$$

because under the great β the value m is approximately equal to $2^{1/2}$ and $n(1-\beta^2)>1$. The change of the order by (+1) results in the increase, and by (−1) results in the decrease of this function by the values which coincide by the absolute value with the accuracy up to the terms $O(1-\beta^2)^{3/2}$ and $1/n\beta$. Indeed, substracting (5.188) from (5.187) we have:

$$\left[\frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)} - \frac{J'_n(n\beta)}{J_n(n\beta)}\right] - \left[\frac{J'_n(n\beta)}{J_n(n\beta)} - \frac{J'_{n+1}(n\beta)}{J_{n+1}(n\beta)}\right] = \frac{2m_\beta(m_\beta^2-1)(1-\beta^2)^{3/2}}{\beta\left[1-m_\beta^2(1-\beta^2)\right]} - \frac{2}{n\beta}. \qquad (5.189)$$

Under $\beta \approx 1$ (5.189) has the order of difference

$$O\left[(1-\beta^2)^{3/2} - \frac{2}{n\beta}\right]. \qquad (5.190)$$

Therefore, under the great values of n and small values of $(1-\beta^2)$ it is possible in a good approximation to use the interpolation:

$$\frac{J'_n(n\beta)}{J_n(n\beta)} \approx \frac{1}{2}\left[\frac{J'_{n+1}(n\beta)}{J_{n+1}(n\beta)} + \frac{J'_{n-1}(n\beta)}{J_{n-1}(n\beta)}\right]. \qquad (5.191)$$

The term we neglect has the order of (5.190).

By means of (5.191) it is possible to obtain the value m_β and together with it all the necessary expressions. Taking into account (5.182) and (5.185) it is possible to represent (5.191) in the form:

$$\frac{2m_\beta(1-\beta^2)^{1/2}}{\beta} = \frac{2m_\beta\beta(1-\beta^2)^{1/2}}{1-m_\beta^2(1-\beta^2)} - \frac{2}{n\beta}, \qquad (5.192)$$

or

$$m_\beta(1-\beta^2)^{1/2}\left[\frac{1-m_\beta^2(1-\beta^2)-\beta^2}{1-m_\beta^2(1-\beta^2)}\right] = \frac{m_\beta(1-\beta^2)^{3/2}(1-m_\beta^2)}{1-m_\beta^2(1-\beta^2)} = -\frac{1}{n},$$

from where

$$n_\beta = \frac{1 - m_\beta^2 (1 - \beta^2)}{m_\beta (m_\beta^2 - 1)(1 - \beta^2)^{3/2}} . \tag{5.193}$$

It is easy to see that (5.193) means that the right-hand side of (5.189) is equal to zero. Consequently, the found dependence corresponds to the exact but not to the approximate satisfaction of the condition (5.191).

For the number of the unknown harmonic the expression (5.159) has been already found.

Comparing (5.193) and (5.159) we have:

$$1 + m_\beta^2 (1 - \beta^2) = \frac{1 - m_\beta^2 (1 - \beta^2)}{m_\beta^2 - 1} . \tag{5.194}$$

or

$$(1 - \beta^2)\, m_\beta^4 + m_\beta^2 - 2 = 0 ,$$

from where

$$m_\beta^2 = \frac{\pm \sqrt{1 + 8(1 - \beta^2)} - 1}{2(1 - \beta^2)} . \tag{5.195}$$

Since m_β is the real number we retain only the sign "+" before the root. So,

$$m_\beta^2 = \frac{\sqrt{1 + 8(1 - \beta^2)} - 1}{2(1 - \beta^2)} . \tag{5.196}$$

In the limit when $\beta \to 1$

$$\lim_{\beta \to 1} m_\beta^2 = 2 . \tag{5.197}$$

From (5.194) and (5.159) we can obtain one more important relation. We rewrite (5.159) in the form:

$$n_\beta = \left[\frac{1}{m_\beta} + m_\beta (1 - \beta^2)\right] : (1 - \beta^2)^{3/2} , \tag{5.198}$$

and represent (5.194) in the form:

$$\frac{1}{m_\beta} + m_\beta (1 - \beta^2) = \frac{2}{m_\beta^3} . \tag{5.199}$$

Then from (5.198) it follows that

$$n_\beta = \frac{k_\beta}{(1-\beta^2)^{3/2}}, \tag{5.200}$$

where $k_\beta = \frac{2}{m_\beta^3}$ is a certain monotonous and slowly changing function.

From (5.198), taking into account (5.196), we can derive directly the following expression:

$$k_\beta = \frac{2^{5/2}(1-\beta^2)^{3/2}}{[\sqrt{1+8(1-\beta^2)}-1]^{3/2}}, \tag{5.201}$$

and consequently,

$$n_\beta = \frac{2^{5/2}}{[\sqrt{1+8(1-\beta^2)}-1]^{3/2}}. \tag{5.202}$$

The formulae (5.202) and (5.201) can be represented in another form, more suitable for the calculation:

$$n_\beta = \frac{[1+\sqrt{1+8(1-\beta^2)}]^{3/2}}{4(1-\beta^2)^{3/2}}; \tag{5.203}$$

$$k_\beta = \frac{[1+\sqrt{1+8(1-\beta^2)}]^{3/2}}{4}. \tag{5.204}$$

It is easy to see that (5.202) and (5.203) are identical.

From (5.204) it follows that under $\beta = 0$ we have $k_\beta = 2$, and under $\beta = 1$ we have $k_\beta = 2^{-1/2}$. The point $n = (1-\beta^2)^{-3/2}$ under $k_\beta = 1$ is a boundary one for the conditions $k_\beta < 1$ and $k_\beta > 1$, and we have to consider either the case $n < (1-\beta^2)^{-3/2}$, or $n > (1-\beta^2)^{-3/2}$. Since we are interested in the ultrarelativistic case, we choose the upper domain when $k_{\beta\,\max} = 1$, from where

$$\beta_{\min} = \left(1 - \frac{(2^{4/3}-1)^2-1}{8}\right)^{1/2} = 0.914\,472\,5$$

Now we can represent the system of equations (5.140) in the form:

$$\begin{cases} \dfrac{1}{[\sqrt{1+8(1-\beta_1^2)}-1]^{3/2}} - \dfrac{1}{[\sqrt{1+8(1-\beta_2^2)}-1]^{3/2}} = \dfrac{K_1}{2^{5/2}}, \\ \dfrac{\beta_1}{[\sqrt{1+8(1-\beta_1^2)}-1]^{3/2}} - \dfrac{\beta_2}{[\sqrt{1+8(1-\beta_2^2)}-1]^{3/2}} = \dfrac{2\pi K}{2^{5/2}}. \end{cases} \tag{5.205}$$

Before the consideration of the methods of solution of this system we determine the accuracy which could be provided by such solution. The equation (5.193) obtained from the recurrent relations for the Bessel functions under the only supposition given in (5.191) and the exact expression (5.159) for an unknown harmonic, turned out to be compatible algebraically and gave a common solution in the form (5.205). The probability of this coincidence being random is very small. Therefore, it is of interest to clear up whether this coincidence shows that in a particular case, when the order of the Bessel function is determined by (5.159), the dependence (5.191) is valid not approximately but exactly.

When solving (5.194), we restricted the solution to the real domain. By the way, it is easy to see that the equations

$$n_\beta = \frac{1 - m_\beta^2(1-\beta^2)}{m_\beta(m_\beta^2 - 1)(1-\beta^2)^{3/2}} \tag{I}$$

and

$$n_\beta = \frac{1 + m_\beta^2(1-\beta^2)}{m_\beta(1-\beta^2)^{3/2}} \tag{II}$$

are compatible in the real domain of the values m_β not for all β.

To find β_{min} under which m_β is real we write (I) in the following form

$$n_\beta = \frac{1}{m_\beta(1-\beta^2)^{3/2}}\left(\frac{m_\beta^2\beta^2}{m_\beta^2 - 1} - 1\right). \tag{5.206}$$

As $n_\beta > 0$ and $m_\beta(1-\beta^2)^{3/2} > 0$, then it should be $\left(\frac{m_\beta^2\beta^2}{m_\beta^2-1} - 1\right) > 0$, from where $\beta^2 > \left(1 - \frac{1}{m_\beta^2}\right)$. Taking into account (II) we have $\sqrt{1+8(1-\beta^2)} < 3$, i.e. $\beta > 0$. There are no other restrictions.

Thus, (I) and (II) are compatible in the whole real domain of the values of $\beta > 0$, and in the point $\beta = 0$ there is a singularity. This shows that (5.193) and consequently (5.191) strictly coincide in the domain of the values $0 < \beta \leq 1$, provided (5.159) is valid.

Now when we know the domain of the applicability and the accuracy of the system of the equations (5.205) we can begin to solve it.

At first we determine the number of possible solutions of the system in relation to β_1 and β_2 within the interval

$$0.914 < \beta_2 < \beta_1 \leq 1 . \tag{5.207}$$

It can be shown that within this interval the system has the unique solution. Indeed, we represent the system (5.205) in the following form:

$$\begin{cases} \text{I}' \ F_1 = \dfrac{x}{\left[\sqrt{1+8(1-x^2)}-1\right]^{3/2}} - \dfrac{y}{\left[\sqrt{1+8(1-y^2)}-1\right]^{3/2}} = a , & (5.208) \\ \text{II}' \ F_2 = \dfrac{1}{\left[\sqrt{1+8(1-x^2)}-1\right]^{3/2}} - \dfrac{1}{\left[\sqrt{1+8(1-y^2)}-1\right]^{3/2}} = b , & (5.209) \end{cases}$$

and find its solution within the domain (5.207).

We consider (I′) and (II′) as the equations of two families of the curves in the same domain under different values of the parameters a and b. Our proposition will be proved if we show that in any point of the given domain the derivative $dy_{\text{I}'} / dx$ determined for the family I′ would always be greater (or less) than that for the family II′ of the curves of the considered system of equations.

We find the ratio of the derivatives:

$$\frac{dy_{\text{I}'}}{dx} : \frac{dy_{\text{II}'}}{dx} = \frac{9 + 4x^2 - \sqrt{1+8(1-x^2)}}{x} : \frac{9 + 4y^2 - \sqrt{1+8(1-y^2)}}{y} .$$

Analysing the function $f(\beta)$ (x or y) we obtain:

$$f(\beta) = \frac{9 + 4\beta^2 - \sqrt{1+8(1-\beta^2)}}{\beta} ;$$
$$f'(\beta) = -\frac{9}{\beta^2} + 4 + \frac{9}{\beta^2\sqrt{9-8\beta^2}} . \tag{5.210}$$

It is easy to see that within the whole considered interval (5.207) $f'(\beta) > 0$, i.e. $f(\beta)$ monotonously increases. Since $x > y$ then $f(x) > f(y)$. The function $f(y)$ also monotonously increases because it has the same form as $f(x)$. Consequently, $\frac{f(x)}{f(y)} > 1$ or $dy_{\text{I}'} / dx > dy_{\text{II}'} / dx$ in the entire considered domain of the values x and y. That was demanded to be proved. Thus, in the domain, interesting for us, the system of the equations (5.205) has the only solution.

To find it, we determine the approximate values of n_1 and n_2 by expanding the expression under the root in (5.203) into a series and taking the first two terms of this expansion:

$$n_1 = \frac{[1 + \sqrt{1 + 8(1 - x^2)}\,]^{3/2}}{4(1 - x^2)^{3/2}} \approx \frac{[2 + 4(1 - x^2)]^{3/2}}{4(1 - x^2)^{3/2}} \approx$$
$$\approx \frac{1 + 3(1 - x^2)}{2^{1/2}(1 - x^2)^{3/2}} = \frac{1}{2^{1/2}(1 - x^2)^{3/2}} + \frac{3}{2^{1/2}(1 - x^2)^{1/2}}; \tag{5.211}$$

$$n_2 \approx \frac{1}{2^{1/2}(1 - y^2)^{3/2}} + \frac{3}{2^{1/2}(1 - y^2)^{1/2}}. \tag{5.212}$$

Then the system of the equations

$$\begin{cases} n_1 - n_2 = K_1, \\ xn_1 - yn_2 = 2\pi K \end{cases} \tag{5.213}$$

in a certain approximation takes the form:

$$\begin{cases} \left[\dfrac{1}{(1 - x^2)^{3/2}} - \dfrac{1}{(1 - y^2)^{3/2}}\right] + 3\left[\dfrac{1}{(1 - x^2)^{1/2}} - \dfrac{1}{(1 - y^2)^{1/2}}\right] \approx \sqrt{2}\, K_1, \\ \left[\dfrac{x}{(1 - x^2)^{3/2}} - \dfrac{y}{(1 - y^2)^{3/2}}\right] + 3\left[\dfrac{x}{(1 - x^2)^{1/2}} - \dfrac{y}{(1 - y^2)^{1/2}}\right] \approx \sqrt{2}\, 2\pi K. \end{cases} \tag{5.214}$$

Solving this system we obtain:

$$(1 - x^2)^{1/2} \approx \frac{2}{\left[\dfrac{2}{3\left(1 - \dfrac{2\pi K}{K_1}\right)} - \dfrac{26}{3} K_1^2 \left(1 - \dfrac{2\pi K}{K_1}\right)^2 + 4\right]^{1/2} + \sqrt{2}\, K_1 \left(1 - \dfrac{2\pi K}{K_1}\right)}, \tag{5.215}$$

$$(1 - y^2)^{1/2} \approx \frac{2}{\left[\dfrac{2}{3\left(1 - \dfrac{2\pi K}{K_1}\right)} - \dfrac{26}{3} K_1^2 \left(1 - \dfrac{2\pi K}{K_1}\right)^2 + 4\right]^{1/2} - \sqrt{2}\, K_1 \left(1 - \dfrac{2\pi K}{K_1}\right)}. \tag{5.216}$$

By substituting the values $(1 - x^2)$ and $(1 - y^2)$ into (5.211) and (5.212) we can calculate the approximate values of n_1 and n_2.

So, the values of the principal internal parameters of the system, i.e. the velocities β_1 and β_2, the numbers of the critical harmonics n_1 and n_2, the value R_1 / R_2 and the ratio of the distance between the circular currents l to the radius $\frac{l}{R_1} = \frac{R_1 - R_2}{R_1} = 1 - \frac{R_2}{R_1}$, are the unambiguous functions of the integer parameters K and K_1. As to the parameters, we know only that they are integers and should satisfy the considered system of the equations.

From (5.215) and (5.216) it is seen that within the interval

$$0.914 < y < x < 1 \tag{5.217}$$

the condition of the uniqueness of y and x under the given K and K_1 requires also the unambiguous connection between both parameters K and K_1. Really, if a certain integer K_1 is given then the value K cannot be varied because under the change of K even by one, when K_1 is fixed, either the condition (5.217) or the unambiguity condition of the solution under the given values of the parameters is violated.

Thus, there is an unambiguous connection between the parameters K and K_1. The given value of K_1 corresponds to the only value K.

The physical significance of this mathematical conclusion is rather obvious. The parameter K_1 is the function of the critical numbers of the harmonics ($K_1 = n_1 - n_2$), and K is the number of wave lengths (the same for both harmonics), placed within the range of $R_1 - R_2$. It is clear that if the difference between the numbers of the harmonics with the same wave-length is known, it means that the distance between the radii $R_1 - R_2$ is fixed,and different numbers of the wave-lengths created by both systems of charges in no way can be placed within the same interval. Consequently, $K = (R_1 - R_2) / \lambda$ under the given K_1 should have the only value. So, the determination of the integer parameters K and K_1 is reduced to the determination of one of them.

To find all possible solutions of the system (5.213), as the possible values of the parameter K, we may consider a series of natural numbers, beginning from one. Such method surely gives the right result, but it is very labour-consuming even with the use of a computer. Yet, there is a possibility of a sharp decrease of the number of the considered values K, if we pay attention to the fact that under $\beta \rightarrow 1$

$$\frac{K_1}{K} \Big|_{\beta \to 1} \longrightarrow 2\pi . \tag{5.218}$$

The nearer β is to the unit, the more accurate satisfaction of the condition (5.218) occurs.

It is easy to see that not all pairs of the numbers but strictly definite ones satisfy the condition (5.218). For example, if $K = 7$ then only under $K_1 = 44$ the condition (5.218) is satisfied in the best way. By simple substitution it is easy to see that the values of K from 1 to 6 inclusively do not give any solution of (5.205) at all because for them it is impossible to find such an integer K_1 under which the condition (5.218) is satisfied. At the same time the values K and K_1 divisible by 7 and 44 respectively, e.g. 14 and 88; 21 and 132, etc. give the solution. Yet, with the increase of the absolute value of K, under its certain maximal value, there is no solution either. The last value of K, which in the above-mentioned series of the numbers divisible by 7 gives the solution of the system in the real domain, is equal to $K_{max} = 7 \cdot 112 = 784$.

Thus, the values $K = 7$ and $K_1 = 44$ and the numbers divisible by them, form a certain series of possible solutions of the system of equations.

From (5.215) and (5.216) it is also easy to see that under the constant $K_1 / 2\pi K$, greater values x and smaller values y have to correspond to greater values K. If the ratio $K_1 / 2\pi K$ changes, then it is necessary for K_1 / K, in the subsequent case, to be nearer to 2π than in the previous one, to obtain greater value of ratio $K_1 / 2\pi K$.

By taking into account the unambiguity of the solution proved previously and the evident monotony of x and y dependence on K, it follows directly that the subsequent series of the numbers of K and K_1, which can give the solution of the system, has to be formed by another pair of the integers satisfying the following condition:

$$\left[\left(\frac{K_1}{K}\right)_I - 2\pi\right] > \left[\left(\frac{K_1}{K}\right)_{II} - 2\pi\right]. \tag{5.219}$$

After 44/7 only the pair of the numbers 710/113 and numbers divisible by them satisfy this condition. Indeed, $1 - \frac{2\pi \cdot 7}{44} = 4.02\ldots 10^{-4}$, and $1 - \frac{2\pi \cdot 113}{710} = 8.49\ldots 10^{-8}$. Between $K = 7$ ($K_1 = 44$) and $K = 113$ ($K_1 = 710$) there are no pairs of numbers satisfying (5.219) better than 113 and 710. These numbers constitute another finite series of the numbers divisible by them, which gives the solutions of (5.213).

Thus, the determination of the numbers giving the solutions of the system of equations is reduced to the determination of the pair of the integers whose ratios satisfy the relations (5.218) and (5.219) in the best way. These conditions should be satisfied under the smallest value K. This rule, by means of not difficult modes, gave the possibility to find the values of the pairs of the integers which might be used as the parameters corresponding to the solution of the system of equations. The first values of the parameters K and K_1 for nine series of the particles, which may in principle exist in the basic and virtual states, are given in table 5.1.

Thus, we have obtained a rather noteworthy result, according to which only a discrete series of states, characterized by certain pairs of velocities of the charges rotation, satisfies the phase and frequency conditions of non-radiating.

It is essential to note that not only the rotation velocities but the numbers of harmonics and the ratios of the radii corresponding to them are discrete, because it follows from (5.131) and (5.134) that

$$\frac{R_2}{R_1} = 1 - \frac{2\pi K}{\beta_1 n_1} = \frac{1}{1 + \frac{2\pi K}{n_2 \beta_2}}, \qquad (5.220)$$

and both n_1 and n_2 are determined unambiguously from (5.141) via β_1 and β_2.

Table 5.1

NS	K_p	K_{1p}	$A = 1 - \frac{2\pi K}{K_1}$
1	7	44	$4.023 \cdot 10^{-4}$
2	113	710	$8.491 \cdot 10^{-8}$
3	33 215	208 695	$1.056 \cdot 10^{-10}$
4	99 532	625 378	$9.277 \cdot 10^{-12}$
5	364 913	2 292 816	$5.127 \cdot 10^{-13}$
6	1 725 033	10 838 702	$7.049 \cdot 10^{-15}$
7	131 002 976	823 115 974	$6.164 \cdot 10^{-18}$
8	811 528 438	5 098 983 558	$1.755 \cdot 10^{-19}$
9	136 876 735 467 187 340	860 021 893 182 138 486	$2.756 \cdot 10^{-36}$

It is easy to see that the number of the terms in every series cannot exceed the value which is numerically equal to the first value K in the subsequent series. Indeed, if we suppose, for example, that in the first series of the possible values of K there is a term the number of which is 113 then its K is equal to $113 \cdot 7 = 791$. But K in the seventh term of the second series will be just the same.

As it has been shown, the equations of the electrodynamical stability have only one solution and 112 terms should be in the first series. But the 113th term may characterize only a certain metastable state, corresponding to the transition from the first series of the possible states to the second one.

Therefore, the number of the last term in every series of the constants, determining all the possible states of EPs, is defi... by such simple equality:

$$N_{max}(NS) = K_p(NS + 1), \qquad (5.221)$$

where NS is the number of the series.

5.7.
The sixth step. Quark structures in TFF *)

As it was noted, physical vacuum has a great concentration of EPVs. For example, in 1 c^3 of free PV there are approx 10^{39} elementary particles of the proton-antiproton vacuum. The elementary particles cannot exist in PV in the "bare" state. Together with EPVs they form systems which in TFF are called the quark structures (QS). As it is clear from the discussed below, QSs have practically all properties of ordinary quarks. QSs in TFF have some advantages and none of the known drawbacks and difficulties peculiar to the "ordinary" quarks.

In TFF EP-quarks and EPV-quarks are the elements of the quark structures originated from BEPs and EPVs under their joining into the quark structures. The analysis of all possible QSs shows that only the structures given in table 5.2 are stable.

Table 5.2

Diagram number	Objects to be united in QS	QS diagram	Composition of QS forming EP
1	1BEP + 2EPVs		1EP-q + 2 EPV-q
2	2 BEPs + 1EPV		2 EP-q + 1EPV-q
3	1BEP + 1EPV + + surrounding PV		1EP-q + 1 EPV-q

Conventional symbols in diagrams: +(−) is EP-quark; + is double EP-quark; are EPV-quarks (in the second case EPV is greatly excited and BEP enters inside EPV structure); is surrounding PV as QS element. (Sign at the arrow end shows electric charge sign of QS element).

The process of QSs formation is completely determined by the structural features of BEPs and EPVs which become quarks.

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*) Subsection 5.7 was prepared to publication jointly with I. D. Dvas.

The structural features of BEP are schematically given in table 5.3. We decipher them. The structure of BEP in SS $(2 \rightarrow 1)$ is shown in the form of the point charges of the fundamental field situated in the plane perpendicular to the scheme plane. Thus, each pair of the charges situated on the same diameter corresponds to n subparticles situated on the circumference (see subsection 5.5). In this case it is of no importance how numerous the subparticles are and we speak about one total charge.

Table 5.3

Δ	*NS*		
	1	2	3
	hadrons		leptons
1	+ • – ° ↑ —— · —— $q_1 > q_2$ – ° + •	– ° + • ↓ —— · —— $q_1 < q_2$ + • – °	– ° + • ↓ —— —— $q_1 < q_2$ + • – °
2	– • + ° ↓ —— · —— $q_1 > q_2$ + ° – •	– • + ° ↓ —— —— $q_1 > q_2$ + ° – •	– • + ° ↓ —— · —— $q_1 > q_2$ + ° – •
3	+ • – ° ↑ —— · —— $q_1 > q_2$ – ° + •	– ° + • ↓ —— · —— $q_1 < q_2$ + • – °	– ° + • ↓ —— · —— $q_1 < q_2$ + • – °
4	– • + ° ↓ —— · —— $q_1 > q_2$ + ° – •	– • + ° ↓ —— · —— $q_1 > q_2$ + ° – •	– • + ° ↓ —— · —— $q_1 > q_2$ + ° – •

The signs of the external charge q_1 and the internal one q_2 are placed to the left from them. In SS $(2 \rightarrow 1)$ the symmetry of the FF charges (which exist in 2SS when $q_1 = q_2$) is disturbed, and the difference of the FF charges, i.e. the electric charge, appears. The points showing the charges are blacked just there where the greater charge is situated. The dominating charge can be situated on the external circumference as well as on the internal one of the structure. Just this fact determines the notions "particle" and "double-particle" used in TFF. Here we mean that for BEP whose external (with respect to the center) charge of FF dominates in SS $(2 \rightarrow 1)$ the term *par-*

ticle is used, while using the term *double-particle* we mean BEP whose internal charge of FF dominates.

The dipole arms are always considerably less than the radii. In the second series the radii are about sixty times greater, and in the third series 1800 times greater than those in the first series. In table 5.3 they are schematically shown equal.

Besides, the FF charges substantially differ from a series to a series by the velocities of the motion on the circumferences and by the absolute values q_1 and q_2. Yet, though q_1 and q_2 change by many orders the difference between them (the electric charge) has practically the same value. This fact was not explained earlier (see Part IV of the book).

The fact that BEPs correspond to different structural series determines the deep difference in the character of interactions of EPs formed from them. This feature unobservable in our laboratory space but extremely essential for 2SS (the scene of all interactions) was guessed under formation of the modern theory of quarks and was called the "colour", as we have already mentioned. To be concrete, we agree on calling the quarks formed from BEPs of the first series as "red", of the second series as "green", of the third series as "blue" and on denoting them, respectively, by numbers 1, 2, 3. It is necessary to note that the colour and p-even parity are unambiguously determined by the internal structure of BEPs only for the EP-quarks. The internal structure of the EPV-quarks can not be umambiguously determined by these quantum numbers.

Though leptons have the colour indication, BEPs from the third series, preserving the properties peculiar to this series, do not form quark structures with EPVs. Yet, the particles with the properties of the third series can change their structure (the meton effect [7]) so that their properties allow them to take part in formation of quark structures. Below we shall return to this question.

From Table 5.3 it is seen that the BEP structure is determined only by two parameters: the series number NS and the particle state Δ. The series number determines the "colour" and the particle state in a certain series determines the "flavor". There are four basic flavors:

$\Delta = 1$ (corresponds to the flavor u) ;

$\Delta = 2$ (corresponds to the flavor d) ;

$\Delta = 3$ (corresponds to the flavor s) ;

$\Delta = 4$ (corresponds to the flavor c) .

Such subdivision is true for all three series. This symmetry of the properties can be disturbed and the dependence of properties on the series and the type of the quark (EP-q or EPV-q) can appear.

In Table 5.4 all possible quarks are given. The quarks with disturbed symmetry which belong to the first and second series under $\Delta = 1$ or $\Delta = 2$ are denoted now as t-quarks, and under $\Delta = 3$ or

$\Delta = 4$ are denoted now as b-quarks. It is easy to see that the symmetry discussed here is the $SU(3)$-symmetry.

Table 5.4

Δ	*NS*						sign A	A	q_{qu}
	1		2		3				
	EP-q	EPV-q	EP-q	EPV-q	EP-q	EPV-q			
1	u^1 (H)	t^1 (M)	u^2 (B)	t^2 (M)	(t^3) (L)	$u^{3(1)}$	0	$u^{1,2,3}, t^{1,2}$	+ 2/3
2	$d^{3(1)}$ (H)	d^1 (H)	$t^{3(2)}$ (M)	d^2 (H)		(d^3)	0	$d^{1,2,3}, t^3$	- 1/3
3	c^1 (H)	b^1 (M)	c^2 (B)	b^2 (M)	(b^3) (L)	$c^{3(1)}$	+1	$c^{1,2,3}, b^{1,2}$	+ 2/3
4	$s^{3(1)}$ (H)	s^1 (H)	$b^{3(2)}$ (M)	s^2 (H)		(s^3)	-1	$s^{1,2,3}, b^3$	- 1/3

From $SU(3)$ - symmetry it follows that the amount of EP-quarks should be 8, and of EPV-quarks — 10. Since there are three indications of the colour then the flavor should have six variants to have the total number of the quarks equal to 18. The name "flavor" is not felicitous, yet, to keep the succession we leave it as it is. We also leave the notation and the names of the flavors and introduce the notion "quantum number of the flavor" A:

u is the up quark (the quantum number of the flavor is equal to zero);

d is the down quark (the quantum number of the flavor is equal to zero);

s is the strange quark (the quantum number of the flavor is equal to -1);

c is the charmed quark (the quantum number of the flavor is equal to $+1$);

t is the top quark (the quantum number of the flavor is equal to zero);

b is the beautiful quark (the quantum number of the flavor is equal to $+1$). It is important to note that in TFF the indication of the flavor as well as that of the colour is determined by the internal parameters of BEPs, according to table 5.3.

In the theory of quarks formulated without taking into account TFF it is considered that the quarks u, d, s, c, b, t substantially differ in the mass. The statement is almost generally accepted that the distinctly differing "light" and "heavy" quarks do exist. However, it directly contradicts the experience. Indeed, the experiment shows that the "light" quarks can form the heavy nuclei and the "heavy" quarks — relatively light nuclei (Fig. 5.3).

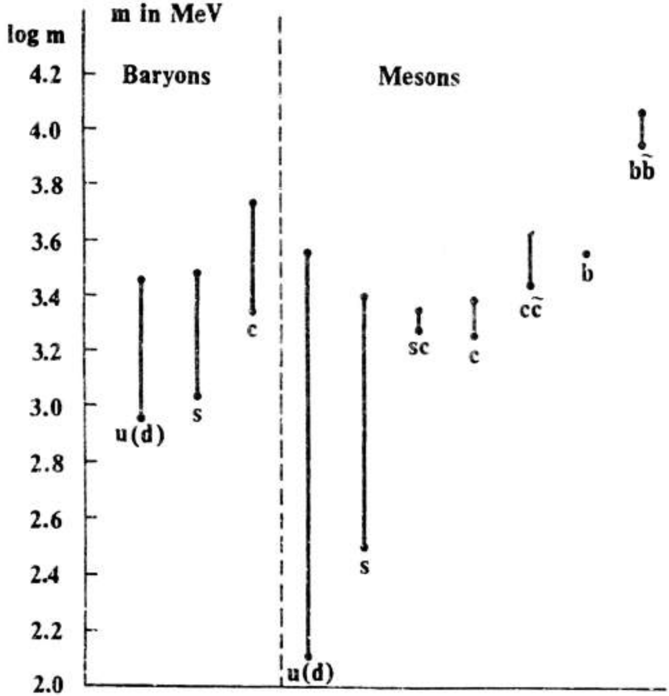


Fig 5.3 Mass range of EPs with various flavors.

In TFF this phenomenon has a natural explanation. The type of the quark is determined only by the series number NS and state Δ of the quarks forming QS. At the same time the mass of the particle substantially depends on the point number NT under the same NS and Δ (for detail see Part IV). The same holds for the value of the particles spin. The spin is determined by NS and Δ

as well as by NT. Therefore, the type of the quark cannot in principle completely determine the mass and spin of the particle.

The process of formation of quarks structures is accompanied by a certain mechanism of division of the electric charge of the "priming" BEP between all elements of the quark structure, i.e. BEP, EPV, PV. Consider this mechanism (table 5.5, the fifth table column).

Coming into interaction with EPV, BEP divides its initial charge +1 or —1 into three equal parts (because there are three elements in the quark structure). BEP can give some part of its charge either to two EPVs (in the structure 1BEP + 2EPVs), or to BEP a nd EPV (in the structure 2BEPs + 1EPV), or to EPV and PV. The charge given to PV, which is the medium but not the constant element of the quark structure, cannot stay there. It has to pass either to EPV-q or to EP-q which directly form the quark structure. In the quark structure with BEP charged positively the PV charge passes to EP-quark and in the structure with the negatively charged BEP the PV charge passes to EPV-quark. Comparing baryon and meson structural schemes we see that in the first structural scheme BEP is replaced by PV and in the second one EPV is replaced by PV.

This process, according to the principle of its physical essence, is indissolubly connected with the fundamental properties of the basic structures of matter discussed in sections 1—4 and 7—16. Here we speak about the electric charge (but not the fundamental one!). According to TFF, the electric charge is the relativistic effect determined by the featurès of the subparticles motion and by the laws of mapping from one subspace onto another. It is clear that physical vacuum cannot be the object in which the electric charge originates or is kept because PV as a whole does not take part in the relativistic processes. PV can only reflect the charge from one object bearing the charge onto another.

We have already mentioned that in TFF the notions "particle" and "antiparticle" have an absolute character but not a relative one. The particles with the positive charge are formed only from the positively charged BEPs having $NS = 1, 2$ and $\Delta = 1, 3$, and the particles with the negative charge are formed only from the negatively charged BEPs having $NS = 1, 2$ and $\Delta = 2, 4$ (see table 5.3). The antiparticles are formed from the corresponding anti-BEPs by the same structural schemes. PV taking part in the discussed processes is the p^+p^- and e^+e^- vacua. It is easy to see that for these types of vacuum the positive electric charge can be reflected from PV only onto EP-quark and the negative one only onto EPV-quark (for detail see sections 7 and 16). This asymmetry is one of the causes of violation of the law of conservation of the spatial even parity under weak interactions inseparably linked with the processes under which the particles exchange the electric charge. The same asymmetry is responsible for the fact that there is the structure 2EPV-q plus the negatively charged EP-q and there is no structure 2EPV-q plus the positively charged EP-q.

Under certain conditions the process of mapping of the charge is added to the mechanism of the charge division when BEP (if there are two of them in the quark structure, then only one

Nos	Baryons						
	Diagram No	Structural diagram	BEP charge	Charge distribution in quark structure	EP charge	Quark composition	QS No
1	2	3	4	5	6	7	8
1	1		+1 +1 +1	= EP-q EP-q EPV-q +1/3 + 1/3 + 1/3 EP-q EP-q EPV-q = +2/3 + 2/3 + 2/3 → = +1/3 + 1/3 + 1/3 (−1) EP-q EP-q EPV-q = +2/3 + 2/3 − 1/3 → no prohibition	+2 +1	$c^1 c^2 u^{3(1)}$ $c^1 c^2 d^2 (d^3)$	1 2
2	1		+1 +1	= EP-q EP-q EPV-q +1/3 + 1/3 + 1/3 EP-q EP-q EPV-q = +2/3 + 2/3 + 2/3 = +1/3 + 1/3 + 1/3 division with mapping prohibited	+2	$c^1 c^2 c^{3(1)}$	3
3	1		+1 +1 +1	= EP-q EP-q EPV-q +1/3 + 1/3 + 1/3 EP-q EP-q EPV-q = +2/3 + 2/3 + 2/3 ≠ *) = +1/3 + 1/3 + 1/3 (−1) EP-q EP-q EPV-q = +2/3 + 2/3 − 1/3 → division without mapping prohibited	+1	$c^1 c^2 d^2 (d^3)$	4
4	2		−1 −1	EP-q EPV-q EPV-q = −1/3 − 1/3 − 1/3 → (+1) EP-q EPV-q EPV-q = −1/3 + 2/3 − 1/3 → no prohibition	-1 0	$s^2 s^1 (d^3)$ $s^{3(1)} s^2 u^{3(1)}$	5 6
5	2		−1	EP-q EPV-q EPV-q = −1/3 − 1/3 − 1/3 → division with mapping prohibited	-1	$s^{3(1)} s^1 s^2$	7
6	2		−1 −1	EP-q EPV-q EPV-q = −1/3 − 1/3 − 1/3 = (+1) EP-q EPV-q EPV-q = −1/3 + 2/3 − 1/3 → division without mapping prohibited	0 0	$s^2 d^1 u^{3(1)}$ $b^2 d^1 u^{3(1)}$	8 9

*) Here the sign ≠ means prohibition of QS formation in such composition.

Table 5.5

Mesons						
Diagram No	Structural diagram	BEP charge	Charge distribution	EP charge	Quark composition	QS No
9	10	11	12	13	14	15
3		+1 +1	EP-q PV EPV-q EP-q EPV-q – +1/3 + 1/3 + 1/3 – +2/3 + 1/3 ⟶ (−1) EP-q PV EPV-q EP-q EPV-q – +1/3 + 1/3 − 2/3 – +2/3 − 2/3 ⟶ no prohibition	+1 0	$c^1\tilde{d}^2$ $c^1\tilde{u}^{3(1)}$	22 23
3		+1	EP-q PV EPV-q EP-q EPV-q – +1/3 + 1/3 + 1/3 – + 2/3 + 1/3 ⟶ division with mapping prohibited	+1	$c^2\tilde{s}^2$	24
3		+1 +1	EP-q PV EPV-q – +1/3 + 1/3 + 1/3 – (−1) EP-q PV EPV-q EP-q EPV-q – +1/3 + 1/3 − 2/3 – + 2/3 − 2/3 ⟶ division without mapping prohibited	0 0	$c^1\tilde{c}^{3(1)}$ $u^1\tilde{u}^{3(1)}$ or $u^1\tilde{t}^1$	25 26
4		−1 −1	EP-q PV EPV-q EP-q EPV-q – −1/3 − 1/3 − 1/3 – − 1/3 − 2/3 ⟶ (+1) EP-q EP-q EPV-q EP-q EPV-q – −1/3 − 1/3 + 2/3 – − 1/3 + 1/3 ⟶ no prohibition	−1 0	$s^{3(1)}\tilde{u}^{3(1)}$ $s^2\tilde{d}^2$	29 30
4		−1	EP-q PV EPV-q EP-q EPV-q – −1/3 − 1/3 − 1/3 – − 1/3 − 2/3 ⟶ division with mapping prohibited	−1	$s^{3(1)}\tilde{c}^{3(1)}$ or $b^{3(2)}\tilde{b}^2$	31
4		−1 −1	EP-q PV EPV-q – −1/3 − 1/3 − 1/3 – (+1) EP-q PV EPV-q EP-q EPV-q – −1/3 − 1/3 + 2/3 – − 1/3 + 1/3 ⟶ division without mapping prohibited	0 0	$s^{3(1)}\tilde{s}^1$ $d^{3(1)}\tilde{d}^1$ or $t^{3(2)}\tilde{u}^2$	28 8

1	2	3	4	5	6	7	8
	5a		+1	= EP-q EP-q EPV-q +1/3 − 1/3 + 1/3			
				EP-q EP-q EPV-q = +2/3 + 2/3 + 2/3 →	+2	$u^1u^2u^{3(1)}$	10
			+1	= +1/3 + 1/3 + 1/3			
7	5		+1	(−1) EP-q EP-q EPV-q = +2/3 + 2/3 − 1/3 →	+1	$u^1u^2d^2(d^3)$	11
				no prohibition			
			−1	EP-q EPV-q EPV-q = −1/3 − 1/3 − 1/3 →	-1	$d^{3(1)}d^2d^1$	13
	5b			(+1)			
			−1	EP-q EPV-q EPV-q = −1/3 + 2/3 − 1/3 →	0	$d^2d^1u^{3(1)}$	12
				no prohibition			
	5a		+1	= EP-q EP-q EPV-q +1/3 + 1/3 + 1/3			
				EP-q EP-q EPV-q = +2/3 + 2/3 + 2/3 →	+2	$c^2u^1u^{3(1)}$	14
			+1	= +1/3 + 1/3 + 1/3			
			+1	(−1) EP-q EP-q EPV-q = +2/3 + 2/3 − 1/3 →	+1	$c^1u^2d^2(d^3)$	15
8	5			no prohibition			
			−1	EP-q EPV-q EPV-q = −1/3 − 1/3 − 1/3 ≠			
				(+1)			
	5b		−1	EP-q EPV-q EPV-q = −1/3 + 2/3 − 1/3 →	0	$d^{3(1)}d^2c^{3(1)}$	16
				division without mapping prohibited			
	5a		+1	= EP-q EP-q EPV-q +1/3 + 1/3 + 1/3			
				EP-q EP-q EPV-q = +2/3 + 2/3 + 2/3 ≠			
			+1	= +1/3 + 1/3 + 1/3			
	5		+1	(−1) EP-q EP-q EPV-q = +2/3 + 2/3 − 1/3 →	+1	$u^1u^2s^2(s^3)$	17
9				division without mapping prohibited			
			−1	EP-q EPV-q EPV-q = −1/3 − 1/3 − 1/3 →	−1	$s^{3(1)}d^1d^2$	18
	5b			(+1)			
			−1	EP-q EPV-q EPV-q = −1/3 + 2/3 − 1/3 →	0	$s^2d^1d^2(d^3)$	19
				no prohibition			

Table 5.5 continuation

9	10	11	12	13	14	15
6a		+1	EP-q PV EPV-q EP-q EPV-q – +1/3 + 1/3 + 1/3 – +2/3 + 1/3 ⟶ (−1)	+1	$u^1\tilde{d}^1$	35
6		+1	EP-q PV EPV-q EP-q EPV-q – +1/3 + 1/3 – 2/3 – +2/3 – 2/3 ⟶ no prohibition	0	$u^1\tilde{u}^{3(1)}$	36
		−1	EP-q PV EPV-q EP-q EPV-q – −1/3 – 1/3 – 1/3 – – 1/3 – 2/3 ⟶ (+1)	-1	$d^{3(1)}\tilde{d}^1$	38
6b		−1	EP-q PV EPV-q EP-q EPV-q – −1/3 – 1/3 + 2/3 – – 1/3 + 1/3 ⟶ no prohibition	0	$d^{3(1)}\tilde{u}^{3(1)}$	37
6a		+1	EP-q PV EPV-q EP-q EPV-q – +1/3 + 1/3 + 1/3 – + 2/3 + 1/3 ⟶ (−1)	+1	$u^2\tilde{s}^2$	39
		+1	EP-q PV EPV-q EP-q EPV-q – +1/3 + 2/3 + 1/3 – – 1/3 + 1/3 ⟶ no prohibition	0	$d^2\tilde{s}^2$	40
4		-1	– – 1/3 – 1/3 – 1/3 – division without mapping prohibited	0	$b^{3(2)}\tilde{d}^2$	32
4		-1	– – 1/3 – 1/3 – 1/3 –	-1	$s^{3(1)}\tilde{c}^{3(1)}$	33
4		-1	– – 1/3 – 1/3 – 1/3 –	-1	$b^{3(2)}\tilde{b}^2$	34

1	2	3	4	5	6	7	8
	5a	+ ↑↓ +	+1	= EP-q EP-q EPV-q +1/3 + 1/3 + 1/3			
			+1	= +1/3 + 1/3 + 1/3; EP-q EP-q EPV-q = +2/3 + 2/3 + 2/3 ≠			
10	5		+1	(−1) EP-q EP-q EPV-q = +2/3 + 2/3 − 1/3 → division without mapping prohibited	+1	$u^1u^2d^2(d^3)$	20
			−1	EP-q EPV-q EPV-q = −1/3 − 1/3 − 1/3 ≠			
	5b	− ↑	−1	(+1) EP-q EPV-q EPV-q = −1/3 + 2/3 − 1/3 → division without mapping prohibited	0	$d^{3(1)}d^2u^{3(1)}$	21

of them) maps the charge, equal to one and having the sign opposite to its initial charge, onto EPV. In this case the charge of the EPV-quark is equal to the sum of the charges obtained by it as the result of division and mapping, i.e. if under division the EPV-quark obtained the charge +1/3 and, besides, BEP induced the charge —1 on it, then the total charge of EPV-quark would be equal to (+1/3 − 1) = −2/3.

Thus, from one structural quark scheme two states (two EPs) can be obtained: the first EP, the formation of which is accompanied only by division of the charge, and the second EP whose formation is accompanied by two simultaneously going processes — division and mapping of the charge from BEP. Just this fact originates the charge difference of the similar particles constituting the isomultiplet.

Two particles obtained from one structural quark scheme form an isomultiplet of two particles. Yet, each separately taken particle can also form an independent isomultiplet consisting of one particle. Besides the isomultiplets consisting of particles obtained according to one and the same structural scheme, isomultiplets of particles can also be obtained according to different structural schemes. For example, the isomultiplet can be constituted of three particle: the first two particles obtained according to the structural scheme 2BEPs + 1EPV and the third one whose formation process was accompanied by division with mapping. According to the structural quark scheme 1BEP + 2EPVs, the isomultiplet can also consist of three particles.

All possible quark structures of baryons are given in table 5.6 and those of mesons — in table 5.7. The quark composition, the electric charge and the values I; I_3; Y; Y-B are shown in the tables. It is shown below how these quantum numbers are determined for the quark structures described in TFF.

9	10	11	12	13	14	15
6a						
6			no meson analogue to baryons			
6b						

From the definition of the isomultiplet it follows that the particles constituting one isomultiplet should satisfy the following conditions:

1. The hypercharge of all particles of an isomultiplet is the same.
2. The particles of an isomultiplet should have the same quantum number of flavor.
3. All particles of an isomultiplet have the same isotopic spin.

From tables 5.6 and 5.7 it is seen that these conditions hold. Now it is also demanded that the particles constituting an isomultiplet should have the exact equality of their masses. According to TFF (see sections 7 and 10), the mass of a particle can deviate from the average stationary state by the value $2\alpha / \pi$ of the average mass. Therefore, the mass of particles constituting an isomultiplet can differ by the value $2\alpha m_{av} / \pi$, where m_{av} is the average mass of particles constituting this isomultiplet.

For the obtained in TFF quark isomultiplets the following quantum numbers can be determined directly from their structure and composition: the baryon (lepton) number B (L); the isotopic spin I; the projection of the isotopic spin I_3; the hypercharge Y; the flavor and the colour. The baryon number is obtained directly from the structural diagram. If there are two quarks in QS and physical vacuum takes part as a time-element of the structure then $B = 0$, but if the number of the quarks is odd then $B = 1$. The isotopic spin is determined by the known formula $I = \frac{N-1}{2}$, where N is the number of the particles in the isomultiplet. The projection of the isotopic spin is determined as follows: the value $I_3 = I$ is taken for the particle with the greatest electric charge, the value by one less than I_3 is taken for the subsequent particle (by the value of the

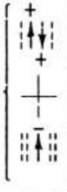
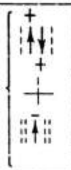
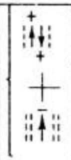
B a r y

Iso-multi-plets	Struc-tural dia-gram	Quark structure			Electric charges $q, \sqrt{\alpha \hbar c}$		
		Conventional symbol	Symbol in TFF (NS, Δ)		EP-q	EPV-q	QS(EP)
			EP-q	EPV-q			
1	2	3	4	5	6	7	8
1		$\{c^1c^2u^{3(1)}$ $c^1c^2d^2(d^3)$	1.19	 2.3	$\{$ +2/3 + 2/3 +2/3 + 2/3	+2/3 −1/3	+2 +1
					no prohibition		
2		$c^1c^2c^{3(1)}$	1.7		+2/3 + 2/3	+2/3	+2
					division with mapping prohibited		
3		$c^1c^2d^2(d^3)$	1.3		+2/3 + 2/3	−1/3	+1
					division without mapping prohibited		
4		$\{s^2s^1(d^3)$ $s^{3(1)}s^2u^{3(1)}$	1.2 1.8	2.4 2.22	$\{$ −1/3 −1/3	−1/3 − 1/3 −1/3 + 2/3	−1 0
					no prohibition		
5		$s^{3(1)}s^1s^2$	1.20		−1/3	−1/3 − 1/3	−1
					division with mapping prohibited		
6		$s^2d^1u^{3(1)}$	1.5	2.8	−1/3	−1/3 + 2/3	0
6a		$b^{3(2)}d^1u^{3(1)}$		2.7	−1/3	−1/3 + 2/3	0
7		$\{u^1u^2u^{3(1)}$ $u^1u^2d^2(d^3)$ $d^2d^1u^{3(1)}$ $d^{3(1)}d^2d^1$	1.17 1.21	2.17 2.18 2.6 2.2	$\{$ +2/3 + 2/3 +2/3 + 2/3	+2/3 −1/3	+2 +1
					no prohibition		
					−1/3 −1/3	−1/3 + 2/3 −1/3 − 1/3	0 −1
					no prohibition		

Table 5.6

o n s

I	I_3	Y	$Y-B$	Experimentally found particles		QS No
				Stable particles	Resonances	
9	10	11	12	13	14	15
1/2	+1/2	3	+2	Ξ_c		1
1/2	−1/2	3	+2			2
0	0	4	+3	Ω_c	—	3
0	0	2	+1	Λ_c^+	—	4
1/2	−1/2	−1	−2	Ξ^0	Ξ -resonances	5
1/2	+1/2	−1	−2			6
0	0	−2	−3	Ω^-	—	7
0	0	0	−1	Λ^0	Λ -resonances	8
0	0	0	−1	Λ_b	—	9
3/2	+3/2	1	0	—	Δ -resonances	10
3/2	+1/2	1	0			11
3/2	−1/2	1	0			12
3/2	−3/2	1	0			13

1	2	3	4	5	6	7	8
8		$c^2u^1u^{3(1)}$		2.19	+2/3 + 2/3	+2/3	+2
		$c^1u^2d^2$ [(d^3)]	1.23	2.23	+2/3 + 2/3	−1/3	+1
					no prohibition		
		$d^{3(1)}d^2c^{3(1)}$	1.22	2.24	−1/3	−1/3 + 2/3	0
					division without mapping prohibited		
9		$u^1u^2s^2(s^3)$	1.4	2.21	+2/3 + 2/3	−1/3	+1
		$s^{3(1)}d^2u^{3(1)}$	1.24	2.5	division without mapping prohibited		
		$s^2d^1d^2(d^3)$	1.18	2.20	−1/3	−1/3 + 2/3	0
					−1/3	−1/3 − 1/3	−1
10		$u^1u^2d^2(d^3)$	1.1	2.1	+2/3 + 2/3	−1/3	+1
					division without mapping prohibited		
		$d^{3(1)}d^2u^{3(1)}$	1.6		−1/3	−1/3 + 2/3	0
					division without mapping prohibited		

electric charge) etc. The hypercharge Y is determined by the known formula $Y = 2\,(q - I_3)$ for each particle of the isomultiplet.

The discussion of the features of the quark structure in TFF will not be complete if we do not mention why the meson structures, which consist of two quarks, divide the initial charge of BEP not into two parts but into three parts like the quarks structures consisting of three quarks. This is due to the fact that meson structures also have three elements, though the third element is not a separate EPV but the physical vacuum associated with BEP. In this case the whole process of transformation of the integer charge of BEP into fractional charges of the quarks is like that occurring in the ten permitted baryons structures. Yet, since the quark structure itself consists of only two quarks, then one of them should take that part of the charge which physical vacuum temporarily obtains in the process of origination of the quark structure.

It becomes possible only if the EPV-q in the meson structure is the antiquark and, consequently, has the charge equal to −2/3 or +1/3. It is necessary to note that the Pauli principle and the relation between the spin and statistics are due to the mentioned above difference between the meson and baryon quark structures. Indeed, the meson quark structures have

9	10	11	12	13	14	15
1	1	2	+1	Σ_c	—	14
1	0	2	+1			15
1	−1	2	+1			16
1	1	0	−1	$\Sigma^{\pm}_{0}$	Σ-resonances	17
						18
1	0	0	−1			
1	−1	0	−1			19
1/2	+1/2	1	0	p	N-resonances	20
1/2	−1/2	1	0	n		21

no colour field (it is equal to zero) because they are formed from the quark and antiquark. In contrast to it, the baryon quark structures have the colour. The colour field prohibits coexistence of two identical quarks with the same quantum numbers in one physical system. This is connected with the fact that in 2SS the FF is situated in the fine string scanning over the cone surface (see sections 1—4 and part IV of this book). To understand the evident impossibility of existence of these two identical particles in the same local space it is enough to draw the structure of such two particles. The cones of anisotropy with the FF strings scanning over their surfaces do not allow two identical particles to coexist. On the contrary, the colourless meson structures may be easily situated in one system, having the same quantum numbers.

Indeed, in this case the FF strings compensate each other and there are no causes preventing these identical particles from peaceful coexistence. Yet, according to TFF, the concentration of mesons cannot be infinitely great because it cannot be greater than the concentration of EPVs in PV surrounding the particles. The question arises why only two positive BEPs from different series can form QS with EPV, according to the structural diagram (2BEPs + 1EPV). We now explain this fact.

Iso-multiplets							M e s
	Structural diagram	Quark structure			Electric charges (q, $\sqrt{\alpha\hbar c}$		
		Conventional symbol	Symbol in TFF (NS, Δ)		EP-q	EPV-q	QS (EP)
			EP-q	EPV-q			
1	2	3	4	5	6	7	8
1		$c^2\tilde{d}^2$ $c^1\tilde{u}^{3(1)}$	1.27 1.15	2.11 2.15	+2/3 +2/3	+1/3 −2/3	+1 0
						no prohibition	
2		$c^2\tilde{s}^2$	1.10	2.27	+2/3	+1/3	+1
						division with mapping	
3		$c^1\tilde{c}^{3(1)}$	1.31	2.31	+2/3	−2/3	0
						division with mapping	
3a		$u^1u^{3(1)}$	1.13	2.13	+2/3	−2/3	0
						division without mapping	
4		$d^{3(1)}\tilde{d}^1$	1.14		−1/3	+1/3	0
						division without mapping	
4a		$s^{3(1)}\tilde{s}^1$	1.16		−1/3	+1/3	0
						division without mapping	

o n s						
I	I_3	Y	$Y-B$	Experimentally found particles		QS No
				Stable particles	Resonances	
9	10	11	12	13	14	15
1/2 1/2	+1/2 −1/2	1 1	+1 +1	D_0^+	$D^*_{(2010)}$; $D_{1\,(2420)}$	22 23
0 prohibited	0	2	+2	D_s^*	D_s^*	24
0 prohibited	0	0	0		η_c; J/ψ; χ_{c0}; χ_{c1}; χ_{c2}; ψ	25
0 prohibited	0	0	0		ω (783); η (958); f_0 (975); ϕ (1620); h_1 (1170); f_2 (1270); η (1280); f_1 (1285); f_0 (1400); f_1 (1420); η (1430); f_2 (1525); f_1 (1530); f_0 (1590); ω_3 (1670); ψ (1680); f_2 (1720); f_2 (2010); f_4 (2050); f_2 (2300);	26
0 prohibited	0	0	0	η		27
0 prohibited	0	0	0			28

1	2	3	4	5	6	7	8
5		$s^{3(1)}\tilde{u}^{3(1)}$ $s^{2}\tilde{d}^{2}$	1.12 1.32	2.10 2.30	−1/3 −1/3	−2/3 +1/3	−1 0
					no	prohibition	
5a		$b^{2(2)}\tilde{u}^{3}$ $b^{3(2)}\tilde{d}^{2}$	1.11	2.26 2.32	−1/3 −1/3	−2/3 +1/2	−1 0
					no	prohibition	
6		$s^{3(1)}\tilde{c}^{3(1)}$	1.28		−1/3	−2/3	−1
						division with	mapping
6a		$b^{3(2)}\tilde{b}^{2}$		2.12	−1/3	−2/3	−1
						division with	mapping
7		$u^{1}\tilde{d}^{1}$ $u^{1}\tilde{u}^{3(1)}$	1.9 1.29	2.9 2.29	+2/3 +2/3	+1/3 −2/3	+1 0
						no prohibition	
		$d^{3(1)}\tilde{a}^{1}$ $d^{3(1)}\tilde{u}^{3(1)}$	1.30 1.26	2.14 2.25	−1/3 −1/3	+1/3 −2/3	0 −1
						no prohibition	
8		$u^{2}\tilde{s}^{2}$ $d^{2}\tilde{s}^{2}$	1.25	2.28 2.16	+2/3 −1/3	+1/3 +1/3	+1 0
						charge putting	upon

The internal structure of BEP and dynamics of the fundamental field charges distribution inside this structure are shown in table 5.3. It is seen from the table that the positive BEPs of the first and the second series ($\Delta = 1$ and 3) differ from each other. The FF dominant positive charge of positive BEP of the first series is situated on the external orbit, while that of the second series is on the internal one. Therefore, these two positively charged BEPs from different series can be united and form a stable system whose components do not annihilate. This is provided by the fact that in spite of the equal charges these two BEPs do not seek to push away each other because they are attracted by the opposite charges of FF on the orbits: the BEP of the first series has the positive charge of FF and the BEP of the second series has the negative charge on their external orbits, it is vice versa on their internal orbits.

Table 5.7 continuation

9	10	11	12	13	14	15
1/2	−1/2	−1	−1	K^-		29
1/2	+1/2	−1	−1	K_S^0		30
1/2	−1/2	−1	−1	$B^{\bar{0}}$		31
1/2	+1/2	−1	−1			32
0 prohibited	0	−2	−2	D_S^-		33
0 prohibited	0	−2	−2		Υ; χ_{b0}; χ_{b1}; χ_{b2}; Υ_0	34
1	1	0	0	π^+	a_0 (980);	35
1	0	0	0		b_1 (1235); π (1300);	36
1	0	0	0	π^0	a_2 (1320);	37
1	−1	0	0	π^-	ρ_3 (1690); ρ (1700)	38
1/2	+1/2	1	+1	K^+		39
1/2	−1/2	1	+1	K_L^0		40
EPVs prohibited						

For all the negativel, charged BEPs ($NS = 1$ and 2, $\Delta = 2$ and 4) the dominant negative charge of FF is situated on the internal orbit, in this sense they are similar, and because of this fact they cannot form a stable structure from two negatively charged BEPs. Neither can positively charged BEP together with negatively charged BEP form the quark structure besause they annihilate. Just this fact determines the charge features of BEPs forming the quark structure.

As we mentioned above under the description of the mechanism of particles formation, only the division alone is realized somewhere, and somewhere is the division with mapping of the BEP charge. What is the reason of it? In the case of the baryons it occurs because the division of the charge without mapping is possible only when there are three colours of the quarks in the quark structure. If in the quark structure the quarks have two varieties of colour, for example, 1, 2, 2 or

2, 1, 1 (and other combinations), then the mechanism of division is sure to be supplemented by the mapping as if to compensate the absence of one colour (the symmetry responsible for this process can be disturbed).

The mesons have a different feature. If EP-q and EPV-q have the same colour, then only the division of the charge is possible because only in this case the colourlessness is achieved. If in the quark structure the EP-q and EPV-q are of different colours, then the "anticolour" is induced onto the EPV-q from the priming BEP and this process should always be accompanied by the electric charge mapping.

We also mentioned above that the particles of the third series (the leptons) have no quark structure. In this meaning the leptons are the "bare" particles. These statements need explanation which we give herein. The base of physical vacuum is the proton-antiproton ($p^+ p^-$) vacuum. The concentration of EPVs in this type of vacuum is equal to $n_{V(p^+p^-)} = 1.545\,41 \cdot 10^{39}\ c^{-3}$, while the concentration of EPVs of the electron-positron ($e^+ e^-$) vacuum, the nearest to the mentioned above type of vacuum, is equal to $n_{V(e^+e^-)} = 1.730\,09 \cdot 10^{29}\ c^{-3}$, i.e. it is ten orders less. Therefore, the main properties of physical vacuum, in particular the permittivity of vacuum, are determined by the proton (antiproton) parameters. From the mentioned above it necessarily follows that though BEPs of the third series can in principle form the analog of QS, the stable structure with the elementary particles of their vacuum, yet, this structure has a very small probability of existence during the time τ which would satisfy the uncertainty relation $mc^2\tau \geq h$.

The exceptions of this rule are so rare that in spite of the fact that there are about a million permitted BEPs in the third series only ten states of them, according to the computer calculation, have the reasonable probability to be observable in our space (for detail see part IV). Three of these states have been already discovered — the electron, the muon, the τ-lepton and their antiparticles. The fourth state with the mass and charge of the positron, but with the lifetime equal to $1.02 \cdot 10^{-9}$s is also practically found in the solids. Yet, this particle is adopted to be called the "hole" though during fifty years since Dirac introduced this notion nobody has found until now what the "Dirac hole" is like, besides the fact that it is something having the positive charge and the mass of the positron. According to TFF, this is the lepton with the lifetime equal to $1.02 \cdot 10^{-9}$s. The particles of the fourth series and of the subsequent ones are not observable directly in free state in our space.

The lepton states predicted on the basis of TFF but not found yet, which in principle can be observed in our space, have the following parameters:

1. The mass is equal to $4655.82 m_e$, the lifetime is equal to $1.08 \cdot 10^{-13}$ s.

2. The mass is equal to $2793.52 m_e$, the lifetime is equal to $2.68 \cdot 10^{-13}$ s.

3. The mass is equal to $2327.95 m_e$, the lifetime is equal to $3.45 \cdot 10^{-13}$ s.

The parameters of the τ-lepton predicted in the publications of TFF in the beginning of 1975 [7] were completely confirmed in 1982 (for detail see part IV).

Thus, the particles of the third series are observable in very few cases. Besides, the radius of the structure of these particles is three orders more than the radius of the structure of the particles of the first series. Therefore, the particles of the third series can not take part in strong interactions. Yet, there is an analog of the quark structure in the form of the union of the "bare" electron with the excited EPVs of the electron-positron vacuum. But this analog is not the quark structure in that form which we desctibed here. This structure needs a special discussion and we do not give it herein.

This is a brief account of the structural features of the leptons.

The physical model of QS described herein allows to solve the puzzle of K_L^0 and K_S^0 mesons, which was put by the experiment. As it is seen from table 5.7, there are two quark structures (d^2s^2) and (s^2d^2) in multiplets 5 (QS No 30) and 8 (QS No 40) which differ only in the following: in one case d-quark is the EP-quark and s-quark is the EPV-quark while in the other case it is vice versa. Though both structures constituting this isomultiplet have zero charge, their properties (in the first place the lifetime) are different. For the rest both QSs are almost identical. In existing concepts on QS they are totally identical because the difference between the EP-quarks and the EPV-quarks was not known previously.

Besides, in this isomultiplet consisting of two pairs of particles one of the most important symmetries is violated, which results in different hypercharges of the pairs constituting the isomultiplet. Such violation is absent in each of 19 isomultiplets of the baryons and mesons.

As it is known to us, this is the first explanation of the nature of violation of the CP symmetry of K_L^0 and K_S^0 mesons with which this isomultiplet is identified.

We have already mentioned that the features of the quark structure of the baryons and mesons determine their statistics, and the Pauli principle is due to these features. Here we should like to enlarge this statement. The main difference of the baryons quark structure from the mesons quark structure consists in the fact that in the last case physical vacuum is the element of the structure. It is easy to see that in the case when PV takes part in the formation of the structure, the number of analogous particles in a certain finite volume can be greater and is limited only by the concentration of EPVs which is very great. Therefore, the mesons with the same set of quantum numbers can coexist in a small volume in a very great quantity. At the same time two identical baryons can not coexist in one physical system. All properties of baryons are unambiguously determined by the properties of the quarks constituting this baryon and the string structure of these quarks is only one and the same.

Thus, the principal difference of the bosons from the fermions is determined by the fact that physical vacuum is the element of the quark structure of bosons and therefore, this structure can have very great, though not infinitely great, quantity of structural analogs with the identical properties. On the contrary, the structure of the fermions is unambiguously determined by three quarks and the identical analog cannot be formed by these three quarks. It is easy to see that this fact determines the physical essence of the Pauli principle which does not allow fermions to have the identical analog with the same set of quantum numbers within the same system. Thus, the fermions and bosons have different quark structures, different internal symmetries and, consequently, different statistics. The discussed above reasoning of the Pauli principle and of the relation between the statistics of EPs (considered as the quark structure) and the spin results in some corrections of these fundamental principles of modern microphysics.

The first correction consists in the fact that the unified system, where, according to the Pauli principle, two fermions cannot exist simultaneously, should be considered as any physical system consisting of fermions between which, within the bounds of the given system, the interaction of the strings of the fundamental field exists. Outside this system the Pauli principle is not valid, so, for example, it is impossible to state that on the Earth and on the Sun there can not exist two identical protons with the same quantum numbers because of the fact that both these protons belong to the same solar system.

The second correction consists in the fact that the maximal number of bosons per volume unit cannot be above the concentration of EPVs in the vacuum with which these bosons interact and, consequently, can not be infinitely great. Modern concepts allow to suppose the existence of systems with infinitely great amount of bosons in the finite volume.

In conclusion we mention such features of the quark structures in TFF which show that in contrast to ordinary quarks these quark structures have properties completely corresponding to the experiment.

1. In TFF the quarks are the elements of the structure and originate under formation of the structure; under destruction of the structure the EP-quarks transform into BEPs, and the EPV-quarks into EPVs. There are no stable states of free quarks with the fractional charge, which in principle corresponds to the experiment.

2. After destruction of QSs during some time their elements can exist in the "quark" state under the influence of external forces and special external conditions. Yet, this state, like any metastable state, is very unstable and short. This fact completely corresponds to the incontrovertible Fairbank experiments [125], which up to now nobody could explain.

3. The described herein concept of EPs as the quark structures, discussed within the bounds of TFF, allows, as it would be seen in part IV, not only to calculate the parameters of elementary particles in more correct way but also to determine such quantum numbers as the baryon number B, the isotopic spin I and its projection I_3, the hypercharge, the colour and the flavor. Besides, the knowledge of the principal features of QSs makes the correct calculation of masses, charges, spins and the magnetic moments of EPs easier.

6 RÉSUMÉ

1. Substantial analysis of the problem, initial principles and major concepts are discussed.

2. The recognition of the necessity of developing the unified theory, which would include all interactions in matter, took place only recently. For many years most physicists did not agree with Einstein, who during last years of his life upheld the necessity of developing the unified theory of all interactions of substance, just the substance, supposing that the unified theory would include all existing things. As a matter of fact, as it is clear from the whole contents of the book, it concerns not the whole substance but only that part which possesses the mass as a measure of inertia. The modern theory of matter rests upon the quantum theories and both SR and GR. In the basis of the concept of the substance structure there is a notion of the scale of ranks of the quantum objects. Its ranks are the following: the first is molecular-crystalline, the second is atomic, the third is nuclear and the fourth is subnuclear. It was supposed that the enumerated above things exhausted all the matter. The book has shown that it is an unlawful supposition. The closed unified theory may be developed only in the case when deeper stages of structure of matter are also taken into account. It concerns the following: the virtual state, which is postulated, is used, but is not explained; the physical vacuum, which is introduced into physics, but its essence is not clarified; the primary brick of the Universe, called the fundamenton, and its unity with the entire Unverse.

3. A new paradigm is discussed which is called the Paradigm for Viable and Developing Systems (PVDS). This paradigm is considered as the methodological and mathematical basis for the creation of the unified theory of field. It is noted that PVDS is or, to say more correctly, may be the basis for more general theories which include not only matter but also other material forms. In this book the paradigm is used as the basis of TFF.

4. It is shown that modern mathematics cannot be considered only as a tool of the analysis of already discovered, formulated and grounded physical principles of the theory and its regularities. Modern mathematics turns out to be of the heuristic value. It can be not only a tool of the analysis but also the basis of the development of the principles themselves, as well as the laws of the physical theory. These immense heuristic possibilities of mathematics were not seriously used previously and moreover, they were not recognized at all.

Mathematics, as a heuristic tool of modern investigations in natural sciences, is considered in detail in the book. But its comparatively small volume does not allow to reveal thoroughly all the structures of those branches of modern mathematics which can be considered as the ground of the heuristic possibility of constructing the fundamentals of the theory. Therefore, only the principal conclusions of modern mathematics are given here, which enter into the core of the heuristic approach to mathematical reasoning of the fundamentals of the theory. These concise formulations are called the definition-résumés (DR). The principal DRs are enumerated. Their contents are given together with the corresponding references, so that the reader would be able to learn in detail those divisions of modern mathematics which are considered as the basis of heuristics of the development of the theory.

5. In biology there is a very important, in our opinion, even a fundamental notion, which is called the metamorphosis. In fact, this is a particular type of the metamorphosis, i.e. the time metamorphosis. It turns out that nature does not restrict itself to the use of the time metamorphosis, i.e. transformation of an independently living object into different forms during a definite time. In nature not only the time metamorphosis but also the spatial metamorphosis is realized. The spatial metamorphosis is the existence of the same object objectively at the same time in different spaces, i.e. the same object may exist in one space as one object and in another space as quite a different one, according to its structural and vital characteristics. An ordinary Euclidian space cannot realize the spatial metamorphosis. In the three-dimensional Euclidian space, under the time continuously flowing in one direction, the spatial metamorphosis is impossible. Nature uses fiber bundles and multidimensional spaces to realize the spatial metamorphosis. The fiber bundles and multidimensional spaces are considered in the book not as abstract mathematical objects suitable to formalize some laws and concepts but as the essences really existing in nature. The fiber bundles and the multidimensional spaces are not abstract but real things. Without taking into account this fundamental principle, realized by the surrounding nature, the development of the complete closed unified theory of matter is impossible. It is so because the principal objects of matter exist in fiber bundles and naturally cannot be described in the simplest spaces which we considered, and still consider unlawfully, as the single realities of Nature.

6. The Paradigm for Viable and Developing Systems demands that the unified closed structure of all features of the matter bricks should be described by the corresponding space-time diagram, which would satisfy the requirements of the closeness and commutativity. If the principal forms of existence of one or another independent object of matter cannot form (in different subspaces) the closed system satisfying the commutativity conditions, then such system cannot exist independently and what is more, claim viability.

7. It is shown that in the basis of the matter construction there is a scalar field which has its sources-charges. This scalar field forms principal tensions (forces) in the world of matter, unifying all Universe with its principal elements, the centers of the Universe, the charges of the fundamental field. Since any element, basic in matter, is the center of this Universe, then the Universe is a closed geometrical object, any point of which is the center of this object. This object is the closed three-dimensional sphere S^3.

The main equation of the scalar component of the fundamental field is derived. It turned out that from this equation such excluding properties of the scalar field followed which no field, previously considered in physics, had.

In the entire Universe the scalar component of FF creates the finite charge but not the zero or infinite one. It is of special interest and significance that if to integrate the density of the charge, originated by the fundamenton over the entire Universe, it turns out that the integral, summing up this charge, is not only finite but exactly equal to the constant (called the charge), which enters into the equation of the scalar component of the field. Apart from it, the density of the charge of the scalar component of the fundamental field is finite in the entire space, from the center of the charge to any point of the space.

8. It is shown that in TFF the space-time-matter are unified into the Triunity Law (TL). The equation of General Relativity which binds the space-time with the matter (according to Einstein, with the substance), in fact, is not the local law, determining the gravitational interaction, but the unified Triunity Law for all spaces, in which a given object simultaneously exists, i.e. there is a relation of the space-time and matter in all subspaces, in which, in accordance with the spatial metamorphosis, the object of microcosm simultaneously exists: in the base, in the fiber, as well as in the enclosing space enveloping the fiber and the base.

9. In TFF it is shown that the physical vacuum is the material structure which consists of the elementary particles of vacuum. EPV represents the unification of the particle and the antiparticle, coexisting in the fiber of the enclosing space, whose base is the laboratory space. In this space we observe microcosm. In our space the elementary particles have no structure, they are the point particles. At the same time, according to the spatial metamorphosis, the elementary particle simultaneously exists in the fiber where it has an apparent structure. We cannot observe this structure, but we can observe the result of interaction of the structural particles in another subspace (the fiber). Just because of it and only due to this fact, in some experiments we do not observe the structure of the particles, they are observed as the point objects, while in other experiments, observing the result of interaction between the particles, we are convinced that they have the structure. They interact in the space in which the structure exists. The concentration of EPVs is very great: for the electron-positron vacuum it has the order of 10^{29} particles per c^3, for the proton-antiproton vacuum it is ten orders greater. It is clear that elementary particles can not exist in physical vacuum without interaction with it. Therefore, the existence of isolated ("bare") elementary particles (BEPs) is impossible. BEPs are sure to be united with some EPVs. The purely bare elementary particles are only EPVs themselves, therefore, they are not observable in our laboratory space where they are absent. At the same time, when BEPs are united with EPVs, the structure (BEP + EPV) appears. It is that what is called now the quark structure of the elementary particles, i.e. according to TFF, the quark structure is the union of the BEPs and EPVs excited in a certain way. Just these elements of the excited BEPs and EPVs, which formed the quark structure, are the quarks. The quarks theory, based on this principle, not only coincides with the experiment and with the principal ideas of the existing quarks theory, but explains the nature of these elements of particles, i.e. the quarks. It becomes clear why the quarks have the fractional charge, and why they have a certain force field, which at random and unlawfully is called the "colour". It becomes clear which property distinguishes one kind of quarks from others, i.e. the nature of that quark property which is unlawfully called the "flavor". The quarks theory and its consequences are discussed in the last subsection of part I.

PART II

THE PRINCIPAL EQUATIONS OF THE THEORY AND THEIR SOLUTIONS

7 The Triunity Law of the space–time–matter

Rewrite the principal equation of the triunity (see the equation (5.53)):

$$R_{\mu\nu}^{(\zeta)} - \frac{1}{2} g_{\mu\nu}^{(\zeta)} (R_\zeta - 2\Lambda_\zeta) = \frac{8\pi\gamma_\zeta}{c^4} T_{\mu\nu}^{(\zeta)} . \tag{7.1}$$

It is known that there are many solutions of the equations of such type even within the bounds of GR. A part of these solutions was discussed above. Here we shall rest upon the discussed structure of the solutions of the equations of the (7.1) type and especially upon the cardinally new interpretation of the mathematical essence of these solutions. This new approach is connected with the use of the spatial metamorphosis which is the corner-stone of our methodologic basis, i.e. PVDS. Within the bounds of this approach all solutions of (7.1) should be considered as those which are realized only in the fiber bundles. According to our interpretation, the "pseudo-geometries" (including the pseudo-Euclidian Minkowski geometry and the pseudo-Riemannian geometry) have non-equisigned signature by the only reason that the positive terms of the square of, for example, the simplest interval

$$ds^2 = g_{00}c^2dt^2 - g_{11}dr^2 - g_{22}d\theta^2 - g_{33}d\varphi^2 , \tag{7.2}$$

concern the real base of the fiber bundle, the negative ones concern the fiber placed in the imaginary domain, and the entire interval is geometrically placed in the enclosing space which is a complex one.

All the more, according to the principle of the spatial metamorphosis, objects of TFF exist in the Null subspace where the scalar component of FF reveals and in the second and the third subspaces where the charges which are distributed over the entire Null subspace are concentrated in the points which are sure to move with definite velocities. This is the only reason why it is lawful to speak about the velocity of their movement even in the static conditions of the Null subspace.

For the same reason the point structureless charges, observable directly in the first (laboratory) subspace, reveal in it such properties connected with their spatial structure as the spin, the magnetic moment, the mass, etc. These characteristics reveal in the laboratory subspace, but originate and are calculated in other elements of the fiber bundle.

We have reminded the reader of all this so that the calculation of the principal parameters of all kinds of interactions in which EPs can take part would become clear to him and when getting acquainted with these calculations he could restore in memory the information given previously in the book.

We solve the TL equation for the condition:

$$\frac{dE}{dg_{00}} = 0\,, \tag{7.3}$$

taking into consideration that

$$g_{00} = 1 - \frac{2\,r_\gamma}{r}\,;\; g_{33} = r^2\,; \tag{7.4}$$

$r_\gamma = \dfrac{2\,\gamma\, m_\gamma}{c^2}$ (m_γ is the mass generating the field).

From (7.2) and the Hamilton-Jacobi equations it follows directly:

$$E^2 = \left[\frac{M^2}{r_\gamma^2}(1 - g_{00})^2 + m^2c^2 + g_{00}\left(\frac{\partial s}{\partial r}\right)^2\right] g_{00}\, c^2\,. \tag{7.5}$$

Putting the condition (7.3) upon (7.5) we have:

$$\begin{aligned}&\frac{M^2}{r_\gamma^2}(g_{00} - 1)(3g_{00} - 1) + m^2c^2 + \frac{dA_m(g_{00})}{dg_{00}}(1 + g_{00})^2 g_{00} + \\ &+ 2A_s(g_{00})g_{00} + \frac{dA_s(g_{00})}{dg_{00}}\, g_{00} = 0\,.\end{aligned} \tag{7.6}$$

If

$$\frac{M^2}{r_\gamma^2} = \text{const}\,, \tag{7.7}$$

and the orbit is stable, i. e.

$$dr = 0\,, \tag{7.8}$$

then the last three terms in (7.6) are equal to zero and the only left are

$$\frac{M^2}{r_\gamma^2}(g_{00}-1)(3g_{00}-1)+m^2c^2=0. \quad (7.9)$$

Since $(g_{00}-1)(3g_{00}-1)=(1-g_{00})(1-3g_{00})$, then

$$\frac{M^2}{r_\gamma^2}(1-g_{00})(1-3g_{00})+m^2c^2=0, \quad (7.10)$$

from where

$$M^2=-\frac{m^2c^2r_\gamma^2}{(1-g_{00})(1-3g_{00})}, \quad (7.11)$$

or by taking into account (7.4),

$$M^2=-\frac{4m^2\gamma^2m_\gamma^2}{c^2(1-g_{00})(1-3g_{00})}, \quad (7.12)$$

or

$$M=\frac{2i\,m_\gamma\,m\gamma}{c(1-g_{00})^{1/2}(1-3g_{00})^{1/2}}. \quad (7.13)$$

We consider that $m_\gamma=(m_+)+(m_-)$ and that it corresponds to the longitudinal part of the observable mass m, i.e.

$$m_\gamma=\frac{m_0}{(1-\beta^2)^{3/2}}f(\beta)=\frac{m}{(1-\beta^2)}f(\beta), \quad (7.14)$$

where

$$f(\beta)=\frac{a_g(1-g_{00})(1-3g_{00})}{k_f^3\,\varepsilon_f^{3/2}}. \quad (7.15)$$

Here and further on all notations correspond to those adopted in part IV dedicated specially to the calculation of the EPs parameters. The physical sense demands that the following equality should hold:

$$\frac{\gamma m_p^2}{r^2}=\frac{\alpha\hbar c}{r^2}, \quad (7.16)$$

where γ and α are the constants of the equivalent "gravitational" and field interactions of FF. From (7.16) it follows:

$$\alpha = \frac{\gamma m_p^2}{\hbar c} . \tag{7.17}$$

Then, for example, for the proton we have:

$$\alpha_p = \frac{\pi (1-\beta_1^2)_p k_f^{1/2} \varepsilon_f^{3/2}}{a_{gp} (1-g_{00})_p^{1/2} (1-3g_{00})_p^{1/2}} = 7.297\,352\,560 \cdot 10^{-3} , \tag{7.18}$$

$$\gamma_{(el)} = \gamma_p = \frac{\pi \hbar c (1-\beta_1^2)_p k_f^{1/2} \varepsilon_f^{3/2}}{m_p^2 a_{gp} (1-g_{00})_p^{1/2} (1-3g_{00})_p^{1/2}} = 8.246\,437\,574 \cdot 10^{28}\, c^3 / gs^2 , \tag{7.19}$$

This is the constant of the "strong gravitation" for the electromagnetic interactions of the proton.

For any i th particle the "strong gravitation" equivalent to the electromagnetic interactions is determined as follows:

$$\gamma_{(el)} = \frac{s_p^2 (1-\beta_2^2)_i \pi \hbar c k_f^{1/2} \varepsilon_f^{3/2} (1-\beta_1^2)_p}{s_i^2 (1-\beta_1^2)_i K_N m_i^2 a_{gi} (1-g_{00})_i^{1/2} (1-3g_{00})_i^{1/2}} = \text{const} , \tag{7.20}$$

where K_N is a certain normalizing factor the value of which is near to one. The numerical value $\gamma_{(el)}$ is possible to be determined for all EPs !

For example, the value $\gamma_{(el)}$ for the electron which has $(1-\beta_1^2)_e = 6.333\,465\,570 \cdot 10^{-10}$ and $m_e^2 = 8.298\,099\,996 \cdot 10^{-55}$ (see part IV) can be determined as follows:

$$\gamma_{(el)} = \frac{\pi\, 3.161\,530\,263 \cdot 10^{-17} \times 6.333\,465\,571 \cdot 10^{-10} \times 1.000\,000\,549}{8.298\,099\,996 \cdot 10^{-55} K_N} = \frac{7.580\,731\,933 \cdot 10^{28}}{K_N} ,$$

which is by 1.087 815 483 times less than the corresponding value of the proton ($8.246\,437\,574 \cdot 10^{28}$), if we consider K_N to be equal to one.

But for the electron:

$$K_N = \frac{8 s_p^2 (1-\beta_2^2)_p}{9 s_e^2 (1-\beta_1^2)_p} = (1.087\,678\,384)^{-1} . \tag{7.21}$$

Then for the electron and the proton:

$$\gamma_{(el)/e} = \gamma_{(el)/p} = 8.246\,437\,574 \cdot 10^{28}\, c^3 / g\, s^2 ,$$

and for any EP:

$$\alpha_{(el)} = \frac{\pi (1-\beta_1^2) k_f^{1/2} \varepsilon_f^{3/2}}{a_g (1-g_{00})^{1/2} (1-3g_{00})^{1/2}}; \tag{7.22}$$

$$\gamma_{(el)} = \frac{\pi (1-\beta_1^2) k_f^{1/2} \varepsilon_f^{3/2} \hbar c}{a_g (1-g_{00})^{1/2} (1-3g_{00})^{1/2} m^2} = \frac{\alpha \hbar c}{m^2}. \tag{7.23}$$

And so, in 2SS the fundamental field excites the electromagnetic interaction characterized by (7.22) and (7.23).

In 3SS taking into consideration that

$$\begin{cases} g_{00}^{(3)} = (|\beta_1^{(3)}|^2 + |\beta_2^{(3)}|^2 - 1); \\ \beta_1^{(3)} = n_{1p} \beta_{1p}; \beta_2^{(3)} = n_{2p} \beta_{2p}, \end{cases} \tag{7.24}$$

we have for $\alpha^{(3)}$:

$$\alpha^{(3)} = \frac{\pi \left(1 - \dfrac{1}{n_1^2 \beta_1^2}\right)_p k_f^{1/2} \varepsilon_f^{3/2}}{3^{1/2} a_g \left(1 + \dfrac{n_2^2 \beta_2^2}{n_1^2 \beta_1^2}\right)_p \left[1 - \dfrac{1}{\left(1 + \dfrac{n_2^2 \beta_2^2}{n_1^2 \beta_1^2}\right) n_1^2 \beta_1^2}\right]^{1/2} \left[1 - \dfrac{1}{\left(1 + \dfrac{n_2^2 \beta_2^2}{n_1^2 \beta_1^2}\right) 3 n_L^2 \beta_L^2}\right]^{1/2}}. \tag{7.25}$$

According to the physical sense for the third subspace:

$$a_g^{(3)} = \left| \frac{R_2^{(3)} (1-\beta_2^2)^{3/2}}{R_1^{(3)} (1-\beta_1^2)^{3/2}} \frac{a_{gp}^{1/2}}{\varepsilon_{2p}^{3/2}} \right|^2 \frac{(1-\beta_1^2)^{3/2} \varepsilon_{2p}^{1/2}}{(1-\beta_2^2)^{3/2} \varepsilon_{1p}}, \tag{7.26}$$

where

a) the first term is the complete analogue of

$$a_{gp}^{1/2} = \frac{R_2 (1-\beta_2^2)_p^{3/2}}{R_1 (1-\beta_1^2)_p^{3/2}} = \frac{\beta_2 n_2 (1-\beta_2^2)^{3/2}}{\beta_1 n_1 (1-\beta_1^2)^{3/2}} = \frac{\beta_2 k_y}{\beta_1 k_x};$$

b) the second term $\dfrac{a_{gp}^{1/2}}{\varepsilon_{2p}^{3/2}}$ is the factor of the transition from 3SS to the calculation subspace $(3 \to 1)$;

c) $\frac{(1-\beta_1^2)^{3/2}}{(1-\beta_2^2)^{3/2}}$ is an additional factor under mapping;

d) $\frac{\varepsilon_{2p}^{1/2}}{\varepsilon_{1p}}$ is the factor, taking into account the permittivity of physical vacuum.

Taking into account (7.24) we can write (7.25) as follows:

$$\alpha^{(3)} = \frac{\pi(|\beta_1^{(3)}|^2 - 1)k_f \varepsilon_f^2}{a_g^{(3)}(|\beta_1^{(3)}|^2 + |\beta_2^{(3)}|^2 - 1)^{1/2}(3|\beta_1^{(3)}| + 3|\beta_2^{(3)}|^2 - 1)^{1/2}}, \tag{7.27}$$

where

$$a_g^{(3)} = \left|\frac{R_2^{(3)}(1-\beta_2^2)_p^{3/2}}{R_1^{(3)}(1-\beta_1^2)_p^{3/2}}\right|^2 \frac{(1-\beta_1^2)_p^{3/2}\varepsilon_{2p}^{1/2}}{(1-\beta_2^2)_p^{3/2}\varepsilon_{1p}k_{fp}\varepsilon_f^{1/2}}; \tag{7.28}$$

$$\frac{R_2^{(3)}}{R_1^{(3)}} = \frac{m_1^{(3)}\varepsilon a_{gp}^{1/2}}{m_2^{(3)}\varepsilon_{2p}^{3/2}} = \left(\frac{8}{9}\right)^{1/2}\frac{a_{gp}^{1/2}}{\varepsilon_{2p}^{3/2}}. \tag{7.29}$$

By substituting the corresponding numerical values we obtain:

$\alpha^{(3)} = 1.000\,000\,003$,

i.e. $\alpha^{(3)}$ is equal to one, up to the accuracy of our calculation. Since

$$\gamma^{(3)} = \alpha^{(3)}\frac{\hbar c}{|m^{(3)}|^2}, \tag{7.30}$$

then

$$\gamma^{(3)} = \frac{\hbar c}{|m^{(3)}|^2}. \tag{7.31}$$

Thus, we have found the constants of the strong and superstrong interactions.

To find the corresponding constants of the weak interaction we take into account the fact that there is the following relation between the constants of the field interaction in 3SS and CSS (in the latter the weak interaction does take place):

$$\alpha_{\text{weak}} = \alpha^{(3)}\frac{(1-\beta_1^2)_p}{(|\beta_1^{(3)}|^2 - 1)^{3/2}}. \tag{7.32}$$

Since $\alpha^{(3)} = 1$, then

$$\alpha_{\text{weak}} = \frac{(1-\beta_1^2)_p}{(|\beta_1^{(3)}|^2 - 1)^{3/2}} = 9.193\,987\,430 \cdot 10^{-15}. \tag{7.32a}$$

Taking into account the fact that strong (superstrong) and weak interactions are provided by the string of FF, and that along the string the parameters of the field and, consequently, those of the interactions change linearly, and that in the third SS the length scale differs by $\pi\,(1-\beta_2^2)_p^{-1}$ times, we obtain the radius of the weak interaction:

$$R_{\text{weak}} = \frac{\alpha^{(3)}\pi\,(1-\beta_2^2)_p^{-1}}{\alpha_{\text{weak}}}\,R^{(3)}\,. \tag{7.33}$$

Since $R^{(3)} = 1.615950164 \cdot 10^{-33}$ c, then $R_{\text{weak}} = 2.161236440 \cdot 10^{-16}$ c. It corresponds very well to the well-known from the experiment concepts about the radius of action of the weak interaction forces.

Since, for the weak interaction the following formula also holds:

$$\gamma_{\text{weak}} = \alpha_{\text{weak}}\,\frac{\hbar c}{m_p^2}\,, \tag{7.34}$$

then in this case we find $\gamma_{\text{weak}} \equiv \gamma^{(2 \to 1)}$.

Thus, there are three constants of the field interaction:

$$\begin{cases} \text{1) the strong (the superstrong) interaction with } \alpha^{(3)} = 1\,; \\ \text{2) the electromagnetic interaction with } \alpha^{(2)} = 7.297\ 320\ 66 \cdot 10^{-3};\ 7.297\ 352\ 378 \cdot 10^{-3} \\ \text{3) the weak interaction with } \alpha^{(2 \to 1)} = 9.193\ 987\ 430 \cdot 10^{-15}\,, \end{cases} \tag{7.35}$$

and the constants of the strong gravitation corresponding to them:

$$\begin{cases} \text{1) the strong (the superstrong) interaction with } \gamma^{(3)} = 1.130\ 059\ 064 \cdot 10^{31} \text{ and} \\ G^{(3)} = 6.671\ 671\ 75 \cdot 10^{-8}\ \text{c}^3/\text{g s}^2\,; \\ \text{2) the electromagnetic interaction with } \gamma^{(2)} = 8.246\ 437\ 57 \cdot 10^{28}\ \text{c}^3/\text{g s}^2\,; \\ \text{3) the weak interaction with } \gamma^{(2 \to 1)} = 1.832\ 564\ 93 \cdot 10^{17}\ \text{c}^3/\text{g s}^2\,; \\ \text{4) the macroscopic gravitational interaction with } \gamma^{(1)} = 6.672\ 444\ 46 \cdot 10^{-8}\ \text{c}^3/\text{g s}^2\,. \end{cases} \tag{7.36}$$

In TFF, for the first time, the result is obtained, according to which the constants of the gravitational interaction in the most deep regions of microcosm and in macrocosm are very close to each other, almost equal though not exactly.

The result of the calculation of these constants is very important. It shows that

$$\frac{\gamma^{(1)}}{\gamma^{(3)}} = 1.000\,115\,82\,, \tag{7.37}$$

and at the same time

$$\left(\frac{\varepsilon_{1p}}{\varepsilon_{2p}}\right)^{1/2} = 1.000\,115\,83\,. \tag{7.38}$$

Thus, the constants of the gravitational interactions in the third and first subspaces differ by the ratio of the square roots from the permittivities of physical vacuum for the external (ε_{1p}) and internal (ε_{2p}) circular currents of the proton structure in SS(2→1).

8 HOW TFF EXPLAINS THE ORIGINATION OF SPINORIAL AND VECTORIAL FIELDS

It is known [144] that Dirac has obtained the spinorial equation of field from the Klein—Gordon equation of the scalar field by means of quotation of the operator

$$(\Box - m^2)^{*)} . \tag{8.1}$$

Thus, [3]:

$$(\Box - m^2) \equiv (i\gamma^k \frac{\partial}{\partial x^k} + m)(i\gamma^n \frac{\partial}{\partial x^n} - m) . \tag{8.2}$$

To obtain the spinorial equation from the scalar equation of FF we consider the following. The right hand side of (5.34) is equal to zero for the spectrum of permissible values of the constant R on the surfaces of the spheres S_i^2 where R takes the following spectrum of discrete values:

$$R = |R|_1 ; |R|_2 ; \dots |R|_n . \tag{8.3}$$

These spheres are the boundaries of the manifolds for which (5.34) holds. Consequently, for this spectrum of values R on the corresponding S^2 the following condition holds:

$$\Delta \varphi (\pm) R^{-2} \varphi = 0 \quad (R = \frac{\hbar}{mc} \rightarrow \frac{1}{m} , \text{if } \hbar = c = 1) . \tag{8.4}$$

Yet, for the operator $\Delta + R^{-2}$ the Dirac mode (8.2) cannot be used because the quotation of the (8.2) type is not permissible for the operator independent of the time. We introduce the time and replace (5.34) by

$$\Box \varphi (\pm) \varphi R^{-2} = \frac{\varphi}{r^2} \left(\frac{R^2}{r^2} - 2\frac{R}{r} + \frac{r^2}{R^2} \right) \tag{8.5}$$

(the right hand side is the same since it is independent of the time). It is easy to see that in this case the Dirac quotation (8.2) is permissible for the spectrum on these surfaces. Yet, it is permissible not for all possible solutions of (8.5) but only for those which satisfy the condition

$$\frac{\partial}{\partial x_0} \psi = -i (\gamma_0)^{-1} [m\varphi_{FF} + m\psi - i\gamma^k \frac{\partial}{\partial x^k} \psi] , \tag{8.6}$$

*) The notation is borrowed from [3].

where $\psi = \varphi - \varphi_{FF}$ is the potential which is the solution of (8.5);

$$\varphi_{FF_4} = \begin{pmatrix} \varphi_{0FF} \\ \varphi_{1FF} \\ \varphi_{2FF} \\ \varphi_{3FF} \end{pmatrix} \quad \text{is the four-component function of the FF potential.} \qquad (8.7)$$

Consequently, from (8.5) and (8.2) we have two spinorial equations:

$$(i\,\gamma^n \frac{\partial}{\partial x^n} - R^{-1})\,\psi(x) = 0\,; \qquad (8.8)$$

$$(i\,\gamma^k \frac{\partial}{\partial x^k} + R^{-1})\,\psi(x) = 0\,, \qquad (8.9)$$

which hold only for the above-mentioned surfaces S^2.

Under the proper choice of matrices γ^n the equation (8.8) becomes the ordinary Dirac equation [3], and in the case when ψ-function is redefined, (8.9) becomes the spinorial Dirac equation conjugate with the first one. In the case, when ψ-function is not redefined, (8.9) becomes the Dirac equation for the particles with negative masses. Both these results do correspond with the structure of BEPs in TFF. All the more, only the structure of the particles described in this book satisfies the equations (8.5)—(8.9).

Thus, the spinorial equations first found by Dirac are the equations of both the structure and the dynamics of such structure for the sources-charges of the corresponding field. The first work indicative of the fact that the Dirac equation characterizes a certain structure was that of E. Schrodinger, who had found that there was a certain internal motion in the Dirac particles. He called it Zitterbewegung. This motion is characterized by the frequency

$$\frac{2H}{\hbar}, \qquad (8.10)$$

(where H is the hamiltonian of the particle dynamics) and the amplitude

$$\frac{c\hbar^2}{4H^2}\, i\, \dot{\gamma}^k\,. \qquad (8.11)$$

The most curious is the fact that in the case when the momentum of the particle as a whole is equal to zero, the eigen values of the operators of the frequency and amplitude of the internal motion are respectively equal to

$$\nu = \frac{2mc^2}{\hbar} \text{ and } A = \frac{\hbar}{2mc}, \qquad (8.12)$$

and the linear velocity of such motion is exactly equal to the velocity of light c.

This result turned out to be a starting point for a number of works carried out by Honl and Papapetrou (see, for example, [21]) where the authors showed that the Dirac equation described the "mass-dipole" consisting of the positive and negative masses and moving with the velocity of light along the circumference of the radius of the order of the Compton wave-length. These works did not rise any resonance in the principal journals on physics. From the positions of strengthened agnosticism discussed in section 1, such works were "taboo". To justify this unlawful interdiction, practically all physicists caught up the proposition of the English theorists Foldy and Woithoisen to redefine formally the coordinate operator in the Dirac equation and by doing so, as they said, to remove the internal motion in the Dirac particles. It was so much in keeping with the public expectations that the works of Foldy and Woithoisen are still cited even in text books in spite of their complete erroneousness. This "trembling" motion of some internal elements of the Dirac particles cannot be removed in principle within the bounds of the Dirac theory itself. In 1973 this was proved in [141] and in the thesis defended by the same author. Yet, the prejudice proved to be stronger, and [141] together with analogous works of other authors were simply ignored. To Dirac credit it should be noted that he always considered the internal motion to be the property of the particles described by his equation and related the physical nature of the particles spin to this motion [144]. But this opinion was also ignored.

TFF put an end to this discussion lasting for many years about the internal motion in the particles described by the spinorial equations of the Dirac equation type, though there have been other authors who consider that internal motion does exist and is responsible for particles spin. The difficulties, arisen under consideration of the internal "trembling" motion of the elements of the structural spinorial particles, are removed in TFF by considering that this motion occurs in the fibers of the enclosing space of microcosm which are situated in the imaginary domain of this space, if the base of the fiber bundle, the laboratory space, is considered to be situated in the real domain (for detail see the previous section).

The procedures of transition from free spinorial equations to vectorial ones are now well developed. This mathematical apparatus for transition to the interacting fields is also thoroughly developed (see [13, 27]). Therefore, we shall not repeat here these generally known transitions. We only attract the reader's attention to the great additional possibilities of the mapping method which is beyond the bounds of conventional schemes. We illustrate it by the following example.

The scalar component of FF is characterized by the non-linear potential:

$$\varphi = \frac{q}{r}\,[1 - (1 - e^{-R/r})\,]. \tag{8.13}$$

Yet, under certain conditions this potential under mapping can lose the non-linearity and turn into the ordinary linear Coulomb potential. Now, we give an example of the mode of mapping of the scalar potential of FF onto the Coulomb potential. The following chain of mappings is most illustrative:

$$\frac{q}{r}e^{-R/r} \to q\frac{e^{-R/ir}}{ir} \to q\frac{e^{iR/r}}{ir} \to \left(\frac{q}{ir}e^{iR/r}\right)e^{-iR/r} \equiv \frac{q}{ir}. \tag{8.14}$$

Under this mapping the gauge shift by the value of $e^{(\mp)\,iR/r}$ is used. The following mapping can also be obtained in this case:

$$\frac{q}{r} \to \frac{q}{ir} \to \frac{q}{ir}e^{-iR/r} \equiv \frac{q}{ir}e^{+R/ir}. \tag{8.15}$$

Here it is suitable to note that in TFF the scalar component of the fundamental field (5.34) and (8.13) has two important features. Firstly, TL (7.1) gives the following square of interval:

$$ds^2 = e^{-R/r}c^2\,dt^2 - r^2(\sin^2\theta\,d\varphi^2 + d\theta^2) - e^{R/r}\,dr^2, \tag{8.16}$$

it being known that

$$g_{00} = e^{-R/r} \simeq (1 - \frac{R}{r}). \tag{8.17}$$

In this case the triunity equation is solved exactly, and for the mixed components T^i_k we have:

$$T^0_0 = T^1_1 = -\frac{c^4}{8\pi\gamma r^2}\left[e^{-R/r}(1 + \frac{R}{r}) + 1\right]; \tag{8.18}$$

$$T^2_2 = T^3_3 = -\frac{c^4 R^2}{16\pi\gamma r^4}e^{-R/r}. \tag{8.19}$$

Secondly, under the positive sign of the right hand side of (8.5) we have:

$$\Box\,\varphi = \frac{\varphi}{r^2}\left[(1 - \frac{R}{r})^2 - 1\right]. \tag{8.20}$$

This equation for the potential can be represented in the form:

$$\Box\,\varphi - u'(\varphi) = 0, \tag{8.21}$$

where u is the function of φ satisfying the condition

$$u'(\varphi) = \frac{\varphi}{r^2}\left[(1 - \frac{R}{r})^2 - 1\right]. \tag{8.22}$$

In this case without any additional suppositions and assumptions we have all important features of the Higgs equation for the non-linear function of the potential $u(\varphi)$, including the celebrated "Higgs effect".

Indeed, from (5.20) for $u(\varphi)$ we obtain the dependence of u on φ, when two minima are provided and consequently, the Higgs effect is also provided. In TFF for this aim there is no need to introduce artificially the fitting potential. The Higgs effect is peculiar to the principal potential of FF.

Thus, in TFF as well as in other modern gauge theories the appearance of the mass in 1SS, while in 2SS it is equal to zero, is the consequence of the Higgs effect.

In the conclusion of the discussion on the vectorial fields origination in TFF it is necessary to note the following.

1. The scalar field, static in time, existing in 0SS, is mapped onto other subspaces only under the inclusion of the time, forming there, the moving structures connected with the vectorial fields.

2. All the structures arising in other subspaces are the spinorial objects, and in the normal state their spin is equal to 1/2. There are no special spinorial fields. There are spinorial structures arising under the quotation of the equations of the static scalar fields.

3. The symmetry centers of the structures are the geometrical place of mapping of the field, i.e. the charge of this field. The places of location of the charge of the scalar and vectorial components of FF do not coincide, i.e. the complex shift occurs. So. the charges of the scalar component are situated in the centers of the 0SS cells and the charges arisen under mapping and including the time of the vectorial fields, are situated on the boundary of the neighbourhood of the signed point, where the charge of the scalar component is situated which moves along the trajectory placed on this boundary.

4. In contrast to scalar fields having the spherical symmetry, the vectorial fields have the axial symmetry.

9 QUANTUM AND RELATIVISTIC PROPERTIES OF MATTER STRUCTURES

9.1. Principal equations

At first we consider how soliton structures arise in TFF. It is possible to show that the subparticles structure on the circumferences is introduced into TFF in a natural way, if to use the group approach in the subspaces description and the notion of the Lie group with the memory. Yet, this approach does not allow to describe effectively the dynamics of such objects. For the description of the dynamics it is necessary to use the dynamic equations of the field, reduced on the circumference, which turn out to be non-linear in this case. Recently [140], methods were developed of the exact solution of a certain class of the non-linear problems which show that the soliton-like solutions arise in a sufficiently wide class of such equations. In this connection we also investigate the soliton structure of the solutions on circumferences forming the particles substructure in TFF. We shall show that the subparticles moving along circumferences can be considered as the soliton-like clots of the charge density which are regularly situated on the circumferences and move with the constant angular velocity.

Most of solitons studied in [40] are one-dimensional solitons, given on $\mathbb{R}^1$. We introduce the mode of transition from the manifold $\mathbb{R}$ to the manifold $U(1)$, isomorphic to the circumference. For this aim we use the following mapping which is the homomorphism of the groups:

$$\begin{cases} f: \mathbb{R} \to U(1)\,; \\ f(x) = e^{2\pi i x} \in U(1)\,. \end{cases} \tag{9.1}$$

By means of mapping (9.1) it is possible to put the function given on $\mathbb{R}$ in correspondence to any function given on $U(1)$. The reverse is wrong. In order that the function $f: \mathbb{R} \to x$ could be transferred to $U(1)$ by means of (9.1) it is necessary (and sufficient) that f should be the periodical function with the period equal to one, i.e. $f(x) = f(x+1)$ for all $x \in \mathbb{R}$ ..

The differencial equations given on $\mathbb{R}$ can be transferred to $U(1)$, if the dependence of these equations on $x \in \mathbb{R}$ (if any) is also of the periodical character.

The most studied equation, having the soliton solution, is the Corteveg de Vries (CdV) equation:

$$y + V_0 \left(y + \frac{3}{4h} y^2 + \frac{h^2}{6} y'' \right)' = 0\,. \tag{9.2}$$

As we see, this equation does not include the terms dependent on x. Therefore, it can be transferred to $U(1)$ by means of homomorphism (9.1). Further on for studying the model we assume that the charge density on the circumference satisfies this equation. As it would be seen, such assumption does not reduce the accuracy of further calculations.

As it is known, on R the equation (9.2) has the exact soliton solution of the form

$$y(t,x) = y_0 / ch^2\left(\frac{x - vt}{l}\right), \tag{9.3}$$

where $v = v_0 \left[1 + \frac{y_0}{2h} \right]$; $l = \left(\frac{4h^3}{3y_0}\right)^{1/2}$.

To transfer the solution (9.2) to the circumference, the solution should be periodical. The solution (9.3), apparently, is not periodical. Nevertheless, it is possible to use an approximate approach. We introduce the following function into consideration:

$$y_{\infty}^{N}(t,x) = \sum_{n=-\infty}^{\infty} y\left(t, x - \frac{n}{N}\right), N \in N, \tag{9.4}$$

where N is the positive integer; y is determined from (9.4). It is not difficult to see that this series converges for all t, x. Further on, if the soliton width (9.3) is much less than $1/N$, then (9.4) is an approximate solution of (9.2). The profile of the function (9.4) under the fixed t is of the form of the infinite sequence of the peaks situated at a distance of $1/N$ from each other.

The condition under which (9.4) can be considered as an approximate solution of (9.2) is as follows:

$$l = \left(\frac{4h^3}{3y_0}\right)^{1/2} << \frac{1}{N} . \tag{9.5}$$

It is easy to prove by means of a direct estimation of the error. It is also clear that the solution (9.4) is periodical with respect to x, with the period equal to $1/N$, i.e. 1 is also the period.

Indeed,

$$y_{\infty}^{N}\left(t,x + \frac{1}{N}\right) = \sum_{n=-\infty}^{\infty} y\left(t,x - \frac{n}{N} + \frac{1}{N}\right) = \sum_{n'=-\infty}^{\infty} y\left(t,x - \frac{n'}{N}\right) = y_{\infty}^{N}(t,x) . \tag{9.6}$$

If this condition holds it means that the solution (9.4) can be correctly transferred to the circumference $U(1)$ by means of the mapping (9.1). If to make substitution $\theta = 2\pi x$ then the function (9.4) on the circumference is rewritten in the form

$$y_{\infty}^{N}(t,\theta) = \sum_{n=-\infty}^{\infty} y\left(t, \frac{\theta}{2\pi} - \frac{n}{N}\right) . \tag{9.7}$$

It is clear that within the interval $0 \leq \theta \leq 2\pi$ there are exactly N "peaks" of the function (9.7). From the condition (9.5) it follows that they are sharp, narrow peaks; they move along the circumference at the constant angular velocity:

$$\omega = 2\pi\nu = 2\pi\nu_0 \left(1 + \frac{y_0}{2h} \right). \tag{9.8}$$

The effective width of a "peak" is calculated from the formula

$$\theta_{wid} = 2\pi l = 2\pi \left(\frac{4h^3}{3y_0} \right)^{1/2}. \tag{9.9}$$

Taking into account the condition (9.5) we have:

$$\theta_{wid} << \frac{2\pi}{N}. \tag{9.10}$$

If, as it was mentioned above, to interpret the function on the circumference as the charge density, then we obtain N "clots" of the charges regularly situated on the circumference. Due to the condition (9.10) they can be considered as the point particles, moving along the circumference at the constant angular velocity determined by (9.8).

Thus, on the basis of the soliton approach the dynamics of the subparticles can be described in TFF. We also note that an approximate method of obtaining the periodical (with respect to x) soliton-like solutions of the equation (9.2) is used here. (The better the condition (9.5) holds, the more correct the solution is). By now the method has been developed to obtain the exact periodical (with respect to x) solutions of such type equations. It can promote the more exact investigations of the subparticles dynamics in TFF.

As far back as in [19] we noted that the L. de Broglie equation, without fail, has connection with a certain wave process:

$$v = u - \lambda \frac{du}{d\lambda}, \tag{9.11}$$

in which there is the following relation between the phase velocity u and the group velocity v:

$$u\,v = c^2. \tag{9.12}$$

From these equations it follows that

$$\frac{\lambda}{(c^2/v^2 - 1)^{1/2}} = \text{const}. \tag{9.13}$$

If the group velocity v coincides with the velocity of the particle whose mass is m, then assuming the constant in (9.13) to be equal to $\frac{\hbar}{m_0 c}$, we have the L. de Broglie equation

$$\lambda = \frac{\hbar}{mv}. \tag{9.14}$$

It is shown in [33] that the motion, relative to the stationary wave, causes a peculiar wave process, formally adequate to the dispersion. It turns out that this "pseudo-dispersion" when it is very small results in the L. de Broglie equation in limit. A certain coefficient appears, when there is a need to take into account this dispersion in the right hand side of the equation (9.14). In TFF the phenomenon of the "pseudo-dispersion" is interpreted as the result of the particles motion relative to the stationary waves in PV, which were formed under mutual compensation of the radiation by the charges of FF, moving on the "internal" and "external" circumferences of the BEP structure in 2SS [7, 14, 33, 34].

It is very important to emphasize here that the quantum processes in the laboratory SS arise by the only reason that their existence is provided by the processes occurring in other subspaces (fibers) where, though it seems paradoxical, the motion can be quasi-classical with a small quantum of the action or even classical (see Fig. 9.1).

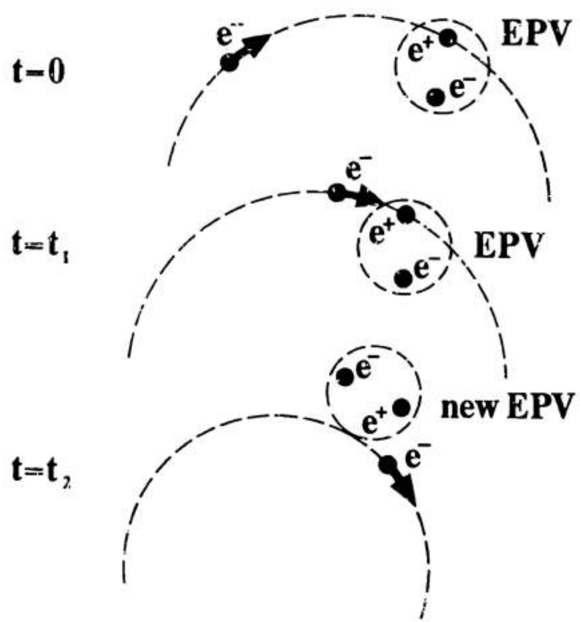


Fig. 9.1 Scheme of origin and annihilation of an electron in the atom in the second subspace (this process is responsible for quantum properties of electron covers).

It turns out that the physical nature of all principal equations of quantum mechanics is connected in this or that way with the processes of interaction of bodies both with physical vacuum or by means of it. This is quite evident under the deduction of the Schrödinger equation.

The Schrödinger equation like other fundamental equations of the modern quantum theory can be deduced in different ways. Here we give the simplest deduction of this equation.

The Schrödinger equation is the equation of stability of the particles described in 1SS. We now write the stability equation for the action s in the following form:

$$\Delta s = 0\,. \tag{9.15}$$

For the instantaneous value of the energy E of this stable system by the non-relativistic approximation from the Hamilton—Jacobi equation we have:

$$E = T + U = \frac{|\vec{p}|^2}{2m} + U(x,y,z) \equiv \frac{1}{2m}\left[\left(\frac{\partial s}{\partial x}\right)^2 + \left(\frac{\partial s}{\partial y}\right)^2 + \left(\frac{\partial s}{\partial z}\right)^2\right] + U\,, \tag{9.16}$$

where T and U are the kinetic energy and the potential one, respectively, and the components of the vector $\vec{p}$ are considered as the partial derivatives of s with respect to the coordinates.

Since the properties of EP in 1SS are determined in 2SS where the particle structure, hidden from us, is situated, we have to search for the solution of the equation in the form in which there is a certain function of the state ψ determined in the imaginary, with respect to 1SS, second subspace, i.e. we search for the solution in the form of

$$s = i\,A \log_e \psi\,(x,y,z)\,. \tag{9.17}$$

Here the constant A relates the momentum $|\vec{p}|$ of the particle with the length of a free run of the particle in PV and is determined below.

Forming the partial derivatives with respect to the coordinates:

$$\begin{cases} \dfrac{\partial^2 s}{\partial x^2} = i\,A\left[\dfrac{1}{\psi}\dfrac{\partial^2\psi}{\partial x^2} + \dfrac{1}{A^2}\left(\dfrac{\partial s}{\partial x}\right)^2\right]; \\ \dfrac{\partial^2 s}{\partial y^2} = i\,A\left[\dfrac{1}{\psi}\dfrac{\partial^2\psi}{\partial y^2} + \dfrac{1}{A^2}\left(\dfrac{\partial s}{\partial y}\right)^2\right]; \\ \dfrac{\partial^2 s}{\partial z^2} = i\,A\left[\dfrac{1}{\psi}\dfrac{\partial^2\psi}{\partial z^2} + \dfrac{1}{A^2}\left(\dfrac{\partial s}{\partial z}\right)^2\right], \end{cases} \tag{9.18}$$

and substituting them into (9.15) we have:

$$\frac{1}{\psi}\left(\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2}\right) + \frac{1}{A}\left[\left(\frac{\partial s}{\partial x}\right)^2 + \left(\frac{\partial s}{\partial y}\right)^2 + \left(\frac{\partial s}{\partial z}\right)^2\right] = 0\,. \tag{9.19}$$

Since, according to (9.16),

$$\left(\frac{\partial s}{\partial x}\right)^2 + \left(\frac{\partial s}{\partial y}\right)^2 + \left(\frac{\partial s}{\partial z}\right)^2 = 2m\,(E - U)\,, \tag{9.20}$$

then from (9.19) and (9.20) we finally have:

$$\Delta\psi + \frac{2m}{A}(E - U)\,\psi = 0\,.$$

And if $A = \hbar$, this is just the Schrödinger equation. We can prove it.

According to the definition, in TFF the constant $A_1 = 2\pi A$ is the product of the momentum of the elements of the particle structure and the length of a free run of its subparticles in PV, i.e.

$$\lambda_{fr}\,p = A_1\,. \tag{9.21}$$

If $n_V = (n_{2p}\,n_{1p})^{1/2}$ is the concentration of the particles in the proton-antiproton vacuum, then it is easy to see that the following equality should hold:

$$\lambda_{fr} = \left(\frac{\pi}{n_V}\right)^{1/3}. \tag{9.22}$$

In TFF

$$n_V = \frac{1}{8\pi^2 R_p^3}\,, \tag{9.23}$$

and then for the length of a free run we have:

$$\lambda_{fr} = 2\pi R_p\,, \tag{9.24}$$

where R_p is the effective external radius of the subparticles motion of the EPV in the proton-antiproton vacuum, which is determined by the equality:

$$R_p = \frac{\hbar}{m_p\beta_p c}\left(\frac{\beta_L\beta_2}{\varepsilon_{2p}}\cdot\frac{\beta_L\beta_1}{\varepsilon_{1p}}\right)^{1/2}, \tag{9.25}$$

where β_L, β_1, β_2 are the linear velocities of the inertia center of the subparticles and of the subparticles themselves, respectively, in the units of light velocity c; ε_{1p} and ε_{2p} are the permittivities of PV for the proton; $\hbar$ is the Plank constant.

From (9.21), (9.24) and (9.25) we have:

$$A_1 = 2\pi\hbar\left(\frac{\beta_L\beta_2}{\varepsilon_{2p}}\cdot\frac{\beta_L\beta_1}{\varepsilon_{1p}}\right)^{1/2}. \tag{9.26}$$

Since the following exact dependence holds for the proton:

$$\left(\frac{\beta_L \beta_1}{e_{1p}} : \frac{\beta_L \beta_2}{e_{2p}} \right) = 1 \, , \tag{9.27}$$

then for the constant A_1 we finally obtain:

$$A_1 = 2\pi\hbar \text{ and } A = \hbar. \tag{9.28}$$

Thus, the constant A is the Plank constant as it should be. And consequently, we have proved here that this global constant has the meaning of the product of the length of a free run of the sub-particles of the proton in physical vacuum and their momentum.

In TFF the quantum properties of matter and the relativistic ones reveal extremely widely. We mentioned them above under the deduction of the equation of the scalar component of FF, under the analysis of the spinorial and vectorial fields, in some way they were touched under the consideration of TL and the geometric construction of the space-time, we mentioned them in the section dedicated to the quarks and we shall discuss them under calculation of the particle parameters, the greatest part of which are, as it is known, the quantum numbers. Therefore, here we restricted our consideration to those quantum properties of particles which are beyond the scope of other sections of this book. As an example we now give the analysis both of the geometrical and some specific properties of the TFF physical objects.

9.2. The structure of the torus as the fiber bundle in 3SS

This structure (Tor_W torus in 3SS) is given by mapping:

$$Tor_W \xrightarrow{p} Tor_B \, , \tag{9.29}$$

where $p(\varphi, \theta, ct) = (\varphi, \theta)$.

Tor_W may be represented as

$$Tor_W = s^1 \times s^1 \times \mathbb{R} \, , \tag{9.30}$$

and since $s^1 \times s^1 = Tor_B$, then (9.30) is equivalent to

$$Tor_W = Tor_B \times \mathbb{R} \, ,$$

which proves the lawfulness of the representation by means of (9.29).

Yet, all these discussions concern the real manifolds which are the base Tor_B, the fiber $\mathbb{R}$ and the enclosing space Tor_W of the fiber bundle (9.29). But Tor_B as the base of the fiber bundle has also a complex structure, i.e. it is the complex space. A natural question arises whether it is possible to generalize this complex structure over the entire space Tor_W .

To consider Tor_W as the complex manifold, it is necessary to establish one-to-one mutual correspondence between the small regions in Tor_W and the open balls in $\mathbb{C}^N$. If such correspondence could not be established, then Tor_W would not be the complex manifold.

This is a significant and non-trivial question. For example, the circle $|z| = 1$ in $\mathbb{C}^1$ is the subset of the complex space but it is not the complex manifold.

The topological structure of Tor_W can be considered as the direct product of (9.30): $\mathrm{Tor}_W = \mathrm{Tor}_B \times \mathbb{R}^1$.

If this structure is left as it is, then evidently it can not be considered as the complex one, at least because it has 3 dimensions, and for the complex structure the real dimensions should be even.

From this situation there are two ways out: either to postulate another structure or to consider Tor_W to be real. The second way out is preferable; yet it is necessary to prove its accordance with the space-time structure. This means that it is necessary:

1) to solve the Killing equation completely;

2) to prove that the arbitrary constants structure is in accordance with the supposed local structure of Tor_W (the neighbourhood is in the complex plane):

$$\mathrm{Loc}\,(\mathrm{Tor}_W) = O_{\mathbb{C}} \times \mathbb{R}^1 . \tag{9.31}$$

The Killing equations on the torus in the apparent form are as follows:

$$\begin{cases} \xi^{\Phi}_{,\Phi} = \xi^{\beta}_{,\beta} = 0 ; & (9.32) \\ \dfrac{\xi^{\beta}_{,\Phi}}{R^2\cos^2\alpha} = - \dfrac{\xi^{\Phi}_{,\beta}}{R^2\sin^2\alpha} . & (9.33) \end{cases}$$

By substituting the variables $u = \dfrac{\xi^{\Phi}}{R^2\cos^2\alpha}$ and $v = \dfrac{\xi^{\beta}}{R^2\sin^2\alpha}$ these equations can be reduced to the form coinciding with the Cauchy-Rieman equations:

$$u_{,\Phi} = v_{,\beta} ; \tag{9.34}$$

$$u_{,\beta} = - v_{,\Phi} . \tag{9.35}$$

Yet, (9.34) is not completely equivalent to (9.32); in fact, it should be equal to zero:

$$u_{,\phi} = v_{,\beta} = 0 . \tag{9.36}$$

Thus, (9.34) and (9.35) determine any analytical function, and (9.36) puts restrictions on it.

We now describe the class of the analytical functions satisfying (9.36).

Let $z = z(W)$ be the analytical function, where

$$z = u + i v , \quad W = \phi + i \beta .$$

We solve the given system of equations (9.34)—(9.36). From (9.36) we have:

$$\begin{cases} u_{,\phi} = 0 \Rightarrow u = u(\beta) ; \\ v_{,\beta} = 0 \Rightarrow v = v(\phi) . \end{cases} \tag{9.37}$$

From (9.35) we have the equation

$$u(\beta)_{,\beta} = - v(\phi)_{,\phi} , \tag{9.38}$$

hence, on both sides of the equation there are constants, i.e. $u(\beta)$ and $v(\phi)$ are the linear functions of their arguments. Thus:

$$\begin{cases} u(\beta) = u_0 + c_z \beta ; \\ v(\phi) = v_0 + b_z \phi . \end{cases} \tag{9.39}$$

We now find the relation between the coefficients c_z and b_z. By substituting (9.39) into (9.35) we have:

$$c_z = - b_z , \tag{9.40}$$

i.e. the functions $u(\beta)$ and $v(\phi)$ have the following form:

$$\begin{cases} u(\beta) = u_0 - b_z \beta ; \\ v(\phi) = v_0 + b_z \phi . \end{cases} \tag{9.41}$$

Thus, the complex function $z(W)$ has the form:

$$z(W) = u + i v = u_0 - b_z \beta + v_0 i + b_z \phi i \tag{9.42}$$

or

$$z(W) = u_0 + i v_0 + i b_z (\phi + i \beta) ,$$

where $u_0 = \text{const}$, $v_0 = \text{const}$, $b_z = \text{const}$.

Thus, we have completely solved the Killing equation in a complex way. Its solution has the complex form:

$$z = z_0 + i b_z w , \tag{9.43}$$

and the real one:

$$z = u + i v = u_0 + i v_0 + ib_z(\phi + i \beta) , \tag{9.44}$$

where $z_0 = u_0 + i v_0 =$ const is the arbitrary complex constant; $b_z =$ const is the arbitrary real constant.

In equation (9.29) it is shown that the local structure of Tor_W is such that it is the real manifold of dimension 3 containing a complex submanifold of complex dimension 1 (i.e. of real dimension 2):

$$\mathrm{Loc}\,(\mathrm{Tor}_W) = \mathbb{C}^1 \times \mathbb{R}^1 . \tag{9.45}$$

We now compare this structure with the arbitrary constants of the Killing equation.

The Killing equations are the equations of the first order and to solve them unambiguously it is necessary to give the initial conditions (b_z , z_0). What are the initial conditions like? This is exactly the point in Tor_W.

The complexity of time with respect to Tor_E reveals in the following: the function $z = z(W)$ in equation (9.45) linearly depends on the angular arguments ϕ and β upon Tor_E . If we consider the steady motion it means that ϕ and β change linearly over time. Yet, this linear factor, as it is shown in (9.30), has to be purely imaginary (it is denoted by $i\,\beta_z$).

On the other hand, this factor is the coefficient of values steady changing over time. Therefore, in this problem it is the time scale. And this scale is the complex number. It means that under the consideration of the motion along the geodetic screw line on Tor_E the time scale is the complex number.

9.3. The origination of n particles instead of one, under the transition into another subspace

In 3SS the fundamenton moves on the surface of the torus. Its trajectory is the screw line. Tor_W is placed in the enclosing space ES3. If in ES3 Tor_W is considered as a geometrical body, then the following construction can be obtained.

We now consider the equator of Tor_W. It is obtained by intersecting Tor_W and the plane perpendicular to the symmetry axis of Tor_W and going through the zero point.

This plane intersects Tor_W , and two circumferences with radii R_1 and R_2, respectively, appear on the intersection (where R_1 and R_2 are the parameters of Tor_W). A particular case $R_2 = 0$ is possible, when the second circumference degenerates into the point coinciding with the zero point. The trajectory of the fundamenton in Tor_W is the screw line

$$\theta = n\,\varphi\,, \tag{9.46}$$

where θ, φ are the angular coordinates in Tor_W ; n is the integer parameter. The result of the intersection of this line and the plane gives n points.

The problem is in the following. Under the approach discussed above n fixed points appear on the plane. But it is necessary to obtain n moving points. The difference of the time scales in the plane and in Tor_W in no way saves the situation here in principle. The time scale change influences only the periodicity of the appearance of these points. Yet, they are the points with the fixed values of the angular coordinate φ.

At first sight a simple way out of this situation is to consider that the whole screw line moves as a unit on the torus surface, rotating around the symmetry axis of the torus with the angular velocity ω. Yet, such approach is wrong. The matter is that the geodetic is not a material object but the trajectory of the movement of a particle. Therefore, the above-mentioned approach is only reduced to a new line but with a different value of the parameter n:

$$\begin{cases} \theta = n'\varphi\,; \\ n' \neq n\,, \end{cases} \tag{9.47}$$

and the result will be analogous, i.e. there simply is n' fixed points instead of n points $(n' \neq n)$.

In TFF there is a geometrical relation between Tor_E and Tor_W which is expressed in the following. Tor_E is the base of the fiber bundle, whose enclosing space is Tor_W and the fiber is $\mathbb{R}^1$:

$$Tor_W \xrightarrow{p} Tor_E\,. \tag{9.48}$$

This means that there is the canonical projection p from Tor_W onto Tor_E which in the apparent form is given as:

$$p\,(\varphi\,,\,\theta\,,\,ct\,) = (\varphi\,,\,\theta)\,, \tag{9.49}$$

where φ , θ are the angular coordinates on Tor_W as well as on Tor_E; ct is the time coordinate on Tor_W.

Thus, it is not necessary to construct additional projections, it is possible to use the canonical projection which we already have.

From formula (9.46) it follows that the geodetic on Tor_E has the same equation

$$\theta = n\,\varphi\,, \tag{9.50}$$

because p in (9.49) retains the angular coordinates, yet, on Tor_E the time coordinate is already absent. Consequently, this geodetic can be parameterized by any affined parameter, because in this case all such parameters are equivalent. Thus, on Tor_E the geodetic can be parameterized as

$$\begin{cases}\varphi = \tau\, k_\varphi ; \\ \theta = \tau\, k_\theta , \end{cases}$$

where k_φ = const , k_θ = const , $k_\theta = n\, k_\varphi$ (the values of k_φ will be determined below in relation to the time scale in ES).

Tor_E can be represented as the quotient space of the plane $\mathbb{R}^2$ on the lattice. In detail it is the following. We now consider the plane $\mathbb{R}^2$ and the equivalence ratio p on $\mathbb{R}^2$, given in the following way:

$$\begin{cases}(x, y) = p\,(x', y') , \text{ if there are such integer numbers } m_1 , m_2 \text{ that} \\ x = 2\pi\lambda_x m_1 + x' ; \\ y = 2\pi\lambda_y m_2 + y' , \end{cases} \tag{9.51}$$

where λ_x = const, λ_y = const are the constants of the length dimension giving the ratio p.

The geometrical meaning of the constants λ_x and λ_y is the following. After the quotation of the plane $\mathbb{R}^2$ with respect to p (in detail the quotation is discussed below) Tor_E is obtained. It has the following topological structure:

$$Tor_E = s^1 \times s^1 . \tag{9.52}$$

Then λ_x is the radius of the first circumference in the product of (9.52), and λ_y is the radius of the second circumference.

We now consider in detail the quotation of $\mathbb{R}^2$ with respect to p (9.51). It is also possible to consider it as the fiber bundle. For further aims it is more suitable to divide the process of quotation into two stages: with respect to x and afterwards with respect to y.

The quotation with respect to x. The points, whose abscissae are placed at a distance divisible by $2\pi\lambda_x$ and the ordinates are equal, are identified. This means that any point of the plane $\mathbb{R}^2$ with the coordinates (x_0, y_0) is attached to the points $(x_0 + 2\pi\lambda_x m_1, y_0)$ for all integer numbers m. Consequently, any straight line y_0 = const turns into the circumference with the radius λ_x. Therefore, the result of mapping $\mathbb{R}^2$ at the first stage is the cylinder

$$B = s^1 \times \mathbb{R},$$

or more exactly:

$$\begin{array}{ccc} \mathbb{R}^2 = \mathbb{R} \times \mathbb{R} & & \mathbb{R}^2 \\ p_1 \downarrow \quad \downarrow id & \Longleftrightarrow & \downarrow \\ s^1 \times \mathbb{R} & & B\,(p_1, id\,) . \end{array} \tag{9.53}$$

Introducing the angular coordinate φ on s^1 we obtain the apparent type of the mapping of p_1 :

$$\varphi = p_1(x) = \frac{x}{\lambda_x}, \tag{9.54}$$

where φ takes any value from $(-\infty)$ to $(+\infty)$. Yet, all values of the function on the argument φ are restricted because the trigonometrical functions are used.

Mind that (9.53) gives the following structure of the fiber bundle:

$$\begin{array}{l} \mathbb{R}^2 \to B, \\ (p_1, id) \end{array} \tag{9.55}$$

where (p_1, id) is the canonical projection; $\mathbb{R}^2$ is the enclosing (total) space; B is the base; $\mathbb{R}^1$ is the fiber.

The apparent form of the canonical projection is

$$p_1(x, y) = (\varphi, y), \tag{9.56}$$

where x, y are the Cartesian coordinates in $\mathbb{R}^2$; (φ, y) are the mixed coordinates on the cylinder B.

The quotation with respect to y. The points of the cylinder B, whose ordinates are placed at a distance divisible by $2\pi\lambda_y$ are identified. The result gives the mapping which is suitable to express in the form of the "half-diagram":

$$\begin{array}{ccccc} B & = & s^1 & \times & \mathbb{R}^1 \\ \Big\downarrow (id_1, p_2) & & \Big\downarrow id & & \Big\downarrow p_2 \\ \mathrm{Tor}_E & & s^1 & \times & s^1 . \end{array} \tag{9.57}$$

The mapping p_2 has the form analogous to p_1 :

$$\theta^{*)} = p_2(y) = \frac{y}{\lambda_y}, \tag{9.58}$$

where y is the coordinate with respect to the cylinder forming line; λ_y = const (see (9.51)).

So, all necessary intermediate mappings are calculated.

Therefore, "at the entrance" of the given method we have Tor_W and the screw geodetic on it; the geodetic equation is

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*) θ is the second angular coordinate on Tor_E

$$\theta = n\varphi, \tag{9.59}$$

where n is the integer parameter; φ, θ are the angular coordinates of Tor_W.

We now act by the canonical projection

$$p : \mathrm{Tor}_W \to \mathrm{Tor}_E. \tag{9.60}$$

Acting by (9.60) onto (9.59) and taking into account that $p(\varphi, \theta, ct) = (\varphi, \theta)$, we obtain the same equation

$$\theta = n\varphi \tag{9.61}$$

but on Tor_E.

The geometrical meaning is the following: we have projected the geodetic onto the base in the enclosing space.

We now consider the fiber bundle generating Tor_E from $\mathbb{R}^2$ as the quotient set $\mathbb{R}^2$ with respect to p (9.51). We act on the line (9.61) in Tor_E (as a quotient set) by the mapping inverse to the canonical projection:

$$\begin{cases} \varphi = \dfrac{x}{\lambda_x}; \\ \theta = \dfrac{y}{\lambda_y}. \end{cases} \tag{9.62}$$

This mapping has the form of (9.62):

$$\begin{cases} \varphi = \lambda_x \varphi; \\ y = \lambda_y \theta; \\ \theta = n\varphi, \end{cases} \tag{9.63}$$

where x, y are the Cartesian coordinates on $\mathbb{R}^2$. Excluding θ, φ from equation (9.63) we obtain the following relation:

$$\begin{cases} \dfrac{\theta}{\varphi} = n; \\ \dfrac{y}{x} = \dfrac{\lambda_y}{\lambda_x}\dfrac{\theta}{\varphi} = \dfrac{\lambda_y}{\lambda_x} n \Rightarrow y = \dfrac{\lambda_y}{\lambda_x} nx. \end{cases} \tag{9.64}$$

Yet, this equation (9.64) is not complete, because the relations (9.51) are not taken into account and, in fact, we have a family of the straight lines:

$$y + 2\pi\lambda_y m_2 = \frac{\lambda_y}{\lambda_x} n (x + 2\pi\lambda_x m_1), \tag{9.65}$$

where m_1, m_2 take all values of the set of the integer numbers.

Express (9.60) as the apparent dependence $y(x)$:

$$y = \frac{\lambda_y}{\lambda_x} nx + 2\pi\lambda_y (nm_1 - m_2) , \qquad (9.66)$$
$$n = \text{const} ; \lambda_x = \text{const} ; \lambda_y = \text{const} ; m_1 , m_2 \in \mathbf{Z} .$$

In a general case, (9.66) determines the infinite two-parameters family of the straight lines on the plane.

We now act on the family of straight lines (9.66) by the mapping (9.53) $(p_1 , id) : R^2 \to B$. According to (9.54):

$$\begin{cases} (p_1 , id)(x , y) = (\varphi , y) ; \\ \varphi = \frac{x}{\lambda_x} . \end{cases} \qquad (9.67)$$

Then in the cylindrical coordinates the equation (9.66) takes the form:

$$y = n \lambda_y (\varphi + 2\pi(m_1 - \frac{m_2}{n})) ;$$
$$y = n \lambda_y \varphi + 2\pi\lambda_y (nm_1 - m_2) . \qquad (9.68)$$

Since the coordinate φ is cyclic, we consider:

$$y (\varphi + 2\pi k) ; k \in \mathbf{Z} ;$$
$$y (\varphi + 2\pi k) = n \lambda_y (\varphi + 2\pi k) + 2\pi\lambda_y (nm_1 - m_2) \Rightarrow \qquad (9.69)$$
$$y = n \lambda_y \varphi + 2\pi\lambda_y (nk + nm_1 - m_2) .$$

This is the equation of the family of the screw lines on the cylinder, taking into account the recurrence of φ.

We now consider the increment of y in (9.68) on the parameter m_2:

$$\Delta m_2 y = n \lambda_y \varphi + 2\pi\lambda_y (nm_1 - m_2) - n \lambda_y \varphi -$$
$$- 2\pi\lambda_y (nm_1 - (m_2 + 1)) \Rightarrow \Delta m_2 y = 2\pi\lambda_y . \qquad (9.70)$$

We now calculate $\Delta_{\varphi y}$:

$$\Delta_{\varphi y} = y (\varphi + 2\pi) - y(\varphi) = n \lambda_y (\varphi + 2\pi) + 2\pi\lambda_y (nm_1 - m_2) -$$
$$- n \lambda_y \varphi - 2\pi\lambda_y (nm_1 - m_2) \Rightarrow \Delta_{\varphi y} = 2\pi n \lambda_y . \qquad (9.71)$$

And finally, for the number of particles we obtain:

$$N = \frac{\Delta_{\varphi y}}{\Delta m_2 y} = \frac{2\pi \, n \, \lambda_y}{2\pi \, \lambda_y} = n .$$

That is what we needed.

10 THE NOETHER THEOREM IN TFF

For action in any theory we can write:

$$s = \int L\,(\varphi^a(x)\,;\,\varphi^a_{,l}(x)\,;\,x^k)\,dx_0\,, \tag{10.1}$$

where φ^a, $\varphi^a_{,l}$ are the values of the fields and their derivatives with respect to the coordinate, respectively. In (10.1) the integral is usually taken over a certain domain of the unfibrated space. In TFF (10.1) is a particular case for Re D_ζ, where D_ζ is a certain domain of the enclosing space. Consequently, instead of (10.1) it should be written:

$$s_\zeta = \int_{D_\zeta} L\,(\varphi^a(x_{(\zeta)})\,;\,\varphi^a_{,l}(x_{(\zeta)})\,;\,x^k_{(\zeta)})\,dx_{0_{(\zeta)}}\,, \tag{10.2}$$

where ζ is the index of subspace; $x^k_{(\zeta)}$ is the coordinate in this subspace; φ^a is the field of this subspace; $\varphi^a_{,l}$ is the derivative with respect to $x^l_{(\zeta)}$.

Consider the Noether theorem in this case. That is, the law of conservation corresponds to any conversion continuously depending on one parameter and retaining the action s_ζ in the subspace with the index ζ invariant.

This theorem includes the Noether theorem in its present form as a particular case for one subspace, which we observe directly. That is why some laws of conservation are of the approximate character in modern theories. They are merely the mappings of the laws of conservation in other subspaces onto our laboratory subspace. Therefore, the violation of them is allowed.

Perform a usual conversion of coordinates and field functions:

$$\begin{aligned} &x^k_{(\zeta)} \to x^{1k}_{(\zeta)} = x^k_{(\zeta)} + \delta x^k_{(\zeta)}\,;\\ &\varphi^a \to \varphi^{1a}(x_{(\zeta)}) = \varphi^a(x_{(\zeta)}) + \delta\,\varphi^a(x_{(\zeta)})\,. \end{aligned} \tag{10.3}$$

In the sufficiently small neighbourhood of any point of the space these transformations can be made linear:

$$\begin{aligned} &\delta x^k_{(\zeta)} = \Lambda^k_\alpha\, G^k_{(\zeta)}\,;\\ &\delta\varphi^a = D^{ab}_\alpha\, \varphi^b\,(x_{(\zeta)})\, G^\alpha_{(\zeta)}\,, \end{aligned} \tag{10.4}$$

where Λ^i_α is the Lorentz conversion matrix with the constant coefficients; $G^\alpha_{(\zeta)}$ are the parameters of the groups of the conversion in the given SS. The variation of s takes the form:

$$\delta s_\zeta = \int \frac{d}{dx^k_{(\zeta)}} (N^k_\alpha(x)\, G^\alpha_{(\zeta)})\, dx_{(\zeta)} , \tag{10.5}$$

where

$$N^k_\alpha = L(x)\, \Lambda^k_\alpha - \frac{\partial L}{\partial \varphi^a_k} \varphi^a_{i,j} \Lambda^j_\alpha + \frac{\partial L}{\partial \varphi^a_k} D^{ab}_\alpha \varphi^b . \tag{10.6}$$

It is easy to see that

$$\frac{dN^k_\alpha}{dx^k_{(\zeta)}} = 0 . \tag{10.7}$$

Consequently, the Noether theorem in the differential form also holds in our case. Besides, we have to keep in mind that (10.5) and (10.6) do not allow the transition from one SS into any other because this is the process of the discrete mapping which can not be represented in the differential form.

The question arises whether this fact takes place in the base of our fiber bundle as well. It is easy to see that it depends on the structure of the fiber bundle. Therefore, the differential laws of conservation are valid in any SS,but they may be violated under the consideration of these processes in the base of our fiber bundle.

Consider the situation with the integral laws of conservation:

$$N_\alpha(\delta) = \int N^k_\alpha(x)\, dx_k , \tag{10.8}$$

where δ is the coordinate for any subspace. In particular, for the time coordinate:

$$N_\alpha(t) = \int N^0_\alpha(x)\, dx ; \tag{10.9}$$

$$t = x_0$$

and

$$\frac{dN_\alpha(t)}{dx} = 0 , \tag{10.10}$$

i.e. the integral laws of conservation related to the time symmetry (and, in particular, the law of the energy conservation) hold in any SS and under the transition from one SS into any other. Yet, in the cases when the symmetry is not reduced to the symmetries determined by the time coordinate, and when N_α includes the values $G^\alpha_{(\zeta)}$ which alter under the transition from one SS into any other, the following condition holds:

$$N^{(\zeta)}_\alpha(x) = \int_\delta N_\alpha(x_{(\zeta)})\, dx_{(\zeta)} . \tag{10.11}$$

Therefore, if the process takes place in one subspace then as previously

$$\frac{dN_a^{(\zeta)}(x)}{dx_{(\zeta)}} = 0 ,$$

and the Noether theorem for the integral laws of conservation is valid.

Under the mapping of phenomena onto the base which is "attached" to the fibers only by the single element of each group $G_{(\zeta)}$, the most part of the information about the features of the symmetry of the given group is lost. And the laws of conservation valid for the fibers and demanded by the Noether theorem, as a rule, are not valid in the base.

Thus, in the fiber bundle the integral laws of conservation connected with the symmetries of the time coordinates may be valid simultaneously in all SSs. As for the base of the fiber bundle, i.e. 1SS, the laws of conservation valid in it, as a rule do not affect other SSs and vice versa, the laws of other SSs are not valid in 1SS, i.e. the base.

We should keep in mind that TL allows the replacement of the matrix Λ_α^i by the more general one $\Lambda_{\alpha(\zeta)}^i$, which coincides with Λ_α^i only in 1SS. In this case in TFF the additional peculiarities of the Noether theorem appear.

From the peculiarities of the Noether theorem in TFF, discussed above, it is seen that the theory demands the validity of all laws of conservation in any given SS and allows the violation of the laws, valid in one SS, under the observation of the process in any other SS. According to TFF, this is the reason for the existence of the violation of the laws of the p-even parity conservation under weak interaction, the violation of certain laws of conservation, when it concerns the virtual states, etc.

Résumé

1. All principal equations of the Triunity Law are given in section 7. For the first time, it is shown there that the solution of these equations, in accordance with the A. Salam true foresight, characterizes what he has called a "strong gravitation". Thus, all types of interactions, i.e. strong, electromagnetic, weak and gravitational, with their constants, are analogous, at least formally, to the gravitational interaction. Field interaction constants and universal gravitation constants are obtained in this section. We use the term "universal" because we believe it defines the essence of gravitation in a more complete and exact way than the term "strong gravitation". Universal gravitation means universal interaction of all forms of matter due to their masses. In each particular case of this interaction display there is its own gravitation constant. All constants of field interaction and universal gravitation are calculated and given in this section.

2. Section 8 shows how with the help of conventional mathematical calculations the spinorial and vectorial fields originate from the scalar field. The physical and mathematical meanings of the spinorial Dirak equation becomes clear. It is shown that the Higgs effect is the evident consequence of the equations of the theory.

3. Section 9 shows the origination of quantum and relativistic properties of matter and the relation between these properties and soliton-like structures formed by a fundamenton in the second subspace.

4. The contents of the Noether theorem is discussed in section 10. Since TFF shows the necessity to use fiber bundles when dealing with all viable and able to develop systems, the Noether theorem is considered in TFF in a different way than in other theories. The present Noether theorem means one space. It should be corrected for a fiber bundle, the correction being as follows. In the conventional form the theorem can be completely used for each subspace taken separately. Some symmetries and, consequently, the conservation laws can be violated when information is spread from the given space to another. These violations are due to the fact that the real space is a fiber bundle.

PART III

THEORY OF INTERACTIONS IN MATTER

11 GRAVITATIONAL INTERACTION

1. The law of gravitation discovered by Newton is in good accordance with the experimental data on weak gravitational fields. Einstein's General Relativity (GR) broadened the possibilities of the theory of gravitation into the domain of strong fields. It stated the existence of relation between the gravitational interaction and the space-time continuum properties. Yet, this relation was not quite cleared up within the bounds of GR. In particular, the fact indicative of it is that in GR the gravitational constant is introduced in the form of a postulate and cannot be in principle calculated theoretically.

A new step in the direction of the cognition of the gravitation nature is made within the bounds of the new unified relativistic theory of the fundamental field (TFF). In [48—52] it was shown that the new theory of gravitation (for short we shall call it "the vacuum theory of gravitation" (VTG)) for the first time allowed to calculate theoretically the value of the gravitation constant and to connect it with other global constants. The fundamental ideas of the new VTG and some of its consequences are discussed in this book.

2. Gravitation in TFF in contrast to GR is considered not as manifestation of the individual interaction between bodies (as the result of the space metrics change due to their masses) but it is considered as the result of the change of the character of the interaction between the particle and vacuum under the influence of another body.

We clear up how the vacuum surrounding particles acts upon them and how the appearance of a third body (or third ones) affects this process.

The physical fundamentals of the vacuum theory of gravitation are the following. Since vacuum is the homogeneous space and the density of matter in it is constant, then the equation (7.1) is of the form

$$R_{ik}^{(V)} = A_V g_{ik}^{(V)}, \qquad (11.1)$$

where A_V is the constant, the dimension of which is the reciprocal square of length. Thus, in vacuum the energy-momentum tensor T_{ik} differs from the metric tensor only by the constant factor, i.e.

$$A_V g_{ik}^{(V)} = \frac{8\pi\gamma_V}{c^4} T_{ik}^{(V)} . \tag{11.2}$$

It is easy to show that

$$T^0_{0(V)} = \frac{m_V c^2 e^{-R_n/r}}{8\pi^2 R_n^{\ 3}} , \tag{11.3}$$

where m_V is the mass of two antiparticles constituting EPV; R_n is the Schwarzschild sphere radius for EPV of the nth vacuum; $r = |\bar{r}|$ is the absolute value of the radius-vector going from the zero point to the proper space point.

It is clear that the constant A_V in (11.1) and (11.2) may be only $(\pi R_n^2)^{-1}$, i.e. $A_V = (\pi R_n^2)^{-1}$. And since

$$R_n = \frac{m_V \gamma_V}{c^2} , \tag{11.4}$$

then from (11.2) and (11.3) we have:

$$g_{00}^{(V)} = e^{-R_n/r} . \tag{11.5}$$

Vacuum exerts pressure upon any EP and EPV from all sides. Under existence of only free vacuum around a particle this pressure acts on any particle with the following force invariable for any particle:

$$F_V = \frac{e_V^2}{r_{\text{un}}^2} , \tag{11.6}$$

where $e_V \equiv \left(\frac{\alpha \hbar c}{\varepsilon_V}\right)^{1/2}$ is the elementary charge; ε_V is the vacuum dielectric constant ($\varepsilon_V = 0.997\,445$); r_{un} is the unit radius. The force F_V is not the result of electromagnetic interaction. Therefore, it reveals both between charged and neutral particles. The observable electric charge e_{un} is invariable due to the equality $e_V^2 = \frac{e_{\text{un}}^2}{\varepsilon_V}$. In TFF the relation $e_V^2 \equiv \frac{\alpha \hbar c}{\varepsilon_V}$ is interpreted as the physical invariant of vacuum which is not only the square of difference of fundamental charges but is the invariable value which is better to call the "moment of the elementary energy", i.e.

$$e_V^2 = E_0\, r_{\text{un}} . \tag{11.7}$$

In its turn, it should be considered as

$$E_0 = F_V r_{un} \text{ and } e_V^2 = F_V r_{un}^2 , \tag{11.8}$$

otherwise: F_V is the elementary force which fulfils work equal to E at a distance of the unit length r_{un}. If at a distance r from a particle there is another one, the latter would screen that part of vacuum which is "behind it" and is situated within the corporal angle θ. Since the force F_V acts within the corporal angle equal to 2π, from which the screened cone is subtracted, it is clear that the force of attraction arises between two particles which is equal to

$$F_g = F_V \frac{\theta}{2\pi} . \tag{11.9}$$

This force is just the gravitational force. Consequently, the following should be valid:

$$F_g = G \frac{m_1 m_2}{r^2} = F_V \frac{\theta}{2\pi} . \tag{11.10}$$

Under interaction of two particles the angular dimension of the "screen" depends both on distances and parameters of EPVs. It also depends on masses of both interacting particles. The corporal angle, under which two particles with masses m_1 and m_2 mutually screen some part of the force F_V, depends on the masses of the interacting particles and the vacuum parameters in the following way:

$$\theta = \frac{(R_1^{(2)} - R_2^{(2)})_p^2}{r^2} a_g \frac{m_1 m_2}{m_V^2} , \tag{11.11}$$

where $(R_1^{(2)} - R_2^{(2)})_p$ is the difference of the radii; on these radii the subparticles of the proton-antiproton vacuum oscillate; m_V is the total mass of two antiparticles constituting EPV of the proton-antiproton vacuum, i.e. equal to two masses of a proton (antiproton); a_g is the metric coefficient of the proton-antiproton vacuum, $a_g = 1.000\,889$ (see section 16). The reason for taking into account in (11.11) only the parameters of proton-antiproton vacuum is the following. The concentration of EPVs of any type of vacuum is determined by the simple expression:

$$n_V = \frac{1}{8\pi^2 R_n^3} . \tag{11.12}$$

For the proton-antiproton vacuum it is equal to $1.545\,4 \cdot 10^{39}\, c^{-3}$ and for the electron-positron vacuum, the nearest to the former, it is ten orders less. The concetration of EPVs of other types of vacuum decreases in the same sharp way, therefore, the main contribution to general vacuum property is made by the proton-antiproton vacuum (the first one in Table 5.1) which is taken into account in (11.11). Other types of vacuum have the substantial influence only under the resonance phenomena in it. Gravitation is an average effect and is not connected with resonance phenomena in vacuum. From (11.10) taking into account (11.11) we have:

$$G = a_g \frac{F_V (R_1^{(2)} - R_2^{(2)})_p^2}{2\pi m_V^2} . \qquad (11.13)$$

The elementary force F_V is determined via the vacuum parameters as follows:

$$F_V = \frac{9}{8\pi^2} \cdot \frac{\alpha \hbar c}{(R_1^{(2)} - R_2^{(2)})_p^2} (\lambda\!\!\!^{-}_p R_\infty)^4 , \qquad (11.14)$$

where $\lambda\!\!\!^{-}_p = \frac{\hbar}{m_V c}$ is the Compton wavelength of a proton; R_∞ is the Rydberg universal constant for the infinitely great mass.

$$G = a_{gp} \frac{9}{8} \left(\frac{\lambda\!\!\!^{-2}_p R_\infty^2 e}{\pi m_V} \right)^2 . \qquad (11.15)$$

This formula for the gravitation constant was given by us [49] without its deduction and proof that it is universal and could be applied to any elementary particle. Taking into account the new experimental values of the global constants [108] from (11.15) we obtain the following numerical value for the gravitation constant:

$G = 6.67\,254\,939\,7 \cdot 10^{-8}\, c^3/gs^2$ which, as previously, is in good correspondence with the experimentally found value [108]:

$G = 6.67\,259\,(85) \cdot 10^{-8} = (6.67\,174 - 6.67\,344) \cdot 10^{-8}\, c^3/gs^2$.

The accuracy of the former is some orders greater than that of the latter.

The obtained result is the following:

1. The theoretical value G can be considered as a forecast until new experimental values of it are obtained.

2. The exactly expressed relation between the gravitation constant and other global constants is stated, which is not given by any "habitual" physical theory.

It is often noted that numerical values and mutual consistence of global constants are not only of fundamental value for modern science. Under the unexpected discovery of their new mutual relations they can result in revision of the principles upon which our concepts of the physical picture of regularities in natural phenomena are based. Therefore, there are reasons to consider that the method of calculation of G, for the first time found theoretically, is indicative of serious possibilities of the new theory of gravitation discussed here as well as of TFF on which it is based.

3. Attention should be paid to the following feature of VTG: the gravitational forces arise only as the result of screening the vacuum tensions which always act upon any particle. Yet, under the

accumulation of a very great number of particles in a small volume, the "forcing out" of a certain part of EPVs and decrease of vacuum tension forces connected with it can occur.

Out of this follows the conclusion: if concentration of particles in a given finite volume is near to that of EPVs, then the forces of gravitational interaction between them may very greatly decrease. So, under the concentration of particles in the center of stars, approaching the value of $10^{39}\ c^{-3}$, corresponding to the concentration of EPVs in the most dense proton-antiproton vacuum, the forces of gravitational interaction would substantially decrease. It would result in the mass defect and the energy release. This is one of the principal sources of the internal energy of stars and planets.

Concentration of particles of the order of $10^{39}\ c^{-3}$ corresponds to the neutron stars. Out of this follows the conclusion that further compression of these stars may be apparently either impossible or for its reasoning would require a new concept of particles structure which is beyond the bounds of TFF. Thus, we come to the conclusion that the origination of "black holes" in macrocosm is impossible. This process is the leading phenomenon in microcosm but not in macrocosm.

The mentioned above circumstance should be taken into account under the construction of different variants of cosmological hypotheses on the origination of the entire observable Universe from a certain very small volume, the radius of which is by far smaller than 10^{-33}c, where matter of immense density is accumulated. Such phenomena cannot occur.

4. It is widely known that, under certain assumptions, by means of GR considered as gravitation theory, it is possible to come to the hypothesis on the expanding Universe, which, at least qualitatively, would explain the metagalactic red shift and would be a stimulus for constructing a number of interesting cosmological hypotheses. Therefore, it seems to be important to clear up what possibilities VTG has, according to the above-mentioned cosmological problems.

In this connection it should be noted that the equation for vacuum (11.1), under the same assumptions as in GR, allows the non-stationary solutions, witnessing the expansion (or compression) of the Universe filled up with physical vacuum. Though VTG allows the expansion (or compression) of the Universe, it does not demand it. Therefore, it is of interest to clear up whether additional possibilities follow from the new theory of gravitation as well.

5. It turned out that VTG predicts a new phenomenon which should reveal in vacuum. This phenomenon is probably suitable to be called "gravitational viscosity", which should accompany the process of photons propagation in vacuum. To get the essence of this phenomenon, the concept of the photons origination, formulated in TFF [7], should be reminded to the reader.

According to TFF, propagation of light is considered as the displacement of excitation process of elementary particles of vacuum, and the birth of any photon is considered as an elementary act of excitation of EPV. As it was mentioned above, in TFF the non-excited EPVs are unobservable in macrocosm, they are situated in the "black hole". When EPV is excited, a pair of virtual antiparticles appears, which is just taken as a photon, provided this pair is not under the action of the field continuously supporting the excitation of this pair, but is subjected to the action of an alternating or impulse field. In the last case the excitation process would propagate from one EPV to another, which would be taken as the propagation of light. Thus, the propagation of light is accompanied by the process of sequential excitation of vacuum particles, i.e. by birth and death of photons, under the same quantity of them in a free vacuum. This process leads to the irretrievable loss of very small but finite energy to overcome gravitational forces under any act of EPV excitation.

Such gravitational viscosity accompanying light propagation process in vacuum can be calculated in TFF. If the initial energy of a photon is $h\nu_0$, and the energy loss due to the gravitational viscosity per second is E, then for the time t the photon energy would decrease and become equal to

$$h\nu = h\nu_0 - \int_0^t E\,dt\,, \tag{11.16}$$

from where

$$\frac{\lambda}{\lambda_0} = 1 + \frac{\int_0^t E\,dt}{h\nu}\,. \tag{11.17}$$

Denoting $E_1 = \frac{E}{\nu}$, where E_1 is the energy lost by a photon per period, we finally obtain:

$$\frac{\lambda}{\lambda_0} = 1 + \frac{\int_0^s E_1\,ds}{hc}\,. \tag{11.18}$$

Considering, as it is usually adopted, that the metagalactic red shift is due to the Doppler effect only, for the wavelength change from λ_0 to λ we obtain the following expression:

$$v = H_0 s\,;\ \frac{\lambda}{\lambda_0} = 1 + \frac{H_0}{c}\,s\,, \tag{11.19}$$

where v is the velocity of the light source; s is the distance from it; H_0 is the Hubble parameter; c is the speed of light.

It is easy to see that the expressions (11.18) and (11.19) coincide. To determine which part of the observed red shift should be attributed to the Doppler effect and which part of it is due to the gravitational viscosity,it is necessary to determine the value of the parameter H_0 from (11.18):

$$H_0 = \frac{\int_0^s E_1\,ds}{s\,h}\ . \tag{11.20}$$

To determine this parameter we recollect that in TFF a particle and an antiparticle, moving apart under excitation to a certain distance x_0 , spend the energy E_1 on overcoming the gravitational viscosity forces f_u :

$$f_u = -\ m \text{ grad } \frac{Gm}{2\pi r\, e^{R/r}(1-\beta^2)}\ , \tag{11.21}$$

where m is the mass of the virtual particle and antiparticle constituting EPV; R is the radius of the EPV structure almost coinciding with the Schwarzschild sphere radius R_n ; $\beta = \frac{v}{c}$ is the velocity of oscillation of EPV structure elements, which is observable only in the particular coordinate frame of EPV and only inside the Schwarzschild sphere. The energy which a photon spends irretrievably on overcoming gravitational forces should be determined only when the virtual antiparticles are "moving apart" from R to x_0, because the direct information from the processes occurring inside the Schwarzschild sphere does not get into macrocosm.

So, for the unknown energy loss we obtain:

$$E_1 = \frac{Gm}{2\pi\,(1-\beta^2)} \int_R^{x_0} \text{grad } \frac{m}{r\,e^{R/r}}\, dr\ , \tag{11.22}$$

or

$$E_1 = \frac{Gm^2}{2\pi e R\,(1-\beta^2)} \left(1\ -\ \frac{R}{x_0\, e^{R/x_0 - 1}}\right)\ . \tag{11.23}$$

In TFF the physical meaning of the fact that the ratio of photon energy to its frequency is equal to the Plank constant in all cases of energy propagation in macrocosm consists of the following simple equality for each photon:

$$x_0 = \lambda\ . \tag{11.24}$$

Then (11.23) takes the form:

$$E_1 = \frac{Gm^2}{2\pi e R\,(1-\beta^2)} \left(1\ -\ \frac{R}{\lambda\, e^{R/\lambda - 1}}\right)\ . \tag{11.25}$$

In TFF the constants R and $(1-\beta)$ are expressed via "external" (experimentally observed) parameters of particles with the accuracy up to the factor equal approx to 1.02. This allows to obtain the following value for the Hubble parameter characterizing the red shift due to gravitational viscosity:

$$H_0 = \frac{3\sqrt{2}\, G m_e^3 c}{e \hbar^2 \alpha^4 s} \int_0^s \left(1 - \frac{R}{\lambda e^{R/\lambda - 1}}\right) ds\,, \tag{11.26}$$

where m_e is the electron mass; $\alpha = 7.297 \cdot 10^{-3}$ is the fine structure constant. Substituting the known values into (11.26) we obtain:

$$H_0 \approx \frac{5 \cdot 10^{-18}}{s} \int_0^s \left(1 - \frac{R}{\lambda_0 e^{R/\lambda}}\right) ds\,. \tag{11.27}$$

The dependence of H_0 on λ, changing with the change of s, is not substantial if $\lambda >> R$. Neglecting this dependence we obtain:

$$H_0 \approx 5 \cdot 10^{-18}\, \mathrm{s}^{-1}\,. \tag{11.28}$$

The theoretically found value of H_0 does not completely correspond to the experimental value of the Hubble parameter adopted now, which characterizes the Doppler red shift. The experimental value of H_0, adopted previously, is greater than the theoretical one mentioned above, and the experimental value adopted recently [108], on the contrary, is less. Taking into consideration the well-known uncertainty in the estimation of the metagalactic distances we can state that the value of the Hubble parameter found from the theoretical calculation is sufficiently close to the observed one.

The increase of the accuracy of the experimental estimation of H_0 will show what is the contribution of gravitational viscosity of photons in vacuum to the observed red shift. If in future it turns out that the value H_0 is less than the theoretical one then it can mean, in particular, that now the Universe is not expanding but is compressing. In any case, gravitational viscosity makes such substantial contribution to the observed red shift that it is impossible to neglect it, as it took place until now.

It seems reasonable to attract the reader's attention to the following fact. Up to now, under the interpretation of the red shift only, in accordance with the hypothesis of the expanding Universe within the bounds of GR, the value of H_0 has not been determined theoretically. At the same time the contribution of the gravitational viscosity to the metagalactic red shift turned out to be estimated theoretically not only qualitatively but quantitatively, the satisfactory correspondence to the observations being not only by the order of the values but with the accuracy comparable with that of the metagalactic distance measurement.

We consider that this fact can also be interpreted as the confirmation of VTG and TFF.

12 FEATURES OF FIELD INTERACTIONS OF PARTICLES *)

12.1. In TFF the consideration of particles interaction acquires some peculiar features in connection with their existence in the fiber bundle. The principal feature consists in the fact that the dimensions, we ascribe to some or other parameters (characteristics) of the particles, can not be the same for all fibers of the enclosing space. Now we ascribe the universal dimensions to elementary particles. These dimensions are considered to hold in any space. For example, if we measure mass in grams, we believe that this dimension holds regardless of the type of the space in which we observe the particles interaction: the Euclidian, two-dimensional, one-dimensional, four-dimensional (pseudo-Euclidian) spaces, etc. We consider that in all cases mass should be measured in grams.

In fact, this is completely unlawful. We have no reasons to consider that the dimension of some or other characteristics of an elementary particle is the same in any fiber of the fiber bundle, regardless of the properties and dimension of such fiber. The postulate about the universality of physical dimensions and applicability of these concepts to any space results, as it is known, in the difficulties and internal contradictions. So, for example, if we spread the concept of the mass measured in grams over the point spaces whose volumes are equal to zero, then we come to divergencies and have to assign the infinitely great density to the objects situated in the point space when the object has finite mass. Other internal contradictions arise as well. Yet, they did not encourage physicists to revise this postulate. In the preface we mentioned that the system of units $\hbar = c = 1$ was not used in the book. We noted that it was due to the necessity to retain the physical meaning. Now it is quite the time to explain this statement.

In the system of units $\hbar = c = 1$ all physical values have dimension of the length raised to different power. For example, mass has dimension not in gram but in centimeter raised to the minus first power (of course, it may be if not centimeter then meter, but it is always the length dimension). Besides this system of units the system offered by Plank is also used in physics, where the third value (the gravitational constant) has also value of one, i.e. all three values are equal to one. In this system of units all physical values have the zero dimension. We cannot ascribe any concepts which we use in the laboratory three-dimensional Euclidian space to them: neither the concept of the force in the usual units, nor the concept of the mass in the usual units, nor that of the length, etc. The essence of these physical values is retained, but all of them are dimensionless.

Usually both systems of units mentioned above are used in the calculation only as a way to save the volume of the work, to cut down the number of the notations and equations and to simplify

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*) Zapatrin R.R and Chuklina T.I. took part in the mathematical treatise of this section.

the calculations. Thus, at first we transform the equation into one of the mentioned above systems of units, which we consider to be the conventional one, then after the result is obtained we transform conventional units into usual and obtain the final result. If we use this mode in one space,then such way is quite lawful. Yet, in the fiber bundle such liberty is inadmissible.

Both above-mentioned systems appeared in physics not by chance and they have a great r e a l mathematical and physical meaning but not a formal one. It means the following. The systems of units which we usually use, for example, the system of units in which all equations in this book are written (the physical system of units: c, g, s), are completely applicable only in the three-dimensional Euclidian space. It is important to note that physical system of units is completely mutual-consistent and the principal values do not require additional coefficients. If we pass to a space of some different dimension (we remind that in TFF the non-Euclidian space is the reality but not the formality), then in the real non-Euclidian spaces other dimensions should be used.

The dimension theory in physics of multidimensional fibrated spaces yet needs its creation and development. In TFF only the first steps are taken in this direction. These first steps are as follows: if the space where the processes occur with one or another microobject is in fact the two-dimensional or linear, or the point one, then we have to revise our concept of dimensions. It has been already mentioned in the book that the fundamental field is situated in the linear space, i.e. the string. In the linear space only that system of units can be used where the Plank constant and the speed of light are equal to one and all physical values have the length dimension raised to one or another power. They have this dimension indeed but not formally, as a way of calculation with subsequent conversion into the "regular dimension".

In the case when the space in question is the point space the physical values in it can be considered only if they have the zero dimension.

12.2. We now prove that for $d = 0$ the dimension of any physical value is equal to one. The main feature of the discrete point space is the fact that it allows any integrations; there are no non-proper integrals there. If usually [170] the non-proper integral on a measure is determined as the integrals limit on the narrowing neighbourhood of a given point then in the discrete case this procedure becomes unnecessary; here the point itself is its neighbourhood.

So, the difference of the case $d = 0$ from others consists in the fact that there is one-point neighbourhood consisting of the only point. Consequently, the integration on such neighbourhood is simply the determination of the value of the integrand in the point:

$$\int_{O_{x_0}} F(x)\, dx = F(x_0)\,. \tag{12.1}$$

The equation (12.1) is not a postulate but the consequence of the discreteness of the topology expressed in the form:

$$O_{x_0} = \{x_0\}\,.$$

Another consequence follows from this fact. Under the mapping of a certain value from the continuous space onto the discrete one all functions, both integrable and non-integrable pass into those which are being summed up. Therefore, under consideration of the prototypes, even of the correctly determined expressions, it is necessary to check their integrability again.

Besides, since under $d=0$ any subset is measurable, we can take the integrals over any subsets of the phase space. In an ordinary case the quantum mechanics forbids to do it due to the uncertainty principle. For example, we can not write the following expression:

$$A = x + p, \tag{12.2}$$

where x is the coordinate; p is the momentum of the same object, because x and p do not exist simultaneously. This agrees with the structure of the measurability (the Borel sets) in the spaces R^d under $d > 0$. But we have $d = 0$, and thus no restrictions on summing up. If any two values can be summed up,it means that their dimensions are the same.

So, if $d=0$, then all values should inevitably have the same dimension. But it is not proved yet that the dimension is equal to one, i.e. that the system of units should be just of the Plank type.

To prove it we consider the deterministic motion of an object. Determinism means that all its characteristics are connected with a functional (but not statistic) relation. Take any characteristic, for example, the coordinate x. Let its dimension be $[x]$. Since all relations are functional, then for any value A we can write the following:

$$A = f_A(x). \tag{12.3}$$

Yet, since the dimensions of all values are the same, we have:

$$[A] = [x]. \tag{12.4}$$

We expand (12.3) into series on the x powers:

$$A = c_0 + c_1 x + c_2 x^2 + \ldots + c_n x^n + \ldots, \tag{12.5}$$

where $c_0, \ldots, c_n$ are certain constant coefficients. These coefficients have the same dimension $[x]$.

We pass from the equality of the values in (12.5) to that of the dimensions:

$$[x] = [x] + [x]^2 + [x]^3 + \ldots + [x]^{n+1} + \ldots. \tag{12.6}$$

Note: the indices of the power in (12.6) are greater than those in (12.5) by one as the dimension of coefficients is taken into account.

Then from (12.6) it follows:

$$[x] = [x]^2 = \ldots = [x]^n = \ldots. \tag{12.7}$$

Consequently, $[x] = 1$ is a dimensionless value, which was to be proved.

12.3. We now consider the linear space ($d = 1$).

Under $d = 1$ the situation is cardinally different in comparison with that when $d = 0$. So, the notion of the measurability appears, i.e. the integral can be taken not on any subset but only on the measurable one. The structure of the measurability, i.e. the Borel sets, is described by means of the standard Carateodori scheme [171]. In short this scheme consists of the following: the measurable sets are obtained as all sorts of unions, intersections and supplements of the semi-intervals of the $[a, b)$ kind, where

$$[a, b) = \{x \in R^1 \mid a \leq x < b\} . \tag{12.8}$$

Therefore, when dealing with integrals in one-dimensional space it is sufficient to prove the corresponding statements for the integrals of the type

$$\int_a^b f(x)\, dx .$$

In the one-dimensional case the Gauss theorem passes into the Newton-Leibniz formula:

$$\int_a^b f(x)\, dx = F(b) - F(a) , \tag{12.9}$$

which is the "bridge" connecting the cases $d = 0$ and $d = 1$. In the case $d = 0$ there is no integration at all, there is summing up. From this it follows that all values should have the same dimension. Under $d = 1$ the situation is different. There is the integration. Consequently, there must be at least two dimensions, because under the integration the dimension is multiplied by x. Consequently, there are two dimensions. The first one is initial and discrete. It is without fail $[L]^0 = 1$. Yet, there must be the second dimension, namely the one on which the integration is possible. This is the dimension $[x] = L$. Formally the second dimension (any but one) is not necessarily that of the length but in the linear space it is natural to take it as the length.

The transition from the system of units $\hbar = c = 1$ or $\hbar = c = G = 1$ should be considered as the mode of mapping of the dimensions existing in the point spaces and the linear ones onto the Euclidian (or pseudo-Euclidian or pseudo-Riemannian) space and vice versa. Otherwise, the procedure of the mapping of the physical processes from the space with $d = 3$ onto the linear or the point space and vice versa is always accompanied by the change of the physical values dimension. It is not a formal change of dimension but a real one.

It is quite clear that the approach to the dimensions and the dimensions system discussed in this section would cardinally influence the methods of calculation of particles interaction in different subspaces and description of the results of the mapping of such interaction onto different subspaces. Since the discussion of the new theory of dimensions necessary for description of features of calculation in TFF is beyond the scope of this book, the questions related to the substantial description of particles interaction are not detailed here so as they should be.

13 CALCULATION OF PARTICLES PRECESSION IN THE CALCULATION SUBSPACE

13.1. The principal formulae and the calculation scheme *)

The angular velocity of the precession is determined by the formula:

$$\bar{\Omega} = \frac{1}{r^3}\left[-\bar{s} + \frac{3(\bar{s}\,\bar{x})\,\bar{x}}{r^2}\right], \tag{13.1}$$

where $\bar{x} = (x_1, x_2, x_3) = (x, y, z)$ are the Cartesian coordinates in the space-time; $r^2 = x^2 + y^2 + z^2$; $\bar{s}$ is the proper moment of momentum of the source.

The metrics used to find the vector $\bar{s}$ length is of the following form:

$$\begin{aligned} ds^2 = &- \left[1 - \frac{2M}{r} + 0\left(\frac{1}{r^3}\right)\right] dt^2 - \left[4\,\varepsilon_{jkl}\, s^k \frac{x^l}{r^3} + 0\left(\frac{1}{r^3}\right)\right] dt\, dx^j + \\ &+ \left[\left(1 + \frac{2M}{r}\right)\delta_{jk} + 0\left(\frac{1}{r}\right)\right] dx^j\, dx^k , \end{aligned} \tag{13.2}$$

where $r = \sqrt{x^2 + y^2 + z^2}$; M is the proper mass of the source; s^k are the components of the proper moment of momentum of the source; ε_{jkl} is the completely antisymmetrical tensor.

We now calculate $\bar{s}$ for the multirotator-source.

1) We introduce the following notations: n_s is the number of the particles of the multirotator-source; m_s is the mass of its particle; ω_s is the angular velocity of the particle rotation.

2) We choose the coordinate frame (x, y, z) so that the multirotator would rotate in the plane (x, y) and its rotation axis would be directed along the z axis.

3) The moment of momentum s is equal to

$$s = J\,\omega , \tag{13.3}$$

where ω is the angular velocity, i.e. $\omega = \omega_s$; J is the total moment of the inertia of the multirotator.

4) The total moment of the inertia J is equal to the sum of the moments of the components, i.e. $J = \Sigma J_k$. Yet the multirotator consists of n_s identical particles, therefore

$$J = n_s J_s , \tag{13.4}$$

where J_s is the moment of the inertia of the point:

$$J_s = m_s R_s^2 ; \tag{13.5}$$

R_s is the radius of the multirotator-source orbit.

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*) In this section the calculation was carried out within the bounds of GR.

5) Substitute (13.5) into (13.4):

$$J = n_s J_s = n_s m_s R_s^2 , \tag{13.6}$$

and (13.6) into (13.3):

$$s = J\omega = n_s m_s R_s^2 \omega_s . \tag{13.7}$$

6) The vector $\overline{s}$ is directed along the vector of the angular velocity. Therefore, it has the following components:

$$\begin{cases} s^x = s^1 = 0 , \\ s^y = s^2 = 0 , \\ s^z = s^3 = n_s m_s R_s^2 \omega_s . \end{cases} \tag{13.8}$$

This is that very set of the values s^k which is used in (13.2) in the second term.

We calculate $\overline{\Omega}$ in the general form. The general formula for Ω in the vector form is given by (13.1):

$$\overline{\Omega} = \frac{1}{r^3}\left[- \overline{s} + \frac{3(\overline{s}\,\overline{x})\,\overline{x}}{r^2} \right] .$$

Write its components:

$$\Omega_x = \frac{1}{r^3}\left[- s^x + \frac{3(\overline{s}\,\overline{x})\,x}{r^2} \right] ; \tag{13.9}$$

$$\Omega_y = \frac{1}{r^3}\left[- s^y + \frac{3(\overline{s}\,\overline{x})\,y}{r^2} \right] ; \tag{13.10}$$

$$\Omega_z = \frac{1}{r^3}\left[- s^z + \frac{3(\overline{s}\,\overline{x})\,z}{r^2} \right] , \tag{13.11}$$

where x, y, z are the coordinates of the multirotator-target which is subjected to the action of the multirotator-source. The values of the latter have index s.

We calculate the scalar product:

$$(\overline{s}\,\overline{x}) = xs^x + ys^y + zs^z = n_s m_s R_s^2 \omega_s z , \tag{13.12}$$

since, according to (13.8), $s^x = s^y = 0$. Now we substitute (13.8) and (13.12) into (13.9)–(13.11):

$$\Omega_x = \frac{3zx}{r^5} s^z ; \tag{13.13}$$

$$\Omega_y = \frac{3zy}{r^5} s^z ; \tag{13.14}$$

$$\Omega_z = \frac{s^z}{r^5}\left[2z^2 - x^2 - y^2\right] \tag{13.15}$$

We return to the spherical coordinates:

$$\begin{cases} x = r\cos\theta\cos\varphi ; \\ y = r\cos\theta\sin\varphi ; \\ z = r\sin\theta . \end{cases} \tag{13.16}$$

$$\Omega_x = \frac{3\sin\theta\cos\theta\cos\varphi}{r^3} s ; \tag{13.17}$$

$$\Omega_y = \frac{3\sin\theta\cos\theta\sin\varphi}{r^3} s ; \tag{13.18}$$

$$\Omega_z = \frac{s}{r^3}\left[3\sin^2\theta - 1\right] . \tag{13.19}$$

These are the values of all components of the angular velocity of the precession

$$\Omega = f(s, r, \theta) . \tag{13.20}$$

Transforming (13.17)—(13.19) we obtain:

$$\Omega_x = \frac{3\sin 2\theta}{2r^3} s\cos\varphi ; \tag{13.21}$$

$$\Omega_y = \frac{3\sin 2\theta}{2r^3} s\sin\varphi ; \tag{13.22}$$

$$\Omega_z = -\frac{3s}{2r^3}\left(\frac{1}{2} + \cos 2\theta\right) . \tag{13.23}$$

The values Ω_x, Ω_y, Ω_z are the components of the vector $\bar{\Omega}$ in the Cartesian coordinate frame. Calculate the absolute value of $|\bar{\Omega}|$:

$$\begin{aligned} \Omega^2 &= |\bar{\Omega}|^2 = \Omega_x^2 + \Omega_y^2 + \Omega_z^2 = \\ &= \left(\frac{3s}{2r^3}\right)^2 \left[\sin^2 2\theta\cos^2\varphi + \sin^2 2\theta\sin^2\varphi + \left(\frac{1}{2} + \cos 2\theta\right)^2\right] = \\ &= \left(\frac{3s}{2r^3}\right)^2 \left[\sin^2 2\theta + \frac{1}{4} + \cos 2\theta + \cos^2 2\theta\right] = \left(\frac{3s}{2r^3}\right)^2 \left[\frac{5}{4} + \cos 2\theta\right] . \end{aligned} \tag{13.24}$$

Since the precession axis is in the plane (x, y), the precession value is the angle θ of declination of the vector $\bar{\Omega}$ from the plane (x, y), i.e.

$$\Omega = \frac{d\theta}{dt} , \tag{13.25}$$

If the Jacobi elliptic function of the 1-st type on modulus $k = \frac{2\sqrt{2}}{3}$ is not taken into account, then $\left(\frac{d\theta}{dt}\right)^2 = \left(\frac{3S}{2r^3}\right)^2\left[\frac{5}{4} + \cos 2\theta\right]$; $\frac{d\theta}{\sqrt{5/4 + \cos 2\theta}} = \frac{3S}{2r^3}dt = k^* dt$. In our concrete case k^* = const.

Now we consider the integral $\int \frac{d\theta}{\sqrt{5/4 + \cos 2\theta}} = \frac{2}{3} \int \frac{d\theta}{\sqrt{1 - 8/9 \sin^2\theta}}$.

$\int \frac{dx}{\sqrt{1 - k^2 \sin^2 x}}$ is the elliptic integral of the first kind in the Legendre form. It is denoted by $F = (k, x)$. So,

$$\int \frac{d\theta}{\sqrt{5/4 + \cos 2\theta}} = \frac{2}{3} F\left(\frac{2\sqrt{2}}{3}, \theta\right), \tag{13.26}$$

and (13.25) becomes

$$F\left(\frac{2\sqrt{2}}{3}, \theta\right) = \frac{3}{2} kt = \left(\frac{3}{2}\right)^2 \frac{s}{r^3} t, \tag{13.27}$$

i.e. the dependence of the time on the precession angle does exist:

$$t = \left(\frac{2}{3}\right)^2 \frac{r^3}{s} F\left(\frac{2\sqrt{2}}{3}, \theta\right). \tag{13.28}$$

To find the dependence $\theta(t)$, the function F should be reversed. It gives the Jacobi elliptic function.

We introduce the notation:

$$u = F\left(\frac{2\sqrt{2}}{3}, \theta\right).$$

Then the Jacobi function is $\mathrm{sn}\,u = \sin\theta$; it means:

$$\theta = \arcsin(\mathrm{sn}\,u), \tag{13.29}$$

and $F\left(\frac{2\sqrt{2}}{3}, \theta\right) = \left(\frac{3}{2}\right)^2 \frac{s}{r^3} t = u$.

Otherwise

$$\theta = \arcsin\left[\mathrm{sn}\left(\left(\frac{3}{2}\right)^2 \frac{s}{r^3} t\right)\right], \tag{13.30}$$

where sn is the Jacobi elliptic function of the first kind on the modulus $k = \frac{2\sqrt{2}}{3}$. This is the exact precession equation in its general form.

Now we obtain the expression for the precession angular velocity from (13.24):

$$\sin\theta = \mathrm{sn}\left[\left(\frac{3}{2}\right)^2 \frac{s}{r^3} t\right] \text{ and } \cos 2\theta = 1 - 2\,\mathrm{sn}^2\left[\frac{9}{4} \frac{s}{r^3} t\right],$$

i.e.

$$\Omega = \frac{3s}{2r^3}\left(\frac{9}{4} - 2\,\mathrm{sn}^2\left(\frac{9}{4}\frac{s}{r^3}t\right)\right)^{1/2}, \tag{13.31}$$

where s is the metrics $ds^2 = g_{in}\,dx^i\,dx^n$; r is the radius-vector of the point; t is the time.

13.2. The apparent formulae

The internal rotator in the field of the external one

In this case the constant s becomes

$$s = n_1\, m_1\, R_1^2\, \omega_1\,, \tag{13.32}$$

where n_1 is the number of the particles on the external ring; m_1 is the mass; ω_1 is the angular velocity; R_1 is the radius of the external ring.

Substituting (13.32) into (13.31) we obtain:

$$\Omega_1 = \frac{3\, n_1\, m_1\, R_1^2\, \omega_1}{2\, R_2^3}\left(\frac{9}{4} - 2\,\mathrm{sn}^2\left[\frac{9}{4}\,\frac{n_1\, m_1\, R_1^2\, \omega_1}{R_2^3}\,t\right]\right)^{1/2}. \tag{13.33}$$

The external rotator in the field of the internal one

Here the formula for Ω is obtained by the exchange of the lower indices $1 \leftrightarrow 2$:

$$\Omega_2 = \frac{3\, n_2\, m_2\, R_2^2\, \omega_2}{2\, R_1^3}\left(\frac{9}{4} - 2\,\mathrm{sn}^2\left[\frac{9}{4}\,\frac{n_2\, m_2\, R_2^2\, \omega_2}{R_1^3}\,t\right]\right)^{1/2}.$$

On the maximal precession angle

This angle changes within the bounds of $-\frac{\pi}{2}$ and $+\frac{\pi}{2}$ for any values s and r because

$$t \in (-\infty\,,+\infty) \Rightarrow \frac{9}{4}\frac{s}{r^3}t \in (-\infty\,,+\infty) \Rightarrow \mathrm{sn}\left(\frac{9}{4}\frac{s}{r^3}t\right) \in [-1\,,+1\,].$$

$$\theta = \arcsin\left(\mathrm{sn}\left(\frac{9}{4}\frac{s}{r^3}t\right)\right) \in \left[-\frac{\pi}{2}\,,+\frac{\pi}{2}\right].$$

13.3.
Reduction to ordinary dimension

We used $G = c = 1$ system of units. In ordinary units the ratio m/r is not dimensionless and substitution is necessary

$$m \rightarrow \frac{G\,m}{c^2}\,, \tag{13.34}$$

and then

$$\Omega_1 = \frac{3\,G\,n_1\,m_1\,R_1^2}{2\,R_2^3\,c^2}\,\omega_1\,\Big[\,\frac{9}{4} - 2\,\mathrm{sn}^2\,\Big(\frac{9\,G\,n_1\,m_1\,R_1^2\,\omega_1}{4\,R_2^3\,c^2}\,t\Big)\Big]^{1/2}; \tag{13.35}$$

$$\Omega_2 = \frac{3\,G\,n_2\,m_2\,R_2^2}{2\,R_1^3\,c^2}\,\omega_2\,\Big[\,\frac{9}{4} - 2\,\mathrm{sn}^2\,\Big(\frac{9\,G\,n_2\,m_2\,R_2^2\,\omega_2}{4\,R_1^3\,c^2}\,t\Big)\Big]^{1/2}, \tag{13.36}$$

where G is the gravitational constant; c is the velocity of light.

Specification of the concept of time

The matter is in the fact that together with other coordinates in the formula for the interval there is the time. Therefore, when the external rotator is considered to give the metrics, it gives not only the spatial components of the metrics but the time component as well. Thus, it follows from nowhere that the time in the formula for Ω_1 is the same as that in the formula for Ω_2. The former and the latter can be supposed to be equal to each other. Yet, we should keep in mind that we made this assumption, otherwise instead of t in the formulae (13.35) and (13.36) we should write t_1 and t_2, respectively.

Now we clarify the consequences following from the assumption that the time factor is equal to the period. First we calculate its value.

In the case (13.35) we have the following expression for the period T_1 :

$$\frac{9\,G\,n_1\,m_1\,R_1^2\,\omega_1}{4\,R_2^3\,c^2}\,T_1 = 2\pi \Rightarrow T_1 = \frac{8\,\pi\,R_2^3\,c^2}{9\,G\,n_1\,m_1\,R_1^2\,\omega_1}\,. \tag{13.37}$$

In the same way we obtain for T_2 :

$$\frac{9\,G\,n_2\,m_2\,R_2^2\,\omega_2}{4\,R_1^3\,c^2}\,T_2 = 2\pi \Rightarrow T_2 = \frac{8\,\pi\,R_1^3\,c^2}{9\,G\,n_2\,m_2\,R_2^2\,\omega_2} \tag{13.38}$$

Now in (13.35) we assume that $t = T_1$. In this case the elliptic sine turns into zero and then

$$\Omega_1\,\Big|_{t_1 = T_1} = \frac{3\,G\,n_1\,m_1 R_1^2}{2\,R_2^3\,c^2}\,\omega_1\,.$$

In the analogous way we obtain:

$$\Omega_2 \Big|_{t_2 = T_2} = -\frac{3\, G\, n_2\, m_2 R_2^2}{2\, R_1^3\, c^2}\, \omega_2 \, . \tag{13.39}$$

Now we consider the ratio of the precession periods. We denote it by k_T :

$$k_T = \frac{T_1}{T_2} = \frac{R_2^3}{n_1\, m_1\, R_1^2\, \omega_1} \cdot \frac{n_2\, m_2\, R_2^2\, \omega_2}{R_1^3} = \frac{n_2\, m_2\, \omega_2\, R_2^5}{n_1\, m_1\, \omega_1\, R_1^5} = \frac{n_2}{n_1} \cdot \frac{m_2}{m_1} \cdot \frac{\omega_2}{\omega_1} \left(\frac{R_2}{R_1} \right)^5 . \tag{13.40}$$

If we introduce the notations

$$k_n = \frac{n_1}{n_2}\, ; \; k_m = \frac{m_1}{m_2}\, ; \; k_\omega = \frac{\omega_1}{\omega_2}\, ; \; k_R = \frac{R_1}{R_2}\, , \tag{13.41}$$

then (13.40) takes the simple form:

$$k_T = \frac{1}{k_n\, k_m\, k_\omega\, k_R^5} \, ,$$

or

$$k_n\, k_m\, k_\omega\, k_R^5\, k_T = 1 \, . \tag{13.42}$$

This is the general formula valid for any set of parameters. Otherwise, (13.42) means such dependence:

$$\frac{n_1}{n_2} \cdot \frac{m_1}{m_2} \cdot \frac{\omega_1}{\omega_2} \cdot \frac{R_1^5}{R_2^5} \cdot \frac{T_1}{T_2} = 1 \, .$$

Consequences following from the equality: $\Omega_1 = \Omega_2$

If we require the literal equality of instantaneous velocities,we obtain a cumbersome expression:

$$\Omega_1 = \Omega_2 \Rightarrow \frac{\Omega_1}{\Omega_2} = 1 \Rightarrow \frac{3\, G\, n_1\, m_1\, R_1^2\, \omega_1\, R_1^3\, c^2}{2\, R_2^3\, c^2\, G\, n_2\, m_2\, R_2^2\, \omega_2} \cdot \frac{\left[\frac{9}{4} - 2\, \mathrm{sn}^2 \left(\frac{9\, G\, n_1\, m_1\, R_1^2\, \omega_1}{4\, R_2^3\, c^2}\, t_1 \right) \right]^{1/2}}{\left[\frac{9}{4} - 2\, \mathrm{sn}^2 \left(\frac{9\, G\, n_2\, m_2\, R_2^2\, \omega_2}{4\, R_1^3\, c^2}\, t_2 \right) \right]^{1/2}} = 1 \, . \tag{13.43}$$

The expression (13.43) is the product of two fractions: the first fraction does not depend on t, the second one depends on t. Yet, their product does not depend on t. The conclusion is that the second fraction should not depend on time either. It means that from the assumption $\Omega_1 = \Omega_2$, besides the algebraic consequences (13.44), the requirement of a certain relation between t_1 and t_2 follows. In any case if $T_1 \neq T_2$ then $t_1 \neq t_2$ either.

First we consider the algebraic consequences of (13.43):

$$\frac{n_1\, m_1\, R_1^2\, \omega_1\, R_1^3}{R_2^3\, n_2\, m_2\, R_2^2\, \omega^2} = 1 \Rightarrow \frac{n_1}{n_2}\frac{m_1}{m_2}\frac{\omega_1}{\omega_2}\left(\frac{R_1}{R_2}\right)^5 = 1 \Rightarrow k_n\, k_m\, k_\omega\, k_R^5 = 1\,, \tag{13.44}$$

where

$$k_n = \frac{n_1}{n_2}\,;\; k_m = \frac{m_1}{m_2}\,;\; k_\omega = \frac{\omega_1}{\omega_2}\,;\; k_R = \frac{R_1}{R_2}\,. \tag{13.45}$$

Now we obtain the relation between t_1 and t_2 in the apparent form from (13.43):

$$\frac{\left[\frac{9}{4} - 2\,\mathrm{sn}^2\left(\frac{9\,G\, n_1\, m_1\, R_1^2\, \omega_1}{4\, R_2^3\, c^2}\, t_1\right)\right]^{1/2}}{\left[\frac{9}{4} - 2\,\mathrm{sn}^2\left(\frac{9\,G\, n_2\, m_2\, R_2^2\, \omega_2}{4\, R_1^3\, c^2}\, t_2\right)\right]^{1/2}} = 1\,.$$

We derive the relation between the constant k_T and other constants of (13.37)—(13.38):

$$k_T = \frac{T_1}{T_2} = \frac{8\pi\, R_2^3\, c^2\, 9\,G\, n_2\, m_2\, R_2^2\, \omega_2}{9G\, n_1\, m_1\, R_1^2\, \omega_1\, 8\pi\, R_1^3\, c^2} = \frac{n_2}{n_1}\frac{m_2}{m_1}\frac{\omega_2}{\omega_1}\left(\frac{R_2}{R_1}\right)^5 = \frac{1}{k_n}\frac{1}{k_m}\frac{1}{k_\omega}\frac{1}{k_R^5}\,. \tag{13.46}$$

The formula (13.46) is a general one, yet we compare it with (13.44) characterizing our case $\Omega_1 = \Omega_2$. It can be rewritten as

$$\frac{1}{k_T} = 1\,;\; k_T = 1\,.$$

And so, if $\Omega_1 = \Omega_2$, then

1) from (13.44) it follows that $k_n\, k_m\, k_\omega\, k_R^5 = 1$.

2) $t_1 = \pm\, t_2$, i.e. the time in both rotators flows with the same velocity but probably in different directions.

13.4. How the calculation changes in the case of a strong field

We use the formula valid in a general case but not only in the case of a weak field:

$$\varepsilon_{\hat{i}\hat{j},\hat{k}}\Omega^{\hat{k}} = \Gamma_{\hat{i}\hat{j},\hat{0}}, \tag{13.47}$$

where $\Gamma_{\hat{i}\hat{j},\hat{0}}$ is the Christoffel symbol of the first kind; $\wedge$ means the proper reference frame. Therefore, the coefficients $\Gamma_{\hat{i}\hat{j},\hat{0}}$ have to be calculated:

$$\Gamma_{kl,i} = \frac{1}{2}\left(-g_{kl,i} + g_{ik,l} + g_{li,k}\right). \tag{13.48}$$

Only $ij,0$ are of interest for us, therefore,

$$\Gamma_{\hat{i}\hat{j},\hat{0}} = \frac{1}{2}\left(-g_{\hat{i}\hat{j},\hat{0}} + g_{\hat{0}\hat{i},\hat{j}} + g_{\hat{j}\hat{0},\hat{i}}\right). \tag{13.49}$$

Now we consider the case of a strong field:

$$ds^2 = g_{00}d(ct)^2 + g_{11}dr^2 + g_{22}d\theta^2 + g_{33}d\varphi^2 + 2g_{03}d\varphi dt, \tag{13.50}$$

where $g_{00} = 1 - \frac{r_g^{\,2}}{p^2}$; $r_g = 2m\frac{G}{c^2}$; $p^2 = r^2 + a^2\cos^2\theta$; $a = \frac{M}{mc}$; M is the moment of the source rotation; m is the mass,

$$g_{00} = 1 - \frac{2mGr}{c^2\left(r^2 + a^2\cos^2\theta\right)}; \tag{13.51}$$

$$g_{11} = -\frac{p^2}{\Delta};$$

$$\Delta = r^2 - r_g r + a^2 = r^2 - \frac{2mGr}{c^2} + \frac{M^2}{m^2c^2}; \tag{13.52}$$

$$g_{22} = -p^2; \tag{13.53}$$

$$g_{33} = -\left(r^2 + a^2 + \frac{r_g r a^2}{p^2}\right)\sin^2\theta; \tag{13.54}$$

$$g_{03} = \frac{r_g r a}{p^2}\sin^2\theta. \tag{13.55}$$

Now we consider more attentively the formula (13.49). The first term contains the derivatives $\frac{\partial}{\partial ct} = \frac{\partial}{\partial x_0}$, yet, not a single coefficient g_{ik} in (13.50) — (13.55) depends on t, therefore, (13.49) can be simplified:

$$\Gamma_{\hat{i}\hat{j},\hat{0}} = \frac{1}{2}\left(g_{\hat{0}\hat{i},\hat{j}} + g_{\hat{j}\hat{0},\hat{i}}\right).$$

And since g_{ij} is symmetrical, then

$$\Gamma_{\hat{i}\,\hat{j},\,\hat{0}} = \frac{1}{2}\left(g_{\hat{0}\,\hat{i},\,\hat{j}} + g_{\hat{0}\,\hat{j},\,\hat{i}}\right). \tag{13.56}$$

Among the coefficients of the type $g_{\hat{0}\,\hat{i}}$, $g_{\hat{0}\,\hat{j}}$ only g_{03} is not equal to zero, therefore, among the indices $\hat{i}\ \hat{j}$ at least one should be equal to 3. And so:

$$\Gamma_{03,0} = \frac{1}{2}\, g_{00,3} = \frac{1}{2}\frac{\partial}{\partial\varphi}\, g_{00} = 0\ ;$$

$$\Gamma_{13,0} = \frac{1}{2}\, g_{03,1} = \frac{1}{2}\frac{\partial}{\partial r}\, g_{03} = \frac{1}{2}\frac{\partial}{\partial r}\, a r_g \sin^2\theta\, \frac{r}{\rho^2} =$$

$$= \frac{a r_g \sin^2\theta}{2}\cdot\frac{\partial}{\partial r}\frac{r}{r^2 + a^2\cos^2\theta} = \frac{a r_g\sin^2\theta}{2}\cdot\frac{r^2 + a^2\cos^2\theta - r(2r)}{\rho^4} = \frac{a r_g\sin^2\theta}{2}\cdot\frac{\rho^2 - 2r^2}{\rho^4}\ ; \tag{13.57}$$

$$\Gamma_{23,0} = \frac{1}{2}\, g_{03,2} = \frac{1}{2}\frac{\partial}{\partial\theta}\frac{a r r_g \sin^2\theta}{\rho^2} = \frac{a r r_g}{2}\cdot\frac{\partial}{\partial\theta}\frac{\sin^2\theta}{r^2 + a^2\cos^2\theta} =$$

$$= \frac{a r r_g}{2}\cdot\frac{2\sin\theta\cos\theta\,\rho^2 + \sin^2\theta\, 2a^2\cos\theta\sin\theta}{\rho^4} = \frac{a r r_g}{2\rho^4}\cdot(\rho^2 + a^2\sin^2\theta)\sin 2\theta\ ; \tag{13.58}$$

$$\Gamma_{33,0} = g_{03,3} = \frac{\partial}{\partial\varphi}\, g_{03} = 0\ .$$

Since $\Gamma_{\hat{i}\,\hat{j},\,\hat{0}} = \Gamma_{\hat{j}\,\hat{i},\,\hat{0}}$, all the non-zero coefficients of connectivity are calculated. They are the following:

$$\Gamma_{13,0} = \Gamma_{31,0} = \frac{a r_g \sin^2\theta}{2}\cdot\frac{\rho^2 - 2r^2}{\rho^4}\ ; \tag{13.59}$$

$$\Gamma_{23,0} = \Gamma_{32,0} = \frac{a r r_g \sin 2\theta}{2}\cdot\frac{\rho^2 + a^2\sin^2\theta}{\rho^4}\ . \tag{13.60}$$

Consequently, the angular velocity vector Ω^k has two non-zero components: $\Omega^1 = \Gamma_{23,0}$, $\Omega^2 = \Gamma_{13,0}$. And $\Omega^3 = 0$. Ω^1 is the radial component of the precession vector; Ω^2 is the θ-component of the precession vector.

13.5. Calculation of precession vector components in an apparent way

The expresssion for Ω^1 is given by the following formula:

$$\Omega^1 = \Gamma_{23,0} = \frac{a\, r\, r_g \sin 2\theta}{2}\cdot\frac{\rho^2 + a^2\sin^2\theta}{\rho^4}\ ; \tag{13.61}$$

$$a = \frac{M}{mc}\ ;\ r_g = \frac{2mG}{c^2}\ ;$$

$p^2 = r^2 + a^2 \cos^2\theta$.

The parameter a is calculated in the following way:

$$M = n_s m_s R_s^2 \omega_s \, . \tag{13.62}$$

Here m is meant as $n_s m_s$, where n_s is the number of the particles of the rotator-source; m_s is the mass; ω_s is the angular velocity; R_s is the radius.

Substitute them into the expression for a:

$$\left. \begin{array}{l} a = \dfrac{M}{mc} \, ; \\ M = n_s m_s R_s^2 \, \omega_s \, ; \, m = n_s m_s \end{array} \right| \Rightarrow a = \frac{R_s^2 \, \omega_s}{c} \, . \tag{13.63}$$

Now obtain the expression for r_g :

$$r_g = \frac{2mG}{c^2} = \frac{2n_s m_s G}{c^2} \, ; \tag{13.64}$$

$$p^2 + a^2 \sin^2\theta = r^2 + a^2 \cos^2\theta + a^2 \sin^2\theta = r^2 + a^2 \, . \tag{13.65}$$

Substitute (13.63)—(13.65) into (13.61):

$$\Omega^1 = \frac{2n_s \, m_s \, R_s^2 \, \omega_s \, G}{c^3} \cdot \frac{r \sin 2\theta}{2} \cdot \frac{1}{p^2} \cdot \frac{r^2 + a^2}{p^2} = \frac{G}{c^3} \cdot \frac{n_s \, m_s \, \omega_s \, R_s^2}{1} \, r \sin 2\theta \, \frac{r^2 + \left(\dfrac{R_s^2 \, \omega_s}{c} \right)^2}{\left[r^2 + \left(\dfrac{R_s^2 \, \omega_s}{c} \right)^2 \cos^2\theta \right]^2} =$$

$$= \frac{n_s \, m_s \, \omega_s \, R_s^2}{c^3} \, G \, r \sin 2\theta \, \frac{r^2 c^2 + R_s^4 \, \omega_s^2}{(r^2 c^2 + R_s^4 \, \omega_s^2 \cos^2\theta)^2} \, c^2 = n_s \, m_s \, \omega_s \, R_s^2 \, \frac{G}{c} \, r \sin 2\theta \, \frac{r^2 c^2 + R_s^4 \, \omega_s^2}{(r^2 c^2 + R_s^4 \, \omega_s^2 \cos^2\theta)^2} \, . \tag{13.66}$$

Now we obtain the analogous apparent formula for the other component, i.e. Ω^2 :

$$\Omega^2 = \Gamma_{13,0} = \frac{a r_g \sin^2\theta}{2} \cdot \frac{p^2 - 2r^2}{p^4} \, . \tag{13.67}$$

We simplify the expression $p^2 - 2r^2$:

$$p^2 - 2r^2 = r^2 + a^2 \cos^2\theta - 2r^2 = a^2 \cos^2\theta - r^2 \, , \tag{13.68}$$

and substitute (13.63), (13.64), (13.68) into (13.67):

$$\Omega^2 = \frac{R_s^2 \omega_s}{c} \cdot \frac{n_s m_s G}{c^2} \sin^2\theta \frac{\frac{R_s^4 \omega_s^2}{c^2} \cos^2\theta - r^2}{\left(\frac{R_s^4 \omega_s^2}{c^2} \cos^2\theta + r^2\right)^2} = \frac{n_s m_s \omega_s R_s^2 G \sin^2\theta}{c^3} \cdot \frac{R_s^4 \omega_s^2 \cos^2\theta - r^2 c^2}{(R_s^4 \omega_s^2 \cos^2\theta + r^2 c^2)^2} c^2 =$$

$$= n_s m_s \omega_s R_s^2 \frac{G}{c} \sin^2\theta \frac{R_s^4 \omega_s^2 \cos^2\theta - r^2 c^2}{(R_s^4 \omega_s^2 \cos^2\theta + r^2 c^2)^2} . \tag{13.69}$$

Thus we can write:

$$\Omega = \frac{n_s m_s \omega_s R_s^2 \frac{G}{c} \sin\theta}{(R_s^4 \omega_s^2 \cos^2\theta + r^2 c^2)^2} \begin{bmatrix} 2r \cos\theta \, (R_s^4 \omega_s^2 + r^2 c^2) \\ \sin\theta \, (R_s^4 \omega_s^2 \cos^2\theta - r^2 c^2) \\ 0 \end{bmatrix} . \tag{13.70}$$

The formula is rather complicated. Yet, the fact that $\Omega^3 = 0$ corroborates it, i.e. the precession has no φ-component but has only the radial component and θ-component.

Now we calculate the absolute value of the precession angular velocity. For this aim we calculate the absolute value of the vector in brackets of the above-mentioned formula. We denote this value by λ_1.

Since the length of the arbitrary vector $\begin{pmatrix} a \\ b \\ c \end{pmatrix}$ written in the polar coordinates is equal to $\sqrt{a^2 + r^2 (b^2 + c^2 \cos^2 b)}$, then

$$\lambda_1^2 = 4r^2 \cos^2\theta \, (R_s^4 \omega_s^2 + r^2 c^2)^2 + r^2 \sin^2\theta \, (R_s^4 \omega_s^2 \cos^2\theta - r^2 c^2)^2 =$$

$$= r^2 \cos^2\theta \, [4 \, (R_s^4 \omega_s^2 + r^2 c^2)^2 + \mathrm{tg}^2\theta \, (R_s^4 \omega_s^2 \cos^2\theta - r^2 c^2)^2 \,] \Rightarrow$$

$$\lambda_1 = r \cos\theta \sqrt{4 \, (R_s^4 \omega_s^2 + r^2 c^2)^2 + \mathrm{tg}^2\theta \, (R_s^4 \omega_s^2 \cos^2\theta - r^2 c^2)^2} . \tag{13.71}$$

Now multiplying (13.71) by the factor from (13.70) we obtain the apparent expression for the precession angular velocity:

$$|\Omega| = \frac{n_s m_s \omega_s R_s^2 \frac{G}{c} r \sin\theta \cos\theta}{(R_s^4 \omega_s^2 \cos^2\theta + r^2 c^2)^2} \sqrt{4 \, (R_s^4 \omega_s^2 + r^2 c^2)^2 + \mathrm{tg}^2\theta \, (R_s^4 \omega_s^2 \cos^2\theta - r^2 c^2)^2} . \tag{13.72}$$

To obtain the concrete formulae for the external rotator in the field of the internal one it is necessary to substitute index 2 for s and R_1 for r , and for the internal rotator in the field of the external one to substitute index 1 for s and R_2 for r .

For that purpose the following equation should be solved:

$$\frac{d\theta}{dt} = \frac{c_1 \sin 2\theta}{(c_2 \cos^2\theta + c_3)^2} \sqrt{c_4 + (c_2 \cos^2\theta - c_3)^2 \, \mathrm{tg}^2\theta} , \tag{13.73}$$

where $c_1 = \frac{1}{2} n_s m_s \omega_s R_s^2 \frac{G}{c} r = \text{const}$ (note: $r = \text{const}$ because we consider not an arbitrary motion but the rotator);

$c_2 = R_s^4 \omega_s^2 = \text{const}$; $c_3 = r^2 c^2 = \text{const}$; $c_4 = 4 (c_2 + c_3)^2$.

14 FEATURES OF FUNDAMENTON STRUCTURE IN TFF

14.1. Motion of fundamenton in 3SS

On the surface of the torus there is a kind of pseudo-Riemannian geometry, the interval equation of which is of the following form:

$$ds^2 = e^{\nu} c^2 dt^2 - R_2^2 d\theta^2 - (R_1 + R_2 \cos\theta)^2 \, d\varphi^2 , \tag{14.1}$$

where $e^{\nu} = g_{00}$ is the time component of the metric tensor;

$$c dt = dx_0 \, ; \, d\theta = dx_1 \, ; \, d\varphi = dx_2 \, ; \, g_{11} = R_2^2 \, ; \, g_{22} = (R_1 + R_2 \cos\theta)^2 \, .$$

We find the relation between the parameters for the object moving on the torus surface along the n-coil screw line which is the geodetic in this geometry.

Solving the equation of the geodetic

$$\ddot{x}^k + \Gamma_{ij} \dot{x}^i \dot{x}^j = 0 \tag{14.2}$$

(where the derivative is taken with respect to the affined parameter of the length dimension l_a), we find the expressions for the principal geometric parameters:

$$\varphi = \frac{l_\varphi}{(R_1 + R_2 \cos\theta)^2} \, ; \tag{14.3}$$

$$\dot{\theta} = \frac{n l_\varphi}{(R_1 + R_2 \cos\theta)^2} \, ; \tag{14.4}$$

$$e^{\nu} = \beta_0 c \, \frac{dt}{dl_a} \, ; \tag{14.5}$$

$$\theta = n \, \varphi \, ,$$

where l_φ , β_0 are the constants of integration.

It turns out that along the geodetic the following value is constant:

$$\left(R_1^2 + \frac{R_2^2}{2}\right)\theta + 2R_1 R_2 \sin\theta + \frac{R_2^2}{4} \sin 2\theta - n l_\varphi l_a = \text{const} \, . \tag{14.6}$$

For g_{00} we have:

$$g_{00} = e^{\nu} = \left[\frac{n_2 R_2^2 l_\varphi^2 \beta_0^2}{(R_1 + R_2 \cos\theta)^4} + \frac{l_\varphi^2 \beta_0}{(R_1 + R_2 \cos\theta)^2} + \frac{s R_2^2 \beta_0^2}{l_\theta^2} \right]^{-1} , \tag{14.7}$$

where s / l_θ^2 is the constant of integration.

For the velocity of motion along the geodetic we have:

$$\upsilon = \frac{n \beta_0 c e^{\nu/2} l_\varphi R_2}{(R_1 + R_2 \cos\theta)^2} \left[\frac{(R_1 + R_2 \cos\theta)^2}{n_2^2 R_2^2} \right]^{1/2}. \tag{14.8}$$

From (14.7) and (14.8), under the condition that the constant of integration $s / l_\theta^2 = 0$, we obtain:

$$\upsilon = c = \text{const} \tag{14.9}$$

under all angles θ and φ and all values of the torus dimensional parameters R_1, R_2, and irrespective of the number of the coils n and the values of the constants of integration l_φ and β_0.

The existence of the invariable velocity of motion along the geodetic in the geometry in question and its equality to the "velocity of light" in (14.9) is rather a noteworthy fact.

As it is known, the invariability of c is postulated in SR and this postulate in this quality is kept in all relativistic theories. The first step is made here to the substantiation of this postulate and to its replacement by the theorem within the bounds of TFF. The result of (14.9) is obtained under $s / l_\theta^2 \to 0$ which corresponds to $R_1 \to \infty$ and means in fact that it is valid only outside the finite surface of the torus in the external space concerning this surface. To determine the velocity of motion just on the torus surface of a finite dimension it is necessary to determine the course of time on it.

Yet, the problem of time in this geometry needs special investigation. There are reasons to suppose that within the bounds of this geometry the time is not the notion usual for us, with the value always flowing in one direction. Here the time increases from 0 to $T/2$ per turn with respect to the angle θ and afterwards it decreases up to 0 again. Mind, that on the torus surface of the finite dimension the velocity of motion is equal to $n\beta c > c$. The charge moving on this surface is the tachyon.

It is important to mind that the mapping of the velocities and time component of the metric tensor g_{00} from 3SS onto SS $(3 \to 2)$, 2SS, SS $(2 \to 1)$ and 1SS is possible under the condition that these values in these subspaces become invariable with respect to the time peculiar to the corresponding subspaces. For this aim it is not necessary to redefine the interpretation of time as above, it is only necessary to set the corresponding law of mapping.

Thus, we obtain the coordination of fundamenton motion on the torus surface and the description of EP in different subspaces.

14.2.
Dynamics of fundamenton motion and calculation of its parameters

Note, that on the torus surface TL in the pseudo-Riemannian geometry for the Einstein tensor

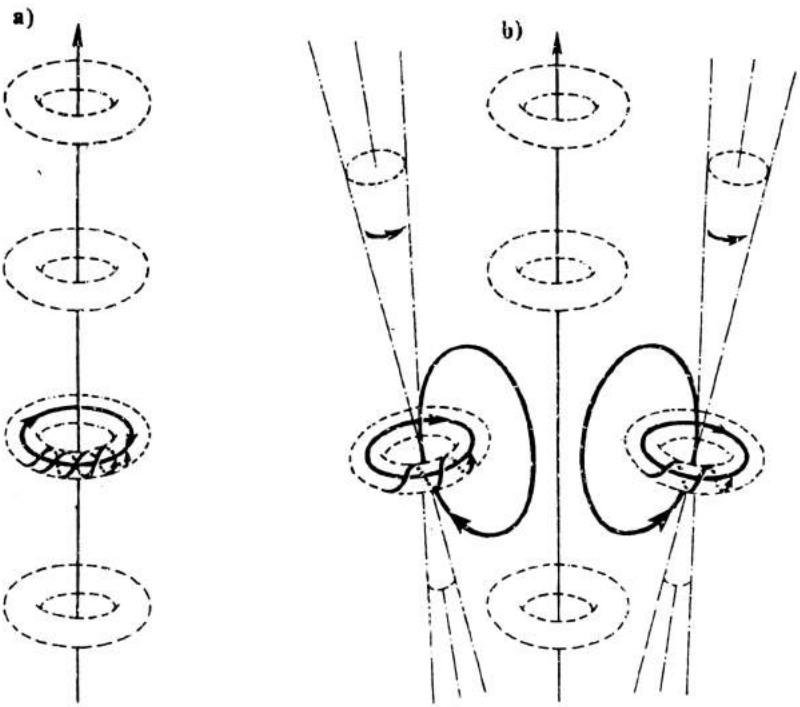

Fig. 14.1 Formation (scheme) of fundamenton as the basic S^3 space cell; a — EPV, b — BEP

$$G^i_k = R^i_k - \frac{1}{2} R \, \delta^i_k \tag{14.10}$$

results in the following values of the Einstein tensor components:

$$G^0_0 = \frac{\cos\theta}{R_2 (R_1 + R_2 \cos\theta)} ; G^1_1 = - \frac{\nu^1 \sin\theta}{2R_2 (R_1 + R_2 \cos\theta)} ; G^2_2 = \frac{2\nu^{11} + \nu^{12}}{4R_2^2} . \tag{14.11}$$

The interpretation of the found relation between the parameters in kinematics of the fundamenton motion and of the fact that on the torus surface in the above-mentioned geometry there is the screw geodetic, leads to a very interesting result. Most probably, the only possibility to explain the dynamics of the fundamenton motion, whose kinematics corresponds to the geodetic on the torus surface, reduces to the control of this motion by the fields of two current strings (Fig. 14.1).

One current string going along the torus symmetry axis and off into the "infinity" (closing itself at a distance of the order of the Universe radius) excites the magnetic field which by interacting with the magnetic field of the second current string,going along the torus forming circumference axis, gives the resulting field along the n-coil screw line on the torus surface. If in 3SS we have both the electric charge in the direction of the angle φ, and the magnetic charge along the trajectory of motion, which is practically orthogonal to the plane secant to the torus, then the description of the fundamenton motion would be complete.

All these problems have to be thoroughly studied and developed in future. Now we can restrict ourselves to that great amount of information given by the already known regularities, which allow, as it is shown below, to calculate the most part of EP and EPV properties. So, we can calculate all parameters of the fundamenton by using the information we have already obtained.

In our space the principal EP is the proton because the concentration of proton-antiproton vacuum is almost by ten orders greater than that of electron-positron vacuum, nearest to the former. Therefore, it is natural to consider that the fundamenton, being in the basic state in 3SS, is mapped onto 1SS as the proton. From this supposition we can determine the fundamenton parameters and make the proton parameters more correct. First we determine the charges of the proton and fundamenton. ΓL and the requirement of the circular orbit stability [7] result in the following equation for γ_ξ in the calculation SS $(2 \to 1)$:

$$\gamma_{(2\to 1)} = (1 - \beta_1^2)_p \, (1 - g_{00})_p^{1/2} \, (1 - 3g_{00})_p^{1/2} \frac{M_p c}{2m_p^2}, \tag{14.12}$$

where the index p means that all parameters correspond to the proton. In Table 16.1 it is shown that

$$g_{001} = 1 - \beta_1^2 \, ; \, g_{002} = 1 - \beta_2^2 \tag{14.13}$$

Then the equation (14.12) becomes

$$\gamma_{(2\to 1)} = (1 - \beta_1^2)_p \left[1 - (\beta_1^2 - \beta_2^2)_p\right]^{1/2} \left[1 - 3(\beta_1^2 - \beta_2^2)_p\right]^{1/2} \frac{M_p c}{2m_p^2}. \tag{14.14}$$

It is known that

$$\gamma_{(2\to 1)} = \frac{\alpha \hbar c}{m^2} \, ; \, (\gamma_{(2\to 1)} = \gamma) \, , \tag{14.15}$$

and

$$M = \frac{\hbar k_f^{1/2} \varepsilon_f^{1/2}}{a_{gp} (1 - g_{00})_p (1 - 3g_{00})_p},$$ (14.16)

where $a_{gp} = \left(\frac{\beta_2 k_y}{\beta_1 k_x}\right)^2 = 1.000\,889\,025$ is the dimensionless constant for the proton; $k_f = 1.000\,004\,305$ and $\varepsilon_f = 1.000\,000\,351$ are the "background" constants of PV (see sections 15 and 16). For the dimensionless constant α, according to (7.18) we have:

$$\alpha = \frac{\pi (1 - \beta_1^2)_p k_f^{1/2} \varepsilon_f^{3/2} \varepsilon_f^{1/3}}{a_{gp} (1 - g_{00})_p^{1/2} (1 - 3g_{00})_p^{1/2}}.$$ (14.17)

In 3SS the charges of FF q_1 and q_2 are equal to each other. This equality holds for SS $(3 \rightarrow 2)$ and 2SS but in SS $(2 \rightarrow 1)$ we have $q_1 \neq q_2$. The difference of the FF charges is the relativistic effect; as the result of that, an electric charge egual to this difference originates in SS $(2 \rightarrow 1)$ and is mapped onto 1SS, retaining its value. In this process of mapping the physical parameters, the dimensionless constant α has the meaning of the ratio of the electric charge square in 1SS and in SS $(2 \rightarrow 1)$ to the FF charge square in 3SS.

Consequently,

$$\alpha = \left(\frac{q^{(1)}}{q_{1,2}^{(3)}}\right)^2 \text{ and } (q_1^{(3)})^2 = (q_2^{(3)})^2 = \hbar c.$$ (14.18)

The calculation formulae and certain results of the calculation of the parameters of all EPs are given below. To find the numerical value of the global constant α we put the numerical values of dimensionless internal parameters of the proton into (14.17) and obtain:

$(1 - \beta_1^2)_p = 2.323\,803\,680 \cdot 10^{-3}$; $(1 - \beta_2^2)_p = 2.554\,886\,718 \cdot 10^{-3}$; $\alpha = 7.297\,352\,378 \cdot 10^{-3}$.

According to the accuracy of the experiment (known by april 1990) [108], this value coincides with the experimental value of $\alpha = 7.29\,735\,04\,(61) \cdot 10^{-3}$. The former has a substantially greater accuracy than the latter.

We now calculate other parameters of the fundamenton.

According to (7.24), the velocities of motion of the dipole of the FF charges constituting the fundamenton in 3SS are the following:

$$\beta_1^{(3)} = n_{1p} \beta_{1p}; \; \beta_2^{(3)} = n_{2p} \beta_{2p},$$ (14.19)

where $n_{1p} = 6330$ and $n_{2p} = 5494$ (see table 18.1). Taking into account the fact that the masses connected with fundamental charges have different signs, for the mapping of mass from 2SS onto SS $(2 \to 1)$ or onto 1SS (which is the same in our case) we should write [7]:

$$m_p = \frac{|m_2^{(2)}| - |m_1^{(2)}|}{(|\beta_2^{(3)}|^2 - 1)}, \tag{14.20}$$

where m_p, $|m_2^{(2)}|$, $|m_1^{(2)}|$ are the proton mass in 1SS and absolute values of masses in 2SS, respectively.

The masses in 2SS are mapped onto 3SS according to the law: *)

$$|m_2^{(2)}| = \frac{|m_2^{(3)}|}{(|\beta_2^{(3)}|^2 - 1)^{3/2}}; \; |m_1^{(2)}| = \frac{|m_1^{(3)}|}{(|\beta_1^{(3)}|^2 - 1)^{3/2}}. \tag{14.21}$$

Then the following relation exists between the masses constituting the fundamenton in 3SS and the masses mapped onto SS $(2 \to 1)$ and, consequently, onto 1SS (in our case it is the proton mass):

$$m_p = \frac{m_2^{(3)}}{(|\beta_2^{(3)}|^2 - 1)^{5/2}} \left[1 - \frac{m_1^{(3)}(|\beta_2^{(3)}|^2 - 1)^{3/2}}{m_2^{(3)}(|\beta_1^{(3)}|^2 - 1)^{3/2}}\right]. \tag{14.22}$$

For the stability of the circular orbit the following condition should also be satisfied: $|m_2^{(3)}| = \sqrt{9/8}\,|m_1^{(3)}|$, and then we obtain:

$$|m_2^{(3)}| = m_p \frac{(|\beta_2^{(3)}|^2 - 1)^{5/2}}{\left[1 - \sqrt{8/9}\,\frac{(|\beta_2^{(3)}|^2 - 1)^{3/2}}{(|\beta_1^{(3)}|^2 - 1)^{3/2}}\right]}. \tag{14.23}$$

In (14.23) the mass of a "bare" proton is given without taking into consideration its interaction with PV. To take it into account the factor $\frac{\alpha_{gp}^{1/2}}{\beta_{2p}^3}$ should be introduced into (14.23) according

*) Here and further on we omit the lower index p for internal parameters because all of them correspond to those of the proton.

to the formulae for masses given in Part IV (see table 16.1). Then the final formula for the calculation of the mass $|m_2^{(3)}|$ for the fundamenton becomes

$$m_2^{(3)} = m_p \frac{a_{gp}}{\beta_{2p}^3} \frac{(n_2^2\beta_2^2 - 1)^{5/2}}{\left[1 - \sqrt{8/9}\,\frac{(n_2^2\beta_2^2 - 1)^{3/2}}{(n_1^2\beta_1^2 - 1)^{3/2}}\right]} . \text{ (for } a_{gp} \text{ see table 16.1)} \qquad (14.24)$$

In (14.23) and (14.24) the positive part of the fundamenton mass is calculated, because only that part contributes to the determination of the effective radius of fundamenton and the gravitational interaction constant.

The following formulae are valid for these parameters:

$$G_f = \frac{q_{1,2}^2}{m_2^{(3)}} = \frac{\hbar c}{m_2^{(3)}} ; \qquad (14.25)$$

$$r_f = \left(\frac{G_f \hbar}{c^3}\right)^{1/2} = \frac{\hbar}{m_2^{(3)} c} = \frac{G_f\, m_2^{(3)}}{c^2} . \qquad (14.26)$$

The determination of the numerical values of all these parameters of the fundamenton is of a special interest. They are determined as the functions of the global constants $\hbar$, c and m_p and the internal parameters of the proton structure obtained in TFF. The internal constants are known with the accuracy up to nine significant digits. The global constants are determined from the experiment [108] with the accuracy mainly up to six significant digits. As it is shown in Section 15 the calculation formulae found in TFF allow to obtain the more correct values of the global constants:

$m_p = 1.67\ 262\ 291 \cdot 10^{-24}$ g (the experiment — $1.67\ 262\ 31\ (10) \cdot 10^{-24}$ g);

$c = 2.99\ 792\ 455\ 6 \cdot 10^{10}$ c/s (the experiment — $2.99\ 792\ 458\ (1.2) \cdot 10^{10}$ c/s);

$\hbar = 1.05\ 457\ 271\ 0 \cdot 10^{-27}$ erg·s (the experiment — $1.05\ 457\ 266(63) \cdot 10^{-27}$ erg·s).

Taking into account these values of the global constants and the given above values of the internal parameters n_1 , n_2 , β_1 . β_2 , for the proton we have:

$$G_f = 6.67\ 177\ 660\ 0 \cdot 10^{-8}\ c^3 \cdot g^{-1} \cdot s^{-2} ;$$

$$r_f = \left(\frac{G_f \hbar}{c^3}\right)^{1/2} = \frac{\hbar}{m_2^{(3)} c} = \frac{G_f\, m_2^{(3)}}{c^2} = 1.61\ 595\ 016\ 4 \cdot 10^{-33}\ c . \qquad (14.27)$$

The given above value of the constant of the gravitational interaction inside the fundamenton surprisingly coincides with the constant of the gravitational interaction in macrocosm, determined from the experiment and equal to 6.67 20 (41) $\cdot 10^{-8} c^3 \cdot g^{-1} \cdot s^{-2}$. Yet, since TFF allows more exact calculation of this constant, it is of interest to compare the given above value of G for the fundamenton with that calculated for the interaction of the proton in macrocosm, i.e. in 1SS, found by the formula published in [48] by V.A. Crat and I.L. Gerlovin:

$$G = a_{gp} \frac{9 \alpha_p \hbar c}{32} \left(\frac{\lambda_p^2 R_\infty^2}{k_p \pi m_p} \right)^2 k_f \varepsilon_f^{1/3} . \tag{14.28}$$

The substitution of the corresponding values into (14.28) gives the value by 1.00011630 times greater than that given in (14.25). It is of interest to note that this value is very close to the ratio $\beta_{1p} / \beta_{2p} = 1.00\,011\,583$. Taking into account the errors of the experimental values used in the calculation by the formula (14.28), such coincidence seems to be complete. In this case we have to wait for the experimental verification of the difference between the gravitational interactions in depths of microcosm and in macrocosm, which is predicted here. Physically this difference is rather clear: inside the fundamenton the PV influence is practically absent while in macrocosm it cannot be neglected and the value $\beta_{1p} / \beta_{2p} = \varepsilon_1^{1/2} / \varepsilon_2^{1/2}$ is one of the important characteristics of PV (see other sections and [7; 14]).

The proton radius in SS (2 → 1) is connected with its mass [7; 14] by the formula:

$$R_p = \frac{\hbar}{m_p c} \cdot \frac{2s}{\beta_1 a_{gp} f(g_{00p})}, \quad \text{(for } f(g_{00p}) \text{ see table 15.1)} \tag{14.29}$$

where $2s = 1 / \cos\alpha$ is the coefficient determined by the precession angle. The ratio of the fundamenton mass $m_f = 2.17\,688\,010 \cdot 10^{-5}$ g to the proton mass is the following:

$$m_2^{(3)} / m_p = 1.30\,145\,700 \cdot 10^{19} ; \tag{14.30}$$

and the ratio

$$\varepsilon_{1p}^{1/2} a_{gp} f(g_{00p}) R_p / 2 s r_f = 1.30\,145\,700\,0 \cdot 10^{19} \tag{14.31}$$

is of the same value. Since the normalizing factors connected with the structure of EPs and their interaction with PV in the ratio of the masses and in the ratio of the radii are not equal, the coincidence of the values in (14.30) and (14.31) is not of a trivial character and is indicative of internal consistency of calculation methods in TFF.

Thus, the Plank particle which has a number of special names (the "maximon", the "plankeon"), is the primary brick of matter, i.e. the fundamenton.

The parameters of the fundamenton are mapped onto our space in a natural way so that the principal particle of matter, i.e. the proton, is observed. Another stable particle in our space, i.e. the electron, can also be considered as the mapping of this very fundamenton onto 1SS. Yet, in this case in the formulae of the type (14.19)—(14.24) the velocities of subparticles in the electron structure appear, and the relation of metric properties substantially changes under the mapping.

It can be shown that any EP represents the mapping of that very fundamenton onto our space (onto 1SS, i.e. the base of the fiber bundle) if the features of the mapping from 3SS onto 1SS are taken into account in a correct way. For unstable particles it is also necessary to take into account the greatly increasing PV influence upon them.

15 EXACT THEORETICAL CALCULATION OF ALL GLOBAL CONSTANTS IN TFF

In TFF a high level of unified consistency of parameters of microcosm particles determined theoretically is achieved. As it was mentioned above, this level is characterized by such high accuracy that the error may be of only three or four units of the tenth significant digit.

The following result is especially important in TFF. Described in section 12, the relation between the physical quantities dimension and that of the space where the quantities reveal, substantially influences the mode of calculation of parameters characterizing the essence of matter. In particular, it influences the method of global constants calculation.

In contrast to the previous ideas on the future possibility of theoretical determination of global constants, our elaborations carried out within the bounds of TFF gave a unique possibility to calculate ALL GLOBAL CONSTANTS, both dimensionless and, which may sound paradoxical, dimensional from THE DIMENSIONLESS CONSTANTS found by the theory. This possibility is connected with the fact that without exception all global constants, having conventional dimensions in three-dimensional space, are in correspondence with a quantity having a single dimension only (e. g. that of length, or time, or mass) in the linear space. And in the point zero-dimensional space any global constant with any dimension is in unambiguous correspondence with a certain dimensionless quantity. Therefore, if, for example, we determine the dimensionless value of the gravitational constant in the zero-dimensional space, we can find the numerical value of this constant in centimeters, seconds or grams in the linear space, and then the numerical value of this dimensional constant in the three-dimensional space, where it has the dimension c^3/gs^2 in the adopted by us system of units.

The calculation of numerical values of global constants is carried out from the dimensionless constants of TFF. All constants of the theory are the direct consequences of its equations and do not include any fitting parameters.

In this section formulae are given by which it is possible to calculate theoretically the principal global constants. The results of this calculation compared with the experimental data are given in table 15.1.

15.1. Both the fundamental interactions via "strong gravitation" (the A. Salam term) and the invariant length are found from the following equations. The constant of gravitational interaction in 3SS (between fundamentons) is determined as follows:

$$\gamma_f = \frac{q_f^2}{m_f^2} = \frac{\hbar c}{m_f^2}, \tag{15.1}$$

where q_f, m_f are the fundamental charge and the fundamenton mass, respectively. The gravitational constant in macrocosm (1SS) is determined via the constants of TFF as follows:

$$G_{\text{Macro}} = G_M = \frac{\alpha_{\text{inv}} R_{1p}^2}{m_p^2\, 2\pi r_{\text{inv}}^2} \left[\frac{a_g\, n^2 (\beta_1 - \beta_2)^2}{\varepsilon_2\, n_1^2 \beta_1^2}\right]_p \hbar c\,, \tag{15.2}$$

where a_g, n_1, n, ε_2, β_1, β_2, R_p, m_p are the parameters of the proton structure; α_{inv}, r_{inv} are the invariable constants of both the electromagnetic interaction and the length in macrocosm, respectively.

The universal constant of the electromagnetic field interaction is determined from the equation:

$$\alpha_{\text{inv}} = s_p\,(\varepsilon_1 + \varepsilon_2)_p\, g_{00p} \left(\frac{3}{2^{1/2}\,(1 - \beta_1^2)_p\, a_{gp}}\right)^{1/2}, \tag{15.3}$$

where s_p, ε_{1p}, ε_{2p}, g_{00p} are the parameters of the proton structure;

$$r_{\text{inv}} = \sqrt{9/8} \text{ of the length unit.} \tag{15.4}$$

The ratio of the constants G_M and γ_f is completely determined by the ratio of the permittivities of the principal component of FF, i.e. the permittivities of the proton structure:

$$\frac{G_M}{\gamma_f} = \left(\frac{\varepsilon_{1p}}{\varepsilon_{2p}}\right)^{1/2}. \tag{15.5}$$

From (15.1)—(15.5) we have for R_{1p}/r_{inv}:

$$\frac{R_{1p}}{r_{\text{inv}}} = \frac{2\pi}{\alpha_{\text{inv}}} \left(\frac{m_p}{m_f}\right)^2 \left(\frac{n_{1p}}{n_p}\right)^2 \frac{\varepsilon_{1p}^{3/2}\,\varepsilon_{2p}^{1/2}}{a_{gp}(\beta_1 - \beta_2)_p^2}. \tag{15.6}$$

From TFF it is known that

$$\frac{m_f}{m_p} = (\,|\,\beta_2^{(3)}\,|^2 - 1)^{5/2} \frac{a_{gp}^{1/2}}{\varepsilon_{2p}^{1/2}} \left[1 - \sqrt{8/9}\, \frac{(\,|\beta_2^{(3)}|^2 - 1)^{3/2}}{(\,|\beta_1^{(3)}|^2 - 1)^{3/2}}\right]^{-1}, \tag{15.7}$$

where $\beta_1^{(3)}$ and $\beta_2^{(3)}$ are the velocities of the internal motion of the "first" and the "second" particles constituting the fundamenton structure. From (15.6) and (15.7), taking into account (15.4), it is easy to calculate the value of R_{1p} in centimeters (because r_{inv} is adopted to be measured in c.).

15.2. In TFF the proton mass m_p can be calculated by the following formula:

$$\overline{m}_p = \frac{2s_p}{R_{1p}\beta_{1p}\, a_{gp}\,(1 - g_{00})_p\,(1 - 3g_{00})_p}\ c^{-1} \quad \left(m_p = \overline{m}_p \frac{\hbar}{c}\ \text{g}\right). \tag{15.8}$$

Nos	Name	Symbol	Numerical values of global		
			The		
			$d=0$	$d=1$	$(2 \to 1)$ (calculation SS, $d=2$)
1.	Fundamenton radius	$r_f \equiv \lambda_f$	—	$1.61595\,0165 \cdot 10^{-33}$ c	—
2.	Fundamenton mass	m_f	—	$6.18\,830\,965\,2 \cdot 10^{32}$ c^{-1}	$2.17\,684\,680\,2 \cdot 10^{-5}$ g
3.	Constant of fundamenton field interaction	α_f	1	1	1
4.	Constant of fundamenton gravitational interaction	γ_f and $G_f\,(G_M)$	1	—	$2.61\,129\,493\,4 \cdot 10^{-66}$ c^2
5.	Fundamenton charge (in c–g–s units)	q_f	1	1	$5.62\,274\,792\,5 \cdot 10^{-9}$
6.	Proton radius	R_p	—	$2.20\,712\,068\,6 \cdot 10^{-14}$ c	$2.20\,712\,068\,6 \cdot 10^{-14}$ c
7.	Compton length of proton	λ_p	—	$2.10\,308\,965\,3 \cdot 10^{-14}$ c	$2.10\,308\,965\,3 \cdot 10^{-14}$ c
8.	Proton mass	m_p	—	$4.75\,490\,903\,8 \cdot 10^{13}$ c^{-1}	$1.67\,262\,291\,5 \cdot 10^{-24}$ g
9.	Constant of proton field interaction	α_p	—	—	—
10.	Constant of proton gravitational interaction	γ_p	—	—	$3.22\,910\,127\,3 \cdot 10^{-30}$ c^2
11.	Proton charge (in c–g–s units)	e_p	—	—	—
12.	Ratio m_f to m_p	$\frac{m_f}{m_p}$	—	$1.30\,145\,700\,0 \cdot 10^{19}$	$1.30\,145\,700\,0 \cdot 10^{19}$
13.	Electron radius	R_e	—	$4.17\,353\,674\,7 \cdot 10^{-11}$ c	$4.17\,353\,674\,7 \cdot 10^{-11}$ c
14.	Electron mass	m_e	—	$2.58\,960\,459\,0 \cdot 10^{10}$ c^{-1}	$9.10\,938\,978\,0 . 10^{-28}$ g
15.	Constant of electron field interaction	α_e	—	$7.29\,732\,076\,5 \cdot 10^{-3}$	$7.29\,732\,076\,5 \cdot 10^{-3}$
16.	Electron charge (in c–g–s units)	e_e	—	—	$4.80\,319\,626\,0 \cdot 10^{-10}$
17.	Compton length of electron	λ_e	—	$3.86\,159\,340\,2 \cdot 10^{-11}$ c	$3.86\,159\,340\,2 \cdot 10^{-11}$ c

Table 15.1

constants in various subspaces		
o r y	Experiment	
$d=3,1$	Information in 1SS from other SS	Direct measurement in 1SS
—	no data	—
$2.17\ 684\ 680\ 2 \cdot 10^{-5}$ g	no data	—
1	1	—
$6.67\ 177\ 660\ 0 \cdot 10^{-8}\ c^3/gs^2$	no data	—
$5.62\ 274\ 792\ 5 \cdot 10^{-9}$	no data	—
$2.20\ 712\ 068\ 6 \cdot 10^{-14}$ c	$\approx (10^{-14} - 10^{-15})$ c	—
$2.10\ 308\ 965\ 3 \cdot 10^{-14}$ c	no data	—
$1.67\ 262\ 291\ 5 \cdot 10^{-24}$ g	—	$1.67\ 262\ 31\ (10) \cdot 10^{-24}$ g
$7.29\ 735\ 323\ 2 \cdot 10^{-3}$	$7.29\ 735\ 3019\ (61) \cdot 10^{-3}$	$7.29\ 735\ 3019\ (61) \cdot 10^{-3}$
—	no data	—
$4.80\ 320\ 694\ 5 \cdot 10^{-10}$	$4.80\ 320\ 68\ (15) \cdot 10^{-10}$	$4.80\ 320\ 68\ (15) \cdot 10^{-10}$
—	no data	—
$4.17\ 353\ 674\ 7 \cdot 10^{-11}$ c	no data	—
$9.10\ 938\ 978\ 0 \cdot 10^{-28}$ g	$9.10\ 938\ 97\ (54) \cdot 10^{-28}$ g	$9.10\ 938\ 97\ (54) \cdot 10^{-28}$ g
$7.29\ 732\ 076\ 5 \cdot 10^{-3}$	no data	no data
$4.80\ 319\ 626\ 0 \cdot 10^{-10}$	no data	no data
$3.86\ 159\ 340\ 2 \cdot 10^{-11}$ c	$3.86\ 159\ 323\ (35) \cdot 10^{-11}$ c	—

Nos	Name	Symbol	Numerical values of global		
			The		
			$d=0$	$d=1$	$(2 \to 1)$ (calculation SS, $d=2$)
18.	Ratio m_p to m_e	$\frac{m_p}{m_e}$	—	183 6.15 253 7	183 6.15 253 7
19	Universal electro-magnetic interaction consiant	α_{Inv}	—	—	$7.29\,735\,217\,7 \cdot 10^{-3}$
20.	Universal macroscopic constant of gravitational interaction	G_M	1	$6.67\,254\,939\,7 \cdot 10^{-8}$ c^3/gs^2	$6.67\,254\,939\,7 \cdot 10^{-8} c^3/gs^2$ $(2.61\,159\,740\,2 \cdot 10^{-66} c^2)$
21.	Ratio G_M to γ_f	$\frac{G_M}{\gamma_f}$		1.00011 5831	1.00011 5831
22	Invariable unit radius	r_{Inv}	1	$\sqrt{9/8}$ c	$\sqrt{9/8}$ c
23.	Plank constant	$\hbar$	1	1	$1.05\,457\,271\,0 \cdot 10^{-27}$ erg·s.
24.	Light velocity	c	1	1	$2.99\,792\,455\,5 \cdot 10^{10}$ c/s
25.	Rydberg constant	R_∞	—	$1.09\,737\,318\,1 \cdot 10^{5} c^{-1}$	$1.09\,737\,318\,1 \cdot 10^{5} c^{-1}$
26.	Boltzmann constant	k	—	—	$1.38\,065\,940\,8 \cdot 10^{-16}$ erg/K
27.	Hubble parameter	H_0	—	—	$5.01\,218\,612\,1 \cdot 10^{-18} s^{-1}$
28.	Cosmological constant	λ	—	$3.82\,951\,763\,5 \cdot 10^{65} c^{-2}$	$2.79\,584\,730\,6 \cdot 10^{-56} c^{-2}$
29.	Background dielectric constant of vacuum	ε_f	—	—	1.00 000 035 1
30.	Universal coefficient of interactions	$k_f = \frac{\alpha_{Inv}}{\alpha_e}$	—	—	1.00 000 430 5
31	Protonic coefficient of interaction	$k_p = \frac{\alpha_p}{\alpha_e}$	—	—	1.00 000 433 2
32.	Time component of proton metric tensor	$g_{00\,p}$	—	—	$2.31\,083\,038\,2 \cdot 10^{-4}$

constants in various subspaces		
o r y	Experiment	
$d=3,1$	Information in 1SS from other SS	Direct measurement in 1SS
183 6.15 253 7	183 6.15 270 1 (37)	183 6.15 270 1 (37)
$7.29735\,217\,7 \cdot 10^{-3}$	no data	no data
$6.67\,254\,939\,7 \cdot 10^{-8} c^3/gs^2$	$6.67\,259\,(85) \cdot 10^{-8} c^3/gs^2$	$6.67\,259\,(85) \cdot 10^{-8} c^3/gs^2$
1.00011 5831	no data	no data
$\sqrt{9/8}$ c	no data	—
$1.05\,457\,2710 \cdot 10^{-27}$ erg·s	$1.05\,457\,266\,(63) \cdot 10^{-27}$ erg·s	$1.05\,457\,266\,(63) \cdot 10^{-27}$ erg·s
$2.99\,792\,455\,5 \cdot 10^{10}$ c/s	$2.99\,792\,458\,(1.2) \cdot 10^{10}$ c/s	$2.99\,792\,458\,(1.2) \cdot 10^{10}$ c/s
$1.09\,737\,318\,1 \cdot 10^{5} c^{-1}$	$1.09\,737\,315\,71\,(4) \cdot 10^{5} c^{-1}$	$1.09\,737\,315\,71\,(4) \cdot 10^{5} c^{-1}$
$1.38\,065\,940\,8 \cdot 10^{-16}$ erg/K	$1.38\,065\,8\,(12) \cdot 10^{-16}$ erg/K	$1.38\,065\,8\,(12) \cdot 10^{-16}$ erg/K
$5.01\,218\,612\,1 \cdot 10^{-18} s^{-1}$	$(5\text{–}10) \cdot 10^{-18} s^{-1}$	—
$2.79\,584\,730\,6 \cdot 10^{-56} c^{-2}$	$< 3 \cdot 10^{-56} c^{-2}$	—
1.00 000 035 1	no data	—
1.00 000 430 5	no data	no data
1.00 000 433 2	no data	no data
$2.31\,083\,038\,2 \cdot 10^{-4}$	no data	no data

Nos	Name	Symbol	Numerical values of global		
					The
			$d=0$	$d=1$	(2 → 1) (calculation SS, $d=2$)
33.	Time component of electron metric tensor	g_{00e}	—	—	$3.18004\,1736 \cdot 10^{-14}$
34.	First dielectric constant of proton structure	$\varepsilon_{1p} \equiv \beta_{1p}^2$	—	—	$(1.00\,232\,9216)^{-1}$
35.	Second dielectric constant of proton structure	$\varepsilon_{2p} \equiv \beta_{2p}^2$	—	$(1.00\,256\,1431)^{-1}$	$(1.00\,256\,1431)^{-1}$
36.	Weak interaction radius	R_{weak}	—	—	—
37.	Field weak interaction constant	α_{weak}	—	$9.19\,398\,7430 \cdot 10^{-15}$	$9.19\,398\,7430 \cdot 10^{-15}$
38.	Gravitational constant of weak interaction	γ_{weak}	—	—	$1.03\,897\,488\,3 \cdot 10^{17}\,c^3/gs^2$ $(4.06\,648\,785\,1 \cdot 10^{-42}\,c^2)$

In the calculation SS (2 → 1) the electron radius is determined from the proton structure radius R_{1p} as follows:

$$R_{1e} = R_{1p}\sqrt{8/9}\,\frac{\varepsilon_{2p}^{3/2}\,\varepsilon_f^{1/2}\,(1-\beta_2^2)_p^{1/2}}{a_{gp}^{1/2}\,k_p\,\varepsilon_{1p}^{1/2}\,(1-g_{00})_p^{1/2}\,(1-3g_{00})_p^{1/2}\,(1-\beta_2^2)_e^{1/2}}, \tag{15.9}$$

where $k_p = \alpha_p/\alpha_e$.

The value of the electron mass is easily calculated as follows:

$$m_e = \frac{\hbar}{R_{1e}c}\,\frac{2s_{ed}}{\beta_{1e}}\left(\text{but}\ \frac{m_p}{m_e} = \frac{m_p\ \text{from (15.8)}}{m_e\ \text{from (15.10)}}\,\varepsilon_f^{-1/3}\right). \tag{15.10}$$

15.3. The constant of the electromagnetic interaction for the electron is determined by the equality

$$\alpha_e = \left(\frac{3\,(1-\beta_2^2)_e^{1/2}\,\varepsilon_{2p}\,\beta_{1e}}{2^{1/2}\,\beta_{Le}}\right)^{1/2}. \tag{15.11}$$

The constant of the field interaction for the proton is determined by the equality:

constants in various subspaces		
ory	Experiment	
$d=3.1$	Information in 1SS from other SS	Direct measurement in 1SS
$3.18\,004\,173\,6 \cdot 10^{-14}$	no data	no data
$(1.00\,232\,921\,6)^{-1}$	no data	no data
$(1.00\,256\,143\,1)^{-1}$	no data	no data
$2.16\,123\,644\,1 \cdot 10^{-16}\,c$	no data	no data
$9.19\,398\,743\,0 \cdot 10^{-15}$	no data	no data
$1.03\,897\,488\,3 \cdot 10^{17}\,c^3/gs^2$	no data	no data

$$\alpha_p = \frac{\pi\,(1-\beta_1^2)_p\,k_f^{1/2}\,\varepsilon_f^{3/2}}{a_{gp}\,(1-g_{00})_p^{1/2}\,(1-3g_{00})_p^{1/2}}\,, \tag{15.12}$$

where $k_f = \alpha_{\mathrm{inv}} / \alpha_e$.

The constant of the field interaction for the fundamenton is determined as follows:

$$\alpha_f = \frac{\pi\,(\,|\beta_1^{(3)}|^2-1)\,k_f\,\varepsilon_f^{3/2}\,\varepsilon_{1p}^{1/2}}{a_{gf}\,(\,|\beta_1^{(3)}|^2+|\beta_2^{(3)}|^2-1)^{1/2}\,(3\,|\beta_1^{(3)}|^2+3\,|\beta_2^{(3)}|^2-1)^{1/2}}\,, \tag{15.13}$$

where

$$a_{gf} = \frac{8}{9}\,\frac{a_{gp}^{3/2}\,n_{1p}}{\varepsilon_{2p}^3\,n_{2p}\,k_f\,\varepsilon_f^{3/2}} \tag{15.14}$$

The background permittivity of vacuum differs from one only by the eighth decimal place. Yet it is of importance for our accurate calculations. In TFF the numerical value of ε_f is determined according to the following condition (see Part IV):

$$\varepsilon_f = \frac{q_{\mathrm{inv}}^2}{3\hbar c}\,. \tag{15.15}$$

Yet it can also be determined within the scope of the calculation of global constants carried out here, according to the following condition for the constant of the field interaction of the fundamenton:

$$\alpha_f = 1 . \tag{15.16}$$

Then solving simultaneously (15.13), (15.14) and (15.15) we find α_f and ε_f.

15.4. In contrast to the known theories, in TFF there are three constants of electromagnetic interaction, differing from each other only by the sixth significant digit. But this fact is of principle value. We have already calculated two constants. They are the electromagnetic interaction constant α_{inv}, determined from (15.3), and that of the lepton interaction α_e, determined via the electron parameters from (15.11). Besides, there is a constant of the electromagnetic interaction for hadrons, determined via the proton parameters from (15.12). Therefore, to make the calculation suitable, the following coefficients were introduced into the calculation formulae:

$$k_f = \frac{\alpha_{inv}}{\alpha_e} , \tag{15.17}$$

$$k_p = \frac{\alpha_p}{\alpha_e} . \tag{15.18}$$

15.5. The universal constant c (the velocity of light) in the subspaces with $d = 0$ and $d = 1$ is equal to the dimensionless unit. But in the subspaces with $d = 2$ and $d = 3,1$ it is unambiguously determined via the values of the fundamenton radius r_f and the dimensionless constants of TFF by the following formula:

$$c = \frac{k_c}{r_f^{1/3}} , \tag{15.19}$$

where

$$k_c = \frac{\varepsilon_{2p}^{5/2} (1 - g_{00})_p^{1/2} (1 - 3g_{00})_p^{1/2} k_p k_f^{1/2}}{2\sqrt{2}\, a_{gp}^{1/2} \varepsilon_{1p} \varepsilon_f^2} . \tag{15.20}$$

15.6. The universal constant $\hbar$ (the Plank constant) is also determined via r_f and the constants of TFF by the following formula:

$$\hbar = r_f k_h , \tag{15.21}$$

where

$$k_h = \frac{n_{2p}^2 \beta_{2p}}{\alpha_p n_{1p} k_p^2 \varepsilon_f^2} . \tag{15.22}$$

15.7. The Rydberg constant. According to physical meaning, the constant of radiation R_∞, introduced by Rydberg, is the ratio of the maximal frequency of the given particle radiation to the velocity of light, i.e.

$$R_\infty = \frac{\nu_{\mathrm{rad\,max}}}{c}. \tag{15.23}$$

In the proper coordinate frame the first harmonic, which a particle can radiate, corresponds to its natural frequency ν_{e0}. For an electron (a double-particle) this frequency is mapped onto the first subspace in the form:

$$\nu_{\mathrm{rad.\,max}} = \sqrt{9/8}\,\frac{2s_{ed}}{\varepsilon_{\lambda p}}\,(1 - \beta_2^2)_e^{1/2}\,\nu_{e1}\,. \tag{15.24}$$

Since

$$R_1 = \frac{2s_{ed}\,\hbar\beta_{1e}}{m_e\,c\beta_{1e}},$$

and

$$\nu_{e1} = \frac{\beta_{1e}\,c}{2\pi R_1}, \tag{15.25}$$

then

$$R_\infty = \sqrt{9/8}\,\frac{\beta_{1e}\,\varepsilon_{2p}\,m_e\,c\,(1-\beta_2^2)_e^{1/2}}{\beta_{Le}\,2\pi\,\hbar}. \tag{15.26}$$

As it is known, there is the following relation between R_∞ and other global constants:

$$R_\infty = \frac{2\pi^2\,m_e\,e^4}{c\,h^3} = \frac{m_e\,c\,\alpha_e^2}{4\pi\hbar}. \tag{15.27}$$

From (15.26) and (15.27) we have:

$$\frac{\alpha_e^2}{2} = \sqrt{9/8}\,\frac{(1-\beta_2^2)_e^{1/2}\,\beta_{1e}\,\varepsilon_{2p}}{\beta_{Le}}, \tag{15.28}$$

or

$$\alpha_e = \left(\frac{3\,(1-\beta_2^2)_e^{1/2}\,\beta_{1e}\,\varepsilon_{2p}}{2^{1/2}\beta_{Le}}\right)^{1/2},$$

which confirms (15.11).

From (15.27) it is not difficult to calculate the value of the Rydberg constant for the electron.

The value R_∞ , observed in most experiments, is connected not with α_e, but with the constant of the electromagnetic interaction of the proton α_p and with the influence of ε_f , therefore, the observed value of this constant should be determined by the formula:

$$R_{\infty\,(\text{experiment})} = \frac{\overline{m}_e (\alpha_p)^2}{4\pi}, \tag{15.29}$$

where $\overline{m}_e$ is the electron mass in the system of units $\hbar = c = 1$, i.e. in c^{-1}

15.8. The Hubble parameter. As it was mentioned above, the vacuum theory of gravitation (VTG) predicts the existence of a new phenomenon called the "gravitational viscosity", which should reveal in vacuum. Being aware of energy loss due to the "gravitational viscosity" we can determine the value of the Hubble parameter:

$$H_\eta = \frac{\int_0^s E_1\, ds}{sh}, \tag{15.30}$$

where E_1 is the photon energy loss per period; s is the distance to the light source. The formula for the Hubble parameter calculation is of the following form:

$$H_0 = \frac{3\sqrt{2}}{2e} \frac{G m_e^3 c}{h^2 \alpha^4 s} \int_0^s \left(1 - \frac{R}{\lambda e^{R/\lambda - 1}}\right) ds, \tag{15.31}$$

where m_e is the electron mass; α is the fine structure constant (the constant of the electromagnetic interaction); R is the radius of the EPV structure; λ is the wave-length of light whose "gravitational viscosity" is calculated.

It is not difficult to see that $\frac{R}{\lambda e^{R/\lambda - 1}} << 1$ and then, with the accuracy up to one, we have:

$$H_0 = \frac{3\sqrt{2}\, G m_e^3 c}{2\pi e h^2 \alpha_{\text{inv}}^4}. \tag{15.32}$$

15.9. The Boltzmann constant. In physical meaning, the Boltzmann constant is the transitional factor from temperature to energy. Within the bounds of TFF for determination of the Boltzmann constant the following formula was derived:

$$k = \frac{2 (2\overline{s}_e)^3 (1 - \beta_2^2)_e\, m_e c^2}{3\pi \alpha_{gp}^{1/2} (1 - g_{00})_p^{1/2} (1 - 3g_{00})_p^{1/2}}. \tag{15.33}$$

where $\overline{2s}_e = \frac{1}{\cos \alpha_e} = \frac{\sqrt{57}}{7}$; α_e is the angle of the string precession in the electron structure; $a_{gp}^{1/2} (1 - g_{00})_p^{1/2} (1 - 3g_{00})_p^{1/2}$ is the normalizing factor differing from one by the sixth decimal place.

The numerical value of this constant given in table 15.1 was obtained by this formula.

15.10. Calculation of the numerical value of the velocity of light can be carried out not only by (15.19) but also by the following simple relation between the principal constants of our great Universe, whose dimensions are invariable for the subspace with $d = 3,1$:

$$c = \frac{H_0 r_{inv}}{R_{\infty} r_f}. \tag{15.34}$$

For the exact calculation of the velocity of light it is necessary under calculation of H_0 to introduce the normalizing coefficient, differing from one by the third decimal place, into the approximate formula (15.32):

$$\frac{\epsilon_{1p}^{3/2} k_f^{1/2}}{\epsilon_{2p}^{1/2} (1 - g_{00})_p^{3/2} (1 - 3g_{00})_p^{3/2}}. \tag{15.35}$$

15.11. The radius of the Universe is determined by such simple formula:

$$r_{(\text{Universe})} = \frac{c}{H_0} = 5.98\,057\,960\,6 \cdot 10^{27}\ \text{c}. \tag{15.36}$$

Then for our macrouniverse the cosmological term is

$$\lambda_{(\text{Universe})} = \frac{1}{r^2_{(\text{Universe})}} = 2.79\,584\,730\,6 \cdot 10^{-56}\ \text{c}^{-2}. \tag{15.37}$$

At the same time for microuniverse with the radius r_f the λ-term is

$$\lambda_{\text{micro}} = \frac{1}{r_f^2} = \frac{1}{G_{\text{micro}}} = 3.82\,951\,763\,5 \cdot 10^{65}\ \text{c}^{-2}. \tag{15.38}$$

This fact represents the radical difference between macrocosm and submicrocosm.

15.12. The numerical values of global constants in the subspaces with $d = 0$, $d = 1$, $d = 2$, $d = 3,1$, which are obtained theoretically, are shown in the summary table of their calculation (see table 15.1). For comparison, the numerical values of these constants, obtained from the experiment, are also shown.

In the table columns with the experimental data two values are shown: the first is taken from the direct measurements, the second from the theoretical treatment of the indirect experimental data. In TFF the latter is interpreted as the information taken from the indirect observations of the processes occurred in other subspaces. For example, the proton structure dimensions are estimated now by treating the experimental data on the EPs dispersion. The dispersion process occurs in 2SS, whereas in 1SS we observe not the dispersion process itself but only its result, which allows to estimate the EPs dimensions under the dispersion.

In those cases when the parameter cannot be observed in a given SS in principle. there is a dash in the table, and when its value has not been got, it is written in the table: "no data".

Résumé

1. Features of purely gravitational interaction are discussed in detail in section 11. We say "purely gravitational" since, being a particular case of the universal interaction, it is due to mass and is completely determined only by mass. Gravitational interaction differs from other manifestations of the fundamental field (strong, electromagnetic, weak interactions) by the fact that it is in conformity not with the fields, the sources of which are particles themselves, but with the universal field of tensions in physical vacuum, which reveals in all points of our Universe. These tensions put a certain pressure upon all elementary particles. Yet, some elements of the structure do not let the force lines of this interaction pass through; they screen them. The screening of force lines, connected with tensions in vacuum, causes the attraction of particles, i.e. it causes that kind of interaction which we call gravitational. This section contains the basis of mathematical apparatus for calculation of the gravitational constant under macroscopic interaction in the Universe and also shows that this interaction is inherent in all structures of matter which have mass.

2. In section 13 the calculation of subparticles precession in the structure of elementary particles in the calculation subspace is given in detail. Just in the calculation subspace, since the dynamics of motion, the number of subparticles, the character of interaction depend on which kind of subspace we consider them in. To calculate the properties of particles observed in the first subspace we have to consider the calculation subspace as the mapping of the dynamics of some or other process or structure in the second and third subspaces onto the first subspace. Just this is observed in the first subspace.

The precession of subparticles strictly defined in the second subspace is deformed in the calculation subspace, and in such deformed state it is mapped onto the first subspace. This procedure results in the following. An ordinary mechanical motion would be observed in the second subspace, if we could fix it. But in fact, it is mapped onto the first subspace and reveals there as a phenomenon called now the "spin of particles".

Thus, the spin of particles is not an ordinary characteristic of the mechanical motion due to the only reason that an ordinary mechanical motion occurs in the second subspace, and the result of this motion is mapped as a projection of the moment of particles on the precession axis onto the first subspace. The spin is the projection of the mechanical moment of particles in the second subspace onto the precession axis. The mechanical moment can be observed only in the second subspace and can not be observed either in the calculation or first subspaces.

3. In section 14 the calculation of all principal characteristics and features of the fundamenton structure is made. The fundamenton structure in the third subspace and the features of the fundamenton motion in this subspace are discussed. It is also discussed how this process is mapped onto the first subspace and indirectly, as it can not be directly observed, reveals in our experiments. The mapping from the third subspace onto the first one can be perceived in it only indirectly. In the first subspace we directly observe the mappings of everything occurring in the second subspace. The mappings from the third subspace onto the first one is connected with a certain correction. It can even be said that the mappings from the third subspace onto the first one are the result of calculation of the characteristics, which we could see in the first subspace, if those characteristics were mapped in such a way that they could be observed. A fundamenton has definite characteristics in the third subspace. Therefore, from the point of view of the first subspace, we should interpret it in a different way, taking into account the transformation of the space and time scales. Thus, that which would be observed in the first subspace from the third one is just the form of the fundamenton existence, which coincides with the Plank particle. We have already mentioned that this particle has different names: plankeon, maximon etc. We shall never be able to observe this particle in the first subspace. But, if we had observed this patricle it would have had the characteristics determined by the calculation. These characteristics are exactly calculated and given in this section.

4. The results obtained in TFF enable us to make a theoretical calculation of many global constants. We have mentioned how the fine structure constant is calculated. Besides, TFF gives possibility to calculate other global constants. Methods of calculation of a whole number of global constants and numerical values of the results of this calculation are given in section 15.