The Evolutionary Sequences of Forms of Motion and Kinds of Matter and the Structure of Matter

V. A. Slobodenyuk

Abstract

The scheme of classification of kinds of matter and corresponding forms of motion is proposed. It takes into account hierarchy in structure of basic units of matter and reflects evolution of matter from simple to complex forms. All basic kinds of matter may be ranged in the following evolutionary sequence: really elementary particles — hadrons — atoms — molecules — microorganisms — multicellular organisms (in particular, man) — communities of creatures (in particular, human societies) — international unions. Here units of every consequent entry of the sequence are built from ones of all previous entries (however, directly previous entry play the main role), and all units of matter are ranged in order of their origin in the evolutionary process. Other units of matter are treated as branches out of this sequence.

1 Introduction.

Philosophic notions on the structure of matter are usually established mainly upon influence of currently available knowledge in natural sciences. Thus, achieved at XIX century sufficiently high level of understanding of natural laws have allowed the number of thinkers to begin creation of the classification systems of forms of motion and kinds of matter and, besides, closely related with them the classification systems of sciences. This has been done by F. Schelling, G. Hegel, A. Comte, and F. Engels.

Nevertheless, natural sciences are being in continuous development and they constantly get more and more deep knowledge about subjects of their investigations. At XX century the rate of development of such sciences as physics, chemistry, and biology became unimaginably high. Amount of knowledge stored during last 100 years essentially exceeds that, which was stored during all previous time of studying of nature.

Naturally, this had to lead to revision of notions on the structure of matter not only in natural scientific aspect, but in philosophic one too. Particularly, these problems were actively discussed in Soviet philosophic literature starting from sixtieth years.[1]) During these discussions general principles of classification of forms of motion and kinds of matter were formulated and got quite wide acknowledgement. They may be worded in brief as follows:

1) An every kind of matter has a specific form of motion called the main form for this kind of matter. And vice versa, every form of motion has a specific kind of matter, for which it is the main form. An every kind of matter includes, besides the main form, any side ones, which are more simple in comparison with it. They are contained in the main form in transformed state.

2) Forms of motion as well as kinds of matter are qualitatively different from each other, besides, for every two of them we can say which one is more and which one is less complex as compared with another. Transition from lower to higher kind occurs as a result of a qualitative leap. The units of matter of any level can interact with each other and be unified into units of more high level. In such way the new kind of matter with more high form of motion arises.

3) Historical development of the matter should be taken into account, so the forms of motion are to be ranged into the sequence according the order of their origin in the history of evolution.

4) All manifestations of the definite form of motion obey common laws (here only the most general laws are assumed, but not special ones).

What about particular schemes of classification, there are sufficiently large number of essentially different variants. Some of them we will discuss briefly.

In paper of Shtoff (1962) as an example of possible lines of development the following sequence of the kinds of matter is represented (it is implied that every element of the sequence has the correspondent form of motion): elementary particles — atoms — molecules — polymers — proteins — macromolecules — cells — multicellular organisms — human societies. Another example is the sequence including minerals, mountains, planets, stars etc. Solopov (1972) presents only fragment of the sequence of kinds of matter: atoms — molecules — precellular organisms — unicellular organisms — multicellular organisms. It is clear that authors does not mean any definite scheme, but only sketches on given topic.

Other variant of classification is proposed by Kedrov (1967, 1984). The kinds of matter are ranged in the following manner: quarks — elementary particles, including nucleons and electrons — atomic nuclei — atoms — molecules. Then the scheme has branching. One branch is: molecules, including proteins — cells, multicellular organisms, including animals — societies. Other one is: molecules — crystals — minerals — rocks. It is implied that there exists a specific form of motion for every kind of matter. Obviously, here the kinds of matter are distinguished not so carefully as modern scientific data permits. Besides, branching with equivalent branches is not satisfactory, particularly, because the second principle of classification is not fulfilled in this case: one cannot say for every two kinds of matter, which one of them is more and which one is less complex, if they belong to the different branches.

There are such schemes of classification, in which all possible structures of material formations are considered as separate kinds of matter. The examples of such schemes are represented in works of Butakov (1974), Melyukhin (1985), Stanis (1985). For the illustration we will pay some attention to one of these schemes, suggested by Stanis (1985): leptons, quarks and fundamental fields: electromagnetic field, gluon field, W- and Z-bosonic fields, and gravitational field — hadrons — atomic nuclei — atoms — molecules. Continuation of the scheme has branching. Structures distinguished on the Earth are: crystals — minerals — rocks. The following units are distinguished at megacosm: stars with planets — stellar clusters — galaxies, quasars — clusters of galaxies — metagalaxy. The following kinds are marked at the world of living matter: biological macromolecules — membranes of cells — organelles of cells — cells — organs of multicellular organisms — tissues — multicellular organisms — populations — biocoenosises — biosphere. It is hard to establish definite form of motion for every kind of matter in such scheme. Besides, there is no transparent connection with evolution of matter in this scheme. It is easier to became involved with its help, then to understand something more clearly.

Modern natural scientific data allow us to develop more orderly and consecutive scheme of the structure of matter, founded on general principles mentioned above, and reflecting in full measure history of the evolution of matter. Important peculiarity of the scheme proposed is following. Among huge variety of the structural units of matter, which are treated by number of the authors as independent kinds of matter, some definite units playing more important role in the classification system are emphasized (we call them *basic*). Namely these basic kinds of matter and respective *basic forms of motion* are considered in the scheme suggested. The other structural units of matter are treated as *derivative* ones and are not considered here in detail (brief discussion one can find in Section 3).

The central point of our consideration is existence of clearly traced hierarchy in the structure of basic units of matter. This hierarchy simultaneously reflects the evolution of matter from the simple to complex forms. So, we can unambiguously range all basic units of matter into the sequence, in which the units of matter of every consequent entry consist of interacting units of matter belonging to all previous entries (however, directly previous entry play the main role). We call this sequence *the evolutionary sequence of kinds of matter*. It obviously images the evolution of matter, because during the evolution of the Universe the new basic kinds of matter were arisen namely in such order, in which they are ranged in the evolutionary sequence. Because every kind of matter has the specific form of motion then one can construct the corresponding *evolutionary sequence of forms of matter motion*. Section 2 is devoted to construction of these sequences. The sequences themselves are presented in Table. In Section 3 some related questions are discussed.

2 The evolutionary sequences of forms of motion and kinds of matter.

2.1 The simplest forms of motion.

Let us start from the most simple forms of motion — from space-time displacements and gravitation. Both forms have remarkable feature — they are universal. There are no any material objects in the nature that do not move in mechanical sense and do not affected by gravitational force. Such universality testifies that these forms are present at every other one as side forms and they are the most simple among all known forms of motion. Nevertheless, they are not studied sufficiently good. There is no satisfactory quantum gravity theory till now, i.e. one does not know how gravitation behaves itself at very small distances and/or very high energies. The problem of quantization of space-time (or structure of space-time at small scales) is now opened too. So, it is hardly to say something definite about the kinds of matter specific for the forms of motion considered. One can only suppose that if quantization of gravitation field and space-time really takes place, then corresponding quanta would play the role of respective units of matter.

2.2 The fundamental form of motion.

The next form of motion, which is more complicated than previously considered, is connected with interactions of elementary particles. Necessary information on related topics one may find, e.g., in book of Kane (1987). We discuss now only such particles which are really elementary ones according to the modern viewpoint and which are really existing but not hypothetical: leptons, quarks, photons, W- and Z-bosons and gluons. General feature of three forms of the fundamental interactions (strong, weak and electromagnetic) is division of interacting particles on two classes: the particles of matter (which are described theoretically by so-called fields of matter; these are leptons and quarks, they are fermions, i.e. their spin is semi-integer) and the interaction carriers (which are described theoretically by gauge fields; these are photons, W- and Z-bosons, and gluons, they are bosons, i.e. their spin is integer). The process of interaction consists of emission of interaction carriers by particles of matter and absorption of them by other particles of matter or other interaction carriers. Formally such processes are described in the framework of quantum field theory.

Let us characterize interactions of different types of elementary particles. Quarks interact by means of three kinds of the fundamental interactions: strong, weak and electromagnetic. Leptons (this class consist of electron, muon, τ-lepton and three corresponding types of neutrino) take part in the weak and electromagnetic interactions. All these interactions are described by the Standard model with symmetry group $SU(3) \times SU(2) \times U(1)$ and have the same level of complexity.

The electromagnetic and weak interactions are described by the unified theory of the electro-weak interaction constructed by Weinberg (1980) and Salam (1980)

($SU(2) \times U(1)$–part of the Standard model). An electromagnetic interaction carrier is massless photon. All charged particles of considered level of complexity (quarks, charged leptons and W-bosons) are subject to this interaction. W- and Z-bosons are carriers of the weak interaction. They are massive particles in contrast to photons. The weak interaction is realized by means of emission and absorption of W- and Z-bosons by quarks and leptons. Besides, W- and Z-bosons can interact directly with each other because of non-Abelian character of the electro-weak theory.

The strong interaction consists in exchange of gluons between "colored", i.e. carrying color charge, quarks and is described theoretically by the quantum chromodynamics ($SU(3)$–part of the Standard model). Gluons similar to photons are massless, but in contrast with photons they can interact not only with quarks, but with each other too (non-Abelian theory). Because of this fact and because of comparatively large value of the coupling constant, the strong interaction generate strongly coupled states called hadrons (well known representatives of hadrons are proton and neutron). This connection is so strong that free quarks have not been observed till now. Moreover, the hypothesis was formulated stating that quarks cannot leave hadrons (hypothesis of quarks' confinement).

All the processes discussed above have the same level of complexity and belong to the same form of motion, which we call *the fundamental form*. It is specific form for all really elementary particles. The fundamental form of motion mainly consists of the strong, weak and electromagnetic interactions of really elementary particles. Although gravity and space-time displacements present here too, but as side forms. The specific for the fundamental form of motion kind of matter includes quarks, leptons and carriers of interactions: photon, W- and Z-bosons and gluons.

2.3 The nuclear form of motion.

Quarks and leptons interacting with each other can form coupled systems. All such systems belong to the next, more high, level of matter organization. But hadrons are the most important for the evolution and the most widespread in nature representatives of these systems. Special information on nuclear interaction may be found at Frauenfelder (1974).

Hadrons are divided into two classes: baryons and mesons. If one wish to trace analogy with the fundamental form of motion, then one can say that baryons correspond to particles of matter and mesons correspond to interaction carriers. Baryons analogously to quarks and leptons are fermions, and mesons analogously to photons,

W- and Z-bosons and gluons are bosons. Baryons and mesons are different in their structure. Baryons consist of three valence quarks or three antiquarks (if baryon is antiparticle), but mesons consist of one quark and one antiquark. Quarks interact in hadrons so as various transformations permanently occur and always there are many virtual quark–antiquark pairs and gluons in a hadron except valence quarks.

Note that mesons, similar to gauge fields in the fundamental form of motion, interact with each other too, but not only carry interaction between baryons.

In fact, interaction between hadrons is rather complicated process including many elementary acts of interactions of different quarks and gluons, belonging to these hadrons. Besides, the most simple forms of motion: space-time displacements and gravitation interactions are always present. Whole totality of these interactions composes *the nuclear form of motion.*

Quarks of a hadron may interact with free elementary particles (i.e. not belonging to any hadron), e.g., with electrons or W-bosons. Such interaction may be considered as *interaction with external environment* of the unit of matter of definite level (hadron). External environment is treated here as totality of the units of matter of all more low levels of complexity.

In some specific cases one can treat interaction of hadrons as exchange of mesons between baryons or between other mesons. That simplified picture is used, e.g., for description of atomic nuclei. It is considered that the nuclear forces are caused by meson exchanges (preferably by π-meson exchanges) between nucleons (i.e. protons and neutrons). Nevertheless, this is only approximate picture, and it does not allow us to get satisfactory and complete description of nucleus. An exact picture should take into account interactions of quarks and gluons of different hadrons, and hadrons themselves are to be treated as bound states of quarks, but not as independent structures. Unfortunately, even this approximate picture is so complicated for real calculation, that physicists are to use yet more rough models for quantitative estimates.

So, the kind of matter, specific for the nuclear form of motion, is the one being represented by hadrons and other bound states of quarks and leptons. Although other bound states are not widely spread in nature, but they should be mentioned here too. Example of such state is a positronium, which is a bound state of an electron and its antiparticle — a positron. The nuclear form of motion includes various interactions between corresponding units of matter. These interactions are the result of many elementary acts of interactions of all units of matter of lower levels, which compose the units of matter of considered level, by means of the strong, weak, and electromagnetic forces as well as by means of gravitation and space-time displacements.

This form is called *nuclear* because its highest manifestation is connected with composition of atomic nuclei as a result of interactions of nucleons.

Note, that so-called elementary particles (traditionally hadrons are classified as elementary particles, although really they are composed particles) occupy two levels in the scheme being proposed. All these particles are studied in the framework of one scientific discipline — physics. This allows us to hope to get whenever detailed description of transition from one level of complexity of matter to another and of genesis the nuclear form of motion from more low forms. Current development of physics permits us to understand this transition only qualitatively, but not quantitatively. Till now physicists have no careful description of generation and evolution of hadrons on the base of the Standard model. There exist many approximate approaches which do not solve the problem completely.

2.4 The chemical form of motion.

Interacting with each other hadrons form bound states — atomic nuclei, which are representatives of more high organized kind of matter as compared with hadrons themselves. One should attribute atoms (for the sake of brevity we will call neutral atoms as well as ionized ones simply as atoms) to the same kind of matter. Adding an electron envelope to nucleus one does not get new complexity level of matter because electrons belong to more low form of matter than nuclei do. Moreover, different exotic atoms, e.g. muonium (including proton and muon instead of electron) and other mesoatoms belong to this kind of matter too.

Nevertheless, we meet here a new phenomenon. From the one hand, one can state that, in fact, electrons of an atomic envelope interact not with a nucleus, as it is supposed in simplified models, and even not with nucleons of a nucleus, but with quarks which compose nucleons, because namely quarks take part in the electromagnetic interaction on fundamental level. Hadrons participate in the electromagnetic interaction only because they include charged quarks. The electromagnetic interaction of hadrons is only some effective interaction, which is introduced to simplify a problem of theoretical description. The electromagnetic interaction is side interaction for hadrons. One can say the same words about relation of this interaction to nuclei.

From the other hand, an electron forms coupled system with entire atom, but not with any one quark, because during sufficiently large time interval it interacts with all quarks of all hadrons of a nucleus and with all other electrons of an atom. Hence, an atom is constructed not only from units of matter of previous level (hadrons), but it is directly constructed from units of matter of lower level (electrons). This phenomenon really takes place for all higher levels of matter.

Atoms interact with each other in definite manner. All possible kinds of such interactions we will call *the chemical form of motion*. This term is due to the fact that significant part of these interactions (but not all) is related to chemical reactions.

The way of interaction of atoms essentially depends on conditions. E.g., if one fast atomic ion collides with another, then nuclear reaction occurs. In this process instead of initial collided nuclei the new nuclei of any other atoms are born and, besides, any elementary particles may be emitted. Any similar things take place in radioactive decays of unstable atoms and in nuclear fusion of new chemical elements. Interaction between atoms is hard here. Practically all constituent particles participate in this process. Quarks interact with quarks, nucleons interact with nucleons and so on. Total set of these interactions of lower levels (space-time displacements, gravitation, strong, weak and electromagnetic interactions, and nuclear interactions of hadrons) compose one act of interaction corresponding to the chemical form of motion.

If slow atoms take part in the interaction, then only interaction of their electron envelopes due to the electromagnetic forces is involved in the process. This is a chemical process in exact sense. Nevertheless, in this case a lot of elementary acts of the electromagnetic interactions occurs. All together they compose one act of interaction between atoms. Such interactions at definite conditions can lead to appearance of qualitatively new kind of matter. Atoms may be combined into molecules or into crystals.

These processes are studied by chemistry and physics. We will not describe in detail features of chemical reactions. Let us notice only essential types of chemical bonds between atoms (or atomic ions): ionic and covalent bonds, which are the most strong ones, metallic and hydrogen bonds, which are more slight, but hydrogen bonds play a very important role in further evolution of matter because they essentially determine properties of protein molecules. One can find detail review, e.g. in Pauling (1970) (besides, herein short review of elementary particle properties and nuclear reactions is present).

2.5 The microbiological form of motion.

Molecules (we mean here neutral as well as ionized molecules) are representatives of the next, more complex, kind of matter. Atomic, ionic, and metallic crystals (we imply here only monocrystals) really are large molecules with monotonously repeated structure (contrary to large organic molecules, which have rich structural variety). So, they are to be considered in the same group with molecules. All these units of matter have specific form of motion, which we will call *the microbiological form*, because its highest manifestations are related with origin of microorganisms.

Notice that crystals in their interactions do not form new basic units of matter. Only molecules have such property. In this sense crystals are deadlock form and we will not discuss them further.

Interaction between molecules occurs preferably due to the electromagnetic forces acting between electrons and quarks (or, approximately, nuclei) of atoms belonging to different molecules. But this bond essentially differs from one between atoms. Interatomic forces are more strong, and only remainders of this forces act between molecules (Van der Waals forces). But now we have qualitatively new feature: interaction of molecules cannot be reduced to simple sum of interactions of separate atoms of one molecule with separate atoms of other molecule. Every atom of one molecule interacts simultaneously with all atoms of other molecule. And because this fact takes place for every atom of definite molecule, then the effect obtained cannot be reduced to sum of pair interactions of atoms. It should be treated only as interaction of entire molecule with another one. Characteristic manifestations of such interaction are various chemical reactions. For instance, two molecules interact with each other and a new molecule or few new molecules appear.

Besides, one is to account that interaction between atoms of different molecules is the main component of intermolecular interaction, but not unique. There are various simpler units of matter in atoms, so they can interact with each other directly. Such interactions give their contributions into intermolecular interactions too. E.g., nuclear conversion may occur with atoms belonging to a molecule or neutrons may undergo β-decay and so on. In this connection, we can remind that there were made attempts to explain asymmetry in spreading of left and right molecules in living nature by nonconservation of parity in the weak interaction.

Note that units of matter of simpler then atoms levels may directly be included in the structure of molecules (indirectly they are always included through atoms). Thus, if atoms are coupled by covalent bond there exist electrons, which are common for two or a few atoms. I.e., they do not belong to any one atom, but they belong to an entire molecule.

Intramolecular interactions seem to be more complicated and varied then interactions of free atoms, because there is a lot of various bonds between different fragments of molecules, which may be disconnected and established again in this case, new relations between other fragments may arise too etc. Examples, where specific features of intramolecular interactions is displayed especially clear, are large organic molecules. In the process of evolution molecules were developed so as complicated protein complexes and furthermore the top for considered kind of matter — DNA and RNA molecules were appeared.

Behavior of these molecules is exclusively rich and diverse. They can reproduce themselves or create other molecules with predetermined structure. They can transport various molecular fragments to definite point of a cell, where other high organized molecules use them for building new organic molecules. They can make fission of large molecular complexes to more simple ones. They can retard or promote definite chemical processes. They can change their spatial configuration due to some specific conditions and so on. These ones and a lot of not mentioned here properties of proteins and nucleic acids cause a possibility for them to compound a very complex structures, which are separated from other similar structures and from environment, which reproduce themselves, which take from external environment necessary molecules and give back unnecessary ones (metabolic process), which react to definite external irritations etc. In other words, these molecules compound living microorganisms in form of cells or precellular organisms. They form qualitatively new kind of matter, which has a specific form of motion called *biological*.

For the sake of brevity we discuss only general features, which are essential for our consideration. Details related to various aspects of living matter one can find, e.g., in book of Ferl et. al. (1996).

Besides interactions with other molecules, which is the main part of the microbiological form of motion, a molecule interacts with units of matter of all simpler levels too, because a molecule itself includes structural units of all lower levels of organization. Such interactions are interactions with external environment. These interactions are not specific forms of motion for considered kind of matter. They are side forms.

2.6 The biological form of motion.

The kind of matter, corresponding to *the biological form of motion*, includes not only cells or precellular organisms mentioned above, but some more simpler units of matter. These are molecular crystals (monocrystals only) and various formations, which have preceded the living matter, e.g. coacervate droplets, proteinoid microspheres and so on. Molecular crystals, so as atomic ones, do not form more complex basic units of matter and they are deadlock branch of evolution. For the first sight, they must not be classified in the same group with protocells and unicellular microorganisms. Indeed, differences between molecular crystals and cells are so huge. But nevertheless, all these units have structural composition of the same type: they are formed by interacting molecules. Fundamental laws governing by these interactions are the same in both cases. Differences are caused only by degree of complexity of molecules participating in construction of crystals or cells. If we consider first stages of origin of life and compare molecular crystals with coacervate droplets, then the number of similar features will be more and the number of differences will be less. Material formations representing predecessors of the living matter have played essential role during biogenesis on the Earth, but now they occupy rather modest place among matter formations.

So, one can say that the biological form of motion is mainly interaction of microorganisms with each other. Interrelation between them are realized preferably by means of interactions of molecules of one microorganism with molecules of another. A separate act of interaction of microorganisms is a result of a huge number of interactions between definitely organized molecules. Also, all simpler units of matter belonging to a cell take part in this interaction too. Such compound interaction, obviously, should be treated as qualitatively new phenomenon, which cannot be reduced simply to a sum of large number of intermolecular interactions.

Characteristic manifestations of the biological form of motion are, e.g., eating of one organism by another, penetrating of one microorganism into another, parasitic existence there and also reduplication within a master cell, separation of a cell on two or a few daughter cells (asexual reduplication), temporal confluence of two cells into one for exchange of a hereditary material with its consequent separation (conjugation) and so on.

Note, that cell-to-cell interaction does not suppose direct contact of cells. It is possible indirect interaction. For instance, one cell may secrete any chemical substance and other cell may adopt or detect it and react to this substance in definite manner. In this example units of matter of lower levels are playing a role of interaction carriers.

Microorganisms are built from molecules and, besides, large organic molecules have a decisive importance. But cells contain more simple units of matter too. Thus, water, which is present in a cell in large quantities, in dissociated state gives an ion H^+, that is really a proton. Free electrons are present in a cell too.

Because microorganisms include inside themselves the units of matter of all lower levels, an interaction of these units with different objects of external environment takes place. So, microorganisms interact with environment too, but not only with each other. However lower forms of motion are present here only as side ones. A specific form of motion for microorganisms is the biological form.

As an inner organization of a cell becomes more complicated new features of relations between microorganisms appear: organisms of the same species due to different causes: either individual cells failing to separate, or individual cells aggregating, or 'hybrid' situation begin to form a colony, in which exchange of feed between their members, joint displacements and some else simple "collective" actions take place.

One can get notion about such colonies taking into account modern colonial *Volvocalles*. If a colony of *Gonium pectorale* consists of 16 unicellular organisms without functional differentiation between them, then the highest representative of this sequence *Volvox globator* includes over 20000 cells and there are groups of cells having narrow specialization in this colony. Further development of similar colonies have led to appearance of the simplest multicellular organisms. This is a qualitative leap, related with appearance of the new kind of matter and, correspondingly, new form of motion.

2.7 The social form of motion.

This new form of motion represents interaction of multicellular organisms with each other. We will call it *the social form* because its highest manifestations are connected with origin of animal's and human societies.

Interrelations of multicellular organisms are more rich and various as compared to ones of microorganisms. A separated act of the social interaction includes a huge number of different interaction acts of lower levels: interactions on cellular, molecular, atomic etc. levels. Also, organisms interact with simpler structures of matter both with microorganisms and with representatives of lifeless nature. These are side forms of motion for considered kind of matter. Interaction between creatures may be realized by means of interaction carriers, whose role various units of matter of lower and given levels may play in this case. Let us give some examples. An animal secretes any substance, which frightens away his enemies by its odour. Here two animals interact with each other through a carrier that is an odour substance. The role of such carrier may be played by sound or light signals or something else. Microorganisms may be carriers too. When an infectious animal infects another one contacting with him, then in this situation microbes causing an infection are carriers of interaction. A bearing of baby animals is example of elementary act of interaction which is similar to decays of hadrons or nuclei, or separation of cell (if one wish to trace analogy with lower levels of matter).

For multicellular organisms as well as for other kinds of matter we are to note that although they are constructed mainly from units of matter of directly previous level — from cells, but besides they contain inside themselves various units of matter of lower levels not belonging to cells. There are different molecules both organic and inorganic, free atoms, protons and electrons in an intercellular substance. Molecular structures being out of cells composing an animal or plant play an important role in the life of organisms. E.g., collagenuos fibers are the main component of a skeletal system of organism. Various microorganisms are sure to present within multicellular organisms too.

First multicellular organisms were rather simple and manifestations of their life did not have such variety of forms which have appeared later during the long time evolution of inner structure of living creatures. With development of organisms interrelations between them becomes more complex. Besides primitive relations connected with looking for feed and reproduction "social" relations have arisen and strengthened in communities of animals. Many species of animals live in separated groups: in families, in colonies, in herds, in packs etc. Besides these high organized communities of animals one is to mention such primitive form of interaction between organisms of different species as biocoenosises. This form is deadlock in sense of transition to more complex form. But relations within packs turned out to be on the progressive line of evolution. The highest form of their development is a human society.

2.8 The international and interunion forms of motion.

A human society has developed from savage herds through a tribalism to a state structure, which is now the highest form of organization of people. A human society is the next in complexity kind of matter after multicellular organisms. But it is only the highest manifestation of the given kind of matter. Besides a society one is to attribute to it herds, packs, colonies of animals and so on. We will use for this kind of matter generalizing term *"communities of creatures"*.

If a number of societies is present in neighborhood, any relations between them arise. These intersociety relations represent the form of motion specific for considered kind of matter. Let us call it *the international form* implying its highest manifestation in interaction between different human societies (states). At early times of development of humanity this form was displayed in relations between tribes (relations between communities of animals occur too, but they are rather primitive). As a society organization becomes more complicated and the state form of governing by society appears, these relations turn into interstate relations, which were rather episodic at early period of a state organization. Later they get necessary international guarantees, become continuous and more and more close. Naturally, besides peaceful relations wars were always necessary (and often even the main) component of intersociety relations. Notice, that we understand "state" here not only as a state machinery, but as a whole society organized in form of a state with all its structures including such ones, which do not belong to a state machinery.

The typical example of interaction of two societies is annexation of one state by another as a result of war. Contrary process is disintegration of a state into two or a few smaller states. Such processes are analogous to compositions and decays of elementary particles, atoms, molecules or cells (processes of that type are present at every level of matter complexity). A society may, besides, interact with all lower units of matter.

If we observe analogy with lower kinds of matter, then we can note that the structure of primitive societies (human as well as animal's) is similar to structure of prokaryotic cells. But the structure of a state, more developed form of society, is similar to more developed form of a cell — to a cell of eukaryotic type. A state has definitely marked a state boundary, which is analog of an external membrane of a cell. There are differentiation of citizens on various groups in correspondence with their social functions. Similar differentiation of groups of molecules presents at eukaryotic cells too. Analogy may be traced with a structure of multicellular organisms. The simplest multicellular organisms have slightly expressed differentiation of their cells, but high developed organisms have various organs, in which cells execute any specific functions.

A state have within itself units of matter of lower levels. Different constructions and devices built by a man consist of molecules, atoms, elementary particles (e.g., beams of protons and electrons at accelerators). It is important to note that "building" of any constructions is usual not only for a man, but, as we have seen previously, it is usual for more low levels of development of matter too. Thus, cells within multicellular organisms "build" their skeleton from molecules, that do not belong to cells, but only to whole creature.

In the modern world relations between states are exclusively wide, various and often even lively necessary. International relations still from ancient epochs have led to appearance of different unions of tribes or states. Usually these unions were temporal, unstable and relations within them were rather limited. In contrast with this, there are unions of states at present, inside which exclusively deep and all-round relations in various fields of human activity are established.

The most characteristic example of such union is European Union (EU). Contrary to different other economic or military unions it has more developed supernational structures, which have got a part of state sovereignty of the states participating in EU. There are transparent boundaries between members of this union, very high level of economical, political, cultural etc. integration, free migration of people. Cooperation has achieved so high level that European states have now the unified currency - Euro.

Another example is Commonwealth of Independent States (CIS) or former USSR. Here the level of integration is essentially lower than in EU. Nevertheless, there are supernational structures, transparent or partially transparent boundaries too and there is desire of the participating states to develop cooperation.

Such international unions are representatives of the next more complex kind of matter. At present this kind of matter is at the beginning of its evolution. This is why the existing now samples of it are rather primitive. Also, they are not numerous and so it is hard to describe their interaction in detail. Nevertheless, it is clear in general that it will be interaction between international unions. It will include, besides, interaction of individual states, which are members of these unions, and interactions of individual men and so on. Composition of all these interactions of matter units of various levels, which are included in different unions of states, will form the new form of motion — *the interunion form.*

This form of motion is the most complicated among the forms existing at the Earth now. Because there are not so many international unions at our planet, then one should not to wait appearance of more complex units of matter at the Earth. If such forms will appear in the future, they, probably, will have a cosmic scale.

3 Discussions.

We have traced in general outline the evolution of matter from its simplest forms till modern state. The way of evolution in a form of the evolution sequences for the forms of motion and corresponding kinds of matter is represented in Table.

Note that when we range in sequence the kinds of matter, we trace only the main way of development of matter. The units of matter that have not been mentioned in the evolutionary sequence should be considered in specific manner. Probably, they may be treated as branches out of the evolutionary sequence. But in contrast with schemes adduced in Introduction we do not consider different branches as equivalent. There is the main sequence — the evolutionary sequence of the kinds of matter. The branches out of it play a secondary role. The units of matter appearing at the branches do not have such level of fundamentality as the units of matter from the evolutionary sequence do. The sequence of the matter units within definite branch reflects only their structural hierarchy, but not order of their origin during the evolution.

Let us represent examples of such branches out of various levels. Atoms, which are not coupled into molecules or crystals, may interact with each other and form different macroscopic systems, e.g., atomic liquids and gases. Molecules form similar macroscopic systems. If we take a colonies of microorganisms, then we can say about definite macrosystem and so on. In all these cases a large value of number of homogeneous matter units composing macrosystems play an essential role. New properties of such systems are due to properties of forming them particles and, in great measure, to statistical laws because of huge number of these units.

Such macrosystems may interact as a whole with other macrosystems, may even form more large systems, the latter may form even more large systems etc. In this way one get planets, stars, galaxies, clusters of galaxies and so on. If one go in other direction, one can display mountains, seas, atmosphere etc. All these systems interact by specific for every of them manner. There exist conformities to natural laws specific namely for these kinds of interactions. They are often considered as separate forms of motion. But these forms are essentially different from basic ones. The main cause of this difference is absence of correspondence between their structural hierarchy and order of their origin during the evolution. For instance, creation of objects of megacosm mentioned above in order of increasing their sizes have occurred in inverse order: from large to small. One cannot say that interacting with each other stars have formed galaxy. Really, stars were born within galaxy when latter yet had exist.

Branches (of derivative forms) appear for the first time not at level of the chemical form of motion, as it is usually treated, but more earlier — at level of the fundamental form of motion. We will give examples of derivative kinds of matter, taking in mind close relation between kinds of matter and forms of motion. A beam of electrons naturally is a structural unit of matter as well as a water in a vessel is. A light ray is a system of photons and so on. These units of matter represent branches from the evolutionary sequence at level corresponding to the fundamental form of motion.

There are branches from the evolutionary sequence at the level of nuclear matter. E.g., beams of protons or the most stable mesons obtained at accelerators represent such macroscopic systems. These structural units of matter rarely appear at ordinary conditions, so they are not usually noticed. One can represent the example of natural macrosystem consisting of elementary particles. This is a neutron star.

Branches from more high levels are well known. Atomic liquids or gas systems branch out of atomic level. Nevertheless, there exist liquids and gases, consisting of molecules. They are branches out of the next level of matter organization. Minerals, consisting of atomic crystals, are branches out of the same level. It is possible to say about branches out of organic forms of matter such as biocoenosises, biogeocoenosises etc. But this is not our task now. We will not discuss derivative forms more.

But instead we consider some questions related to classification schemes. It is introduced many intermediate stages in some classifications. E.g., organelles at cells are considered as a separated kind of matter. Organs of multicellular organisms and even systems of organs are treated as independent kinds of matter too. This approach does not take into account that mentioned structures do not exist in nature separately. There is no organelles outside a cell. A kidney does not live outside an animal in natural conditions and so on. In contrast with this, the basic units of matter may exist independently. There are such cells among variety of cells, that live separately and do not belong to any multicellular organism. There are such animals among variety of animals, that are not members of herds, packs an so on, but live independently. There are states that do not belong to any union of states. Analogous statements may be worded in respect to more simple kinds of matter too.

The classification of the units of matter in correspondence with the evolutionary sequence of the kinds of matter is not absolute and exactly determined. Real world is such variable that one cannot always definitely say to what kind of matter does any material formation belong, and is it necessary to consider it as a basic kind of matter or as a derivative one?

Evolutionary transitions between different kinds of matter occur gradually such that intermediate forms are always present. They in principal cannot be related to any kind of matter. E.g., *Volvox globator* is not a multicellular organism, but it is not simply a join of large number of cells. This is the transitional form. Nevertheless, such exclusions only confirm the general rule.

It is important to stress that contrary to the classification schemes, discussed in the Introduction, the scheme suggested does not simply classify the matter units and the forms of motion according any rules, but it gives to researchers the instruments for scientific proposals, for interdisciplinary investigations and it has great heuristic potential.

To illustrate its potentials let us consider some possible applications of the scheme.

1. The classification proposed allows us to imagine general way of the evolution of matter, because its main stages are marked by definite elements in the evolutionary sequence. The evolutionary sequence of kinds of matter allows us to predict the direction of evolution in long time perspective. One can state that existing now interstate unions will be developed, and new ones will be created. Their evolution will be connected with strengthening of differentiation in functions of participating states. Maybe, transition to more high kind of matter — to unions of interstate unions will occur in remote future. But this will be possible, probably, only in cosmic scales, i.e., either if the Earth civilization will come out of our planet, or if our civilization will contact with unearth civilization, which, maybe, exists somewhere else in the Universe. However, these things are touched on such remote perspectives that they are now subject for science fiction only.

2. It is possible to notice presence of peculiar periodicity (maybe, more correct term is similarity): coming from any element of the sequence to consequent one, one can see repetition in general sense of some properties, but on the other structural level. For instance, a multicellular organism with its various organs is similar in some features to a cell with its organelles and, besides, it is similar to a state with its various structures (ministries, enterprises, social organizations and so on). This property may turn out to be the foundation of rather powerful heuristic method of interdiscipline researches. Tracing analogies between the matter units of different

levels one can deeply understand the processes at the level considered using knowledge about processes of other levels. E.g. comparing behavior of the cell within multicellular organism and behavior of the individual man within society (state) we can make essential conclusions about both multicellular organism and society. For instance, such problems as interrelation between individual man and society and similar will get scientific base for their consideration, because interrelation between individual man and state, if one consider it at the most abstract level, is similar with interrelation between cell and living creature whom this cell belongs, similar with interrelation between molecule of living cell and the cell itself, similar with interrelation between atom of molecule and the molecule itself and so on. We know something about all these interrelations, and we can transit the most general facts on the thing of interest.

Similar viewpoint may be used for consideration of many other problems including social ones. It will permit us to place more realistic scientific base under social investigations.

Let us consider one more example of using of analogies. The process of thinking is one of the ways of interaction of one man with another man and with himself ("self-interaction", as physicists say). Interaction of elementary particles, e.g. of electrons, take place by means of emission and absorption of the quanta of electromagnetic field — photons. In the framework of the approach proposed the analogy between both these processes is exclusively deep. For instance, when we are thinking to ourself we emit and absorb "virtual quanta of social field" so as the electron feels selfinteraction emitting and absorbing the virtual photons. We understand the process of humane thinking in some aspects better then the processes in microworld. And we can apply something from this understanding to elementary particles (e.g. for clarification of the situation with virtual processes in physics, which understanding at the moment is absolutely unsatisfactory). On the other hand, some ideas from the elementary particles physics may be transferred on the base of this analogy into the field of study of thinking processes. And it will not simple mechanical transmission of any lows on not characteristic for them objects of researches. There is deep interrelation between these fields. Besides, one is to understand that such transitions may have only heuristic meaning. The laws "prompted" by this way are to be proved independently in specific field.

3. The scheme allows us to highlight key points in some special disciplines and to order their researches. For example, if we clearly understand that whole three

fundamental levels of the matter (elementary particles, hadrons, and atoms) have fallen within the field of competence of physics, then it is easy to understand that describing them fundamental theories are to be different each other in principle. Besides, ideally the theory of hadrons should follow from the theory of elementary particles, and the theory of atoms for its part should follow from the theory of hadrons. Nevertheless, physicists, as a rule, do not give high profile to fundamental difference between these three levels when choose the methods of description and practically use the same approaches for description of any micro objects.

4. One can to pay attention for possibility in principle to construct in observed future by physicists such theory of elementary particles, that will allow us to understand and describe in detail the process of transition from elementary particles to hadrons (this is transition between the most simple kinds of the matter, so, obviously, it will be studied earliest). Thus for the first time it will be obtained theoretical description of transition between two neighboring kinds of matter, that undoubtedly will enrich our notions not only about this definite transition, but generally about transitions between neighboring kinds of matter, because all these transitions of various levels have some general features, which may be revealed in specific example.

5. Besides, the scheme suggested permits us to understand more exactly and critically the place of *Homo sapiens* at the world. Particularly, it is clear that *Homo sapiens* is not the highest creation of nature contrary to the widespread viewpoint. There already exist two kinds of matter, which are more high organized than the man is. These are communities of creatures (particularly, human societies) and international unions.

Notes

1 Unfortunately, because of restricted exchange of the literature in humanitarian sciences in Soviet period, author has not information about activities of eastern scientists at this field. So, only one side of two which have been recently divided by "iron curtain" is presented at the list of references.

References

[1] Butakov, A. A. 1974. *The main forms of matter motion and their interrelation in light of modern science.* Moscow: Vysshaya shkola (in Russian).

[2] Ferl, R. G., Wallace, R. A., Sanders, G. P. 1996. *Biology. The Realm of Life.* New York: Harper Collins College Publishers.

[3] Frauenfelder, H., Henley, E. M. 1974. *Subatomic Physics.* New Jersey: Prentice-Hall.

[4] Kedrov, B. M. 1967. *Subject and Interrelation of Natural Sciences.* Moscow: Nauka (in Russian).

[5] Kedrov, B. M. 1984. 'Doctrine of the matter in light of "newest revolution in natural sciences".' *Voprosy Filosofii* 5, 20-29, (*'Problems of Philosophy'*, in Russian).

[6] Melyukhin, S. T. 1985. In S. T. Melyukhin (ed.), *Philosophical Problems of Natural Sciences* Moscow: Vysshaya shkola (in Russian).

[7] Pauling, L. 1970. *General Chemistry.* San-Francisco: W.H. Freeman and Company.

[8] Salam, A. 1980. 'Gauge unification of fundamental forces: Nobel Lecture'. *Reviews of Modern Physics* 52, 525-538.

[9] Shtoff, V. A. 1962. In V. I. Svidersky (ed.). *Philosophical Problems of Modern Doctrine of Motion in Nature.* Leningrad: Leningrad State University Publishing (in Russian).

[10] Solopov, E. F. 1972. *The Matter and Motion.* Leningrad: Nauka (in Russian).

[11] Stanis, L. Ya. 1985. In L. Ya. Stanis (ed.). *Sketches in Dialectic Materialism.* Moscow: Nauka (in Russian).

[12] Weinberg, S. 1980. 'Conceptual foundation of the unified theory of weak and electromagnetic interactions: Nobel Lecture'. *Reviews of Modern Physics* 52, 515-524.

Table. The evolutionary sequences of forms of motion and kinds of matter.

Kinds of matter	Forms of motion
? (maybe, graviton (?))	The simplest forms: space-time displacements, gravitation (correlation is not clear)
Quarks, leptons; photons, W- and Z-bosons, gluons	Fundamental
Hadrons (baryons and mesons), coupled systems of leptons	Nuclear
Atoms (neutral and ionized atoms, including atomic nuclei, exotic atoms)	Chemical
Molecules (neutral and ionized), crystals, excluding molecular ones	Microbiological
Microorganisms (precellular and unicellular), coacervate droplets, proteinoid microspheres, protocells etc., molecular crystals	Biological
Multicellular organisms (man as their highest form)	Social
Communities of creatures (human societies as their highest form)	International
International unions (e.g., European Union)	Interunion