https://doi.org/10.26485/0459-6854/2019/69.1/1 PL ISSN 0459-6854

B U L L E T I N

DE LA SOCIÉTÉ DES SCIENCES ET DES LETTRES DE ŁÓDŹ

2019 Vol. LXIX

Recherches sur les déformations no. 1

pp. 11–24

Dedicated to Author's Wife
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BINARY AND TERNARY STRUCTURES IN THE EVOLUTIONS IN THE UNIVERSE ($2 \times 3 \times 2 \times 2 \times \cdots$ -WORLD)

FROM SPACE-TIME TO MOLECULAR BIOLOGY

Summary

First we give a definition of evolution. Introducing the concepts of binary and ternary extensions we describe the hierarchy structure (BTBB-structure) and the complexity systems of the evolution of the universe in a unified manner. Our main results are given and the evolutional tree is constructed in Paragraph 3. Finally we discuss basic problems concerning the evolutions.

Keywords and phrases: binary physical structure, ternary physical structure, polymer, evolution, universe, binary extension, ternary extension, noncommutative Galois extension

Introduction

Evolutions have been discussed in many areas of knowledge recentely. However, no widely approved definition of evolution has been created so far. Here we give the definition of evolution and propose the evolution theory which can describe evolutions from the quark level to the cosmological level in a unified manner, including the birth of intelligence. We would like to stress the fact that we have never seen the theory which could describe the total evolution.

1. General observation on evolution

First we shall give the definition of evolution in terms of entropy. The concept of entropy was introduced by S. Boltzmann, and it describes the tendency of physical phenomena. A glass falls down from the table to the floor easily, but jumps up to the table from the floor with difficulty. Namely, a physical state tends to be the most random one. To measure randomness, we introduce the concept of entropy. Entropy is defined for the set of states $\{X_j\}$ of a given system: $X = \{X_j\}$ in the following way:

$$S(X) = k \log(\#(X_j)),$$

where k is a positive constant, and $\#(X_j)$ is the total number of the states $\{X_j\}$ of the system X [24].

Hence we can see that the physical phenomena will change so that their entropy will increase. The entropy of the pieces of the broken glass is bigger than the that of the glass itself. Another typical example: beautiful palaces will become ruins and eventually, they shall turn to sand in the future.

The evolution in biology tells that a living being evolutes against the physical tendency. Namely, they shall make evolutions so that they decrease the entropy. Plants grow up against the force of gravity. Living beings come up to lands from the sea. Some people call this decreasing entropy *negative entropy.* H. Bergson developed his philosophy of evolutions on the base of these facts.

In this paper we shall consider evolution in the following processes [3].

(1) The birth of evolution. We may assume that the evolution begins with an explosion from an origin (seed) of the evolution. We can find supporting evidence for this claim in the following:

1. The Big-Bang of the universe,
2. The spreads of eggs or seeds,
3. The neutral evolutions in molecular biology [13],
4. The Cambrian year animal explosions.

We may assume that the initial states are created as much randomly as possible and that then they make simple random walks, or Brownian motions. The entropy of the initial state is called *evolution entropy.*

(2) The growth of evolution. We describe the self-organization in terms of the *decrease of the evolution entropy.* In order to discuss the evolution rigorously, we have to assume the existence of its ambient space X_{out} of $X(= X_{in})$. The entropy of X_{in}? (or X_{out}) is denoted by S_{in} (S_{out}, respectively). The time change of the system is given when the time evolution $X_{in}(t)$ satisfies the following inequalities:

$$(S1) \qquad S(X_{in}(t)) \geq S(X_{in}(t')), \quad t < t'$$

$$(S2) S(X_{in}(t) \cup X_{out}(t)) \leq S(X_{in}(t) \cup X_{out}(t')), \quad t < t'.$$

(S1) implies that the evolutional system changes against the Boltzmann principle, ($S2$) implies that the total system changes obeying the Boltzmann principle. A life thing eats food and keeps its body emitting heat outside.

(3) The end of evolution. Finally we describe the end of the evolution. In the process in (2), the evolution entropy S_{in} of X_{in} is decreasing. When the entropy is exhausted, the evolutions proceed no more. This state is called *stable*, or *dead*. When the system X_{in} dies, the ambient space X_{out} continues the evolutions following the original Boltzmann principle. Hence its entropy increases.

2. Binary and ternary extensions

Although this concept of evolution is new, it is not so astonishing. The most important point of our evolution theory is the concrete construction of the evolutions. The heart of our theory is the description of evolution by the use of binary and ternary extensions.

(i) Binary extension: The binary extension is an operation which divides the given states of the initial space X_{in} into two subsets X and X^* and to create a set $\underline{X}^{(2)}$ of pairs between these subsets. Then we have $S(X^{(2)}) \leq S(X) + S(X^*)$.

In mathematical terminology, we may say that the constructed pair $\underline{X}^{(2)}$ is a binary extension of X (Figure 1) [27].

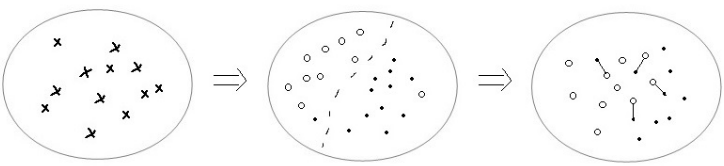

Fig. 1. The idea of binary extension.

(ii) Ternary extension. In the same manner we can introduce the concept of a ternary extensions. We make a division of the space into three parts X, X^*, X^{**} and consider a set $\underline{X}^{(3)}$ of triples of elements. We have the following inequality: $(\underline{X}^{(3)}) \leq S(X) + S(X^*) + S(X^{**})$. In mathematical terminology, we may say that the constructed triple $\underline{X}^{(3)}$ is a ternary extension of X (Figure 2) [27].

3. The random walks in the evolution

Here we will discuss the roles of random walks in the evolution. (1) First we state the roles of simple random walks in the birth of an evolution. We notice the Levi theorem: The one side event happens successively in a one dimensional simple random walk.

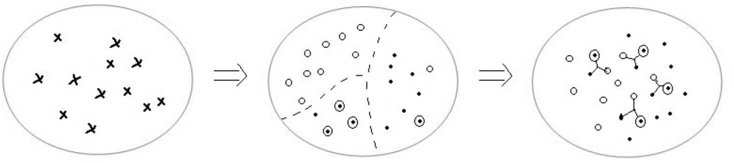

Fig. 2. The idea of ternary extension.

In case of a coin-toss game, this means that if we win, then we win successively. We give an illustration of an experiment in Figure 3 [7].

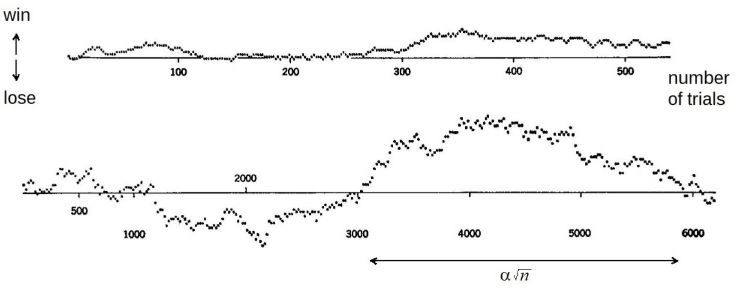

Fig. 3. The experimental results of consecutive coin-toss game.

We can give a simple justification the symmetry breaking. We have not observed 90% of the total mass of the universe and observed very few particles comparing with anti-particles. We can find symmetry breakings in many situations. To understand this, some physicists try to find the initial condition of the evolution of the universe. But untill now they could not find it. The Levi theorem tells that the symmetry breakings happen without any bias. Hence we see that the symmetry breakings are not a mystery. (2) In the complexity system which is given by the successive extensions, we have a self avoiding random walk and the distribution of the states has the distribution of power type [8, 24]. Hence we can find the origin of the power law distribution in the evolution.

4. The evolutions of the universe

Next we shall describe the evolution of the universe which is discussed in this paper. Let us first divide the total evolutions of the universe into the stages as shown in Figure 5 [22].

Then our main problem is how to describe each stage in a unified manner and how to describe the total evolution combining the evolution in each stage.

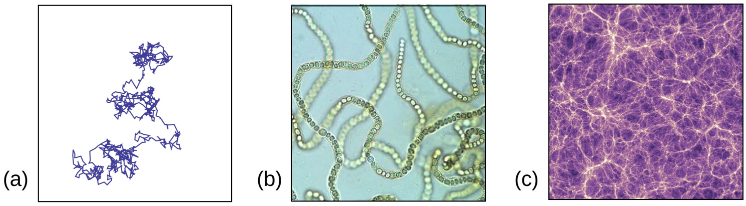

Fig. 4. (a) Brownian motion, (b) nostoc, (c) the universe (computer simulation).

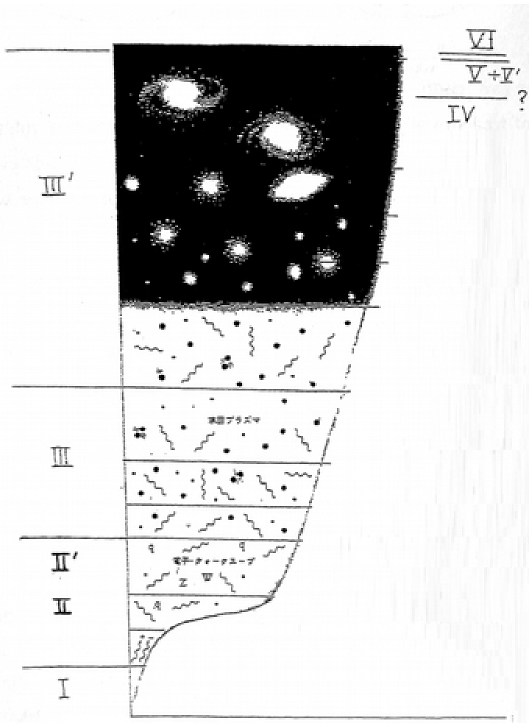

Fig. 5. (I), (I') The evolution of the space-time, (II), (II') The evolution of the elementary particles, (III), (III') The evolution of atomic physics the universe, (IV) The evolution of polymers, (V), (V') The evolutions in biology, (VI) The evolution in natural language.

5. The main results of this paper

With these preliminaries we can state our results. We assume that the birth of the evolution is given by an explosion of a seed. Then a fluctuation in the initial state follows. Next the self-organization is performed by the following two processes (E-I) and (E-2).

(E-I) The construction of hierarchy structure (BTBB-structure). The hierarchy structure is called BTBB-structure when it can be described by the successive extensions of the following type:

$$\{0\} \Longrightarrow B_{(a)} \Longrightarrow T_{(b)} \Longrightarrow B_{(a)} \Longrightarrow B_{(d)},$$

where $\{0\}$ is the initial state and $B_{(*)}, T_{(*)}$ are the binary and ternary extensions, respectively, and $\Longrightarrow$ signifies a successive extension. Let us notice that the ternary extension appears only once and other extensions are binary ones.

(E-II) The construction of the complexity system: After the hierarchy structure is created, the construction of the complexity system begins by the indefinite times of successive binary extensions:

$$B_{(1)} \Longrightarrow B_{(2)} \Longrightarrow B_{(3)} \Longrightarrow B_{(4)} \Longrightarrow \cdots \Longrightarrow \{\infty\},$$

where $\{\infty\}$ is the final state. This generation process can be described by the indefinite times successive binary extensions. When it makes a linear structure, it is called of linear type. This type can be observed in polymers, DNA, RNA and proteins.

(E-III) The total evolution. The total evolution is generated by successive operations of (E-I) and (E-II). The results can be summarized in the Total Evolutionary Tree shown in Figure 6.

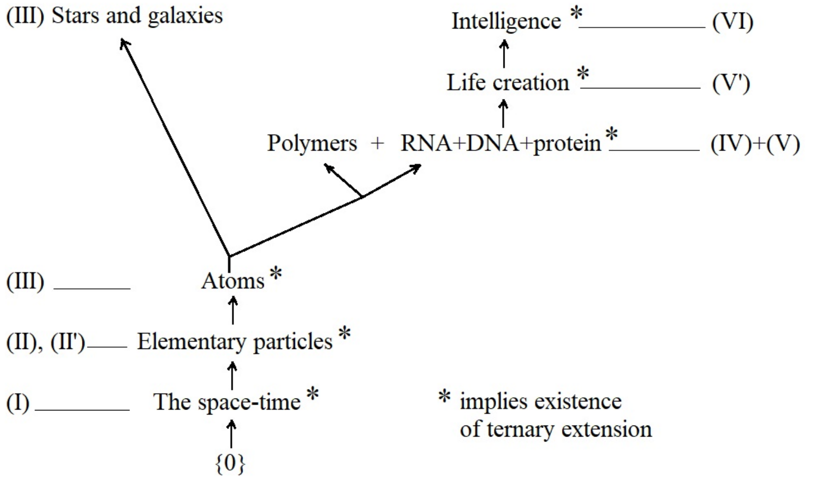

Fig. 6. The Total Evolutionary Tree.

6. Several basic problems

From the structure of evolutional tree, we can propose several basic problems.

1. The problems connected to with the unique ternary extension. In each stage of the evolution, we can observe the ternary extension $T_{(b)}$ only once. Hence we can make the division of the total evolution into stages, finding the ternary extensions and we can analyze the evolution on the base of the ternary extension.

(1) In the stages (I), (II), (III), (IV), we observe ternary extensions.

(2) In the stage (III'), (IV), we have no ternary extensions.

(3) In (V), (V') we have two ternary extensions. Hence we may expect to have the following stages in the total evolution:

$$\text{(I)} \parallel \text{(II)} \parallel \text{(III)+(III')+(IV)} \parallel \text{(V)} \parallel \text{(V')} \parallel \text{(VI)}.$$

We can pose the following questions: can we divide the stage (III)+(III')+(IV) into two/three stages? Can we give a reasonable explanation of the separation between the universe and polymers?

2. Mathematical background of the BTBB-structure. An algebraic equation $f(x) = 0$ with rational numbers coefficient of general type can be solved by the successive root operations if and only if the degree of $f(x)$ is less than 5. Then any solution can be obtained by making root operations in the following process:

$$Q \Longrightarrow \sqrt[2]{\ } \Longrightarrow \sqrt[3]{\ } \Longrightarrow \sqrt[2]{\ } \Longrightarrow \sqrt[2]{\ }.$$

This suggests us that we can develop the (non-)commutative Galois theory for the hierarchy structure including symmetry breaking [27].

3. Theory of everything. Recently some scientists have begun to treat the nature from the global and long time interval point of view. Namely, they have tried to construct Theory of everything. Our theory is also one of the theories of everything. In [2] J. Barrow has proposed problems to construct the theory of everything. We believe our considerations may give solutions to some of his problems.

4. Complex (or complexity) systems. S. Kaufman, L. Smolin and E. Prigogin have discussed the evolution theory based on the complex system. We may discuss their problems from our point of view [12, 21, 23].

In further part of this paper, we will devote ourselves to show that our assertions can be proved in stages (I)-(III) of the evolution. The number of the processes corresponds to that in (E-II). The other stages shall be described in our next paper.

7. The description of the evolutions in the universe (I). The space-time

There are several fundamental questions to be answered. For example, (1) Is the time reversible or not? (2) How the space has chosen 3 dimension? To treat these problems we need a new philosophy for sciences. Here we give a possible trial on the evolution on the space-time.

(1) We may choose the R. Penrose and W. H. Hawking's singularity as the origin. We may associate the initial states to the quantum gravity field of the space-time. Time and space are created and vanish. It makes a simple random walk [18, 10].

(2) The first binary extension creates the past and future and the inner space and outer space. We notice that the concepts of reversible or non-reversible time are still not born at this stage. By Levi theorem the future or past of the space-time is chosen.

(3) The ternary extension creates the 3 dimensional space.

(4) The second binary extension creates the matter sector and the energy sector (Jean's duality).

(5) The local time is created and the entropy is introduced. Hence the direction of the evolution is fixed. Here the local time implies the proper time on materials, for example, living beings. This time starts at some time and ends at some time. This is a non-reversible time.

(6) This process and the final stage (∞) are unknown.

Dark matters and light matters. We may discuss the dark matters in connection to the second binary extension. Following our convictions, we must find the ambient space connected to the light space. Hence we may find the dark matters.

8. The description of the evolutions in the universe (II), (II'). Elementary particles

(II) We make the evolution theory of elementary particles from the birth of particles to u, d-quarks at first.

(1) We may choose the Big-Bang as the origin of the evolution [19, 20]. The vacuum of quantum field is filled with photons and it makes equilibrium states and makes a simple random walk.

(2) The first binary extension creates quarks q and their anti-quarks q^*. We know that $\gamma + \gamma \iff q + q*$, where γ is the photon. Then mesons are constructed. Also the duality between baryons and leptons are created by (I).

(3) The ternary extension creates colors of quarks [20].

(4) The second binary extension creates t-quarks and b-quarks.

(5) The third binary extension creates c-quarks and s-quarks from t-quarks and d-quarks and u-quarks from b-quarks respectively (Figure 6).

(6) The infinitely many compositions of quarks, quasi-particles, particles defined by vertex operators can be generated by binary extensions [20, 25].

(∞) The final state are the statistical elementary particles.

Quark family and quark generation. We see that our construction of quarks asserts that we need no more new kinds of quarks. Hence we see that there exist the 3 quark generations constituting with 6 quarks. By this we can realize the Kobayashi-Masukawa model, as seen in Fig. 7a, b.

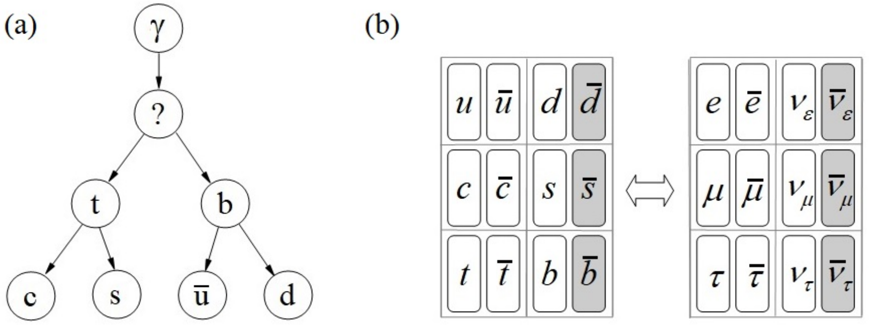

Fig. 7. (a) The third binary extension creates c-quarks and s-quarks from t-quarks and d-quarks and u-quarks from b-quarks respectively; (b) Kobayashi-Masukawa model.

(II') Gel'Mann-Zweig model. Next we consider the evolution starting from u(u*), d(d*) to p and n and we can obtain the meson table and baryon table by the binary and ternary extension respectively.

9. The description of the evolution of the universe (III), (III'). Atoms, stars and galaxies

First let us notice that protons and neutrons make equilibrium states by

$$n \equiv p + e^- + \mu_e.$$

1. The evolutions of atom physics.

(1) The origin of the evolution is the result of the Big-Bang. The equilibrium states of protons and neutrons. They make a simple random walk.

(2) The binary extension: p-p chain generates He from H (Gamov process), see Figure 8.

(3) The ternary extension creates carbon C from helium He: He+He+He $\Longrightarrow$ C (Figure 9).

(4) The second binary extension creates oxygen O from C by α-process: C + He $\Longrightarrow$ O.

(5) The second binary extension creates nitrogen N from O by α-process: O + He $\Longrightarrow$ N.

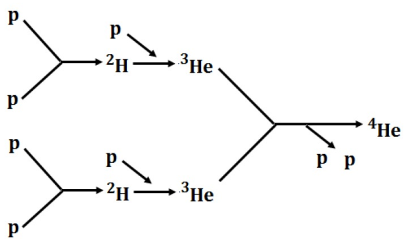

Fig. 8. The Gamov process: binary extension p-p chain generates He from H.

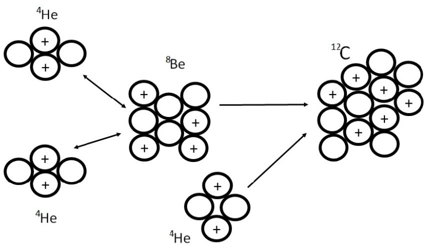

Fig. 9. The ternary extension creates carbon C from helium He: He+He+He $\Longrightarrow$ C.

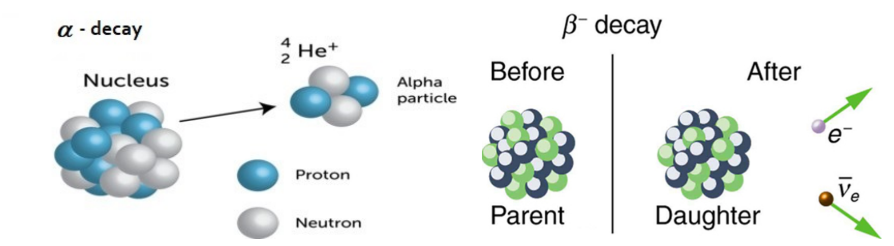

Fig. 10. The α and β decay.

(6) We can generate heavier stable and unstable atoms by indefinite successive binary extensions of α-particle generation or β-decay generation, where α-particle generation absorbs a proton p and β-decay generation absorbs neutron n by β-decay [22].

(∞) The final states might be the complete Mendeleev table of atoms.

2. The evolutions of stars. The scheme of the evolution of atoms continues to that of stars. Because of the difference in size between atoms and stars, we have the effect of gravity and we encounter dark matters through black holes.

(1) The same origin as in the evolution of atoms. The processes **(2)-(5)** are the same as in generation of atoms. The processes **(6)-(∞)** create the evolutions of stars and black holes. The process depends on the mass of stars:

(i) The evolution of a light star with M ¡ 4M0 (M0 is t the mass of the sun). Stars in main sequence (H and He) $\Longrightarrow$ red giant stars $\Longrightarrow$ creation of C and O $\Longrightarrow$ white dwarf.

(ii) The evolution of a heavier star with M>8M0; C and O are created as in (i) $\Longrightarrow$ Fe is created $\Longrightarrow$ neutrons are created at the center $\Longrightarrow$ Type II supernova with neutrons at the center.

(iii) The evolution of heavy stars (Hyper nova): The final blows up $\Longrightarrow$ The gravity becomes stronger $\Longrightarrow$ The creation of black holes.

3. The evolution of the galaxies. (1) We can choose the origin of the evolutions at 10^5 years old universe. The artificial satellite COBE observed that the distribution of the galaxies at this time makes the Plank distribution. This implies that there exists an equilibrium state between matter and emission. The processes **(2) -(5)** are the same as in the atom physics. The processes **(6)-(∞)**: The binary extensions should exist, although we have not found them. The evidence can be observed in voids and great walls in the distribution of the present galaxies (Figure 11). The distribution is of power law type, which implies that they make self avoiding random walks. In fact, we can observe string and textile structures in the universe.

Remark. We may say that our theory is of the character of bottom up theory [22].

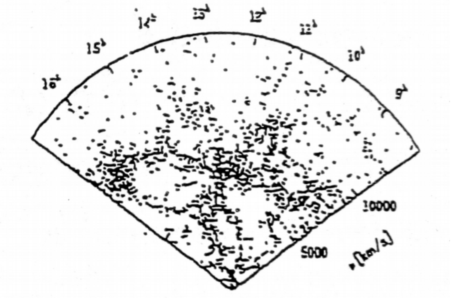

Fig. 11. Voids and great walls in the distribution of present galaxies.

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Presented by Julian Ławrynowicz at the Session of the Mathematical-Physical Commission of the Łódź Society of Sciences and Arts on January 15, 2019.

STRUKTURY BINARNE I TERNARNE W EWOLUCJACH WSZECHŚWIATA (ŚWIAT $2 \times 3 \times 2 \times 2 \times \cdots$)

OD POJĘCIA CZASOPRZESTRZENI DO BIOLOGII MOLEKULARNEJ

S t r e s z c z e n i e

Formułujemy definicję ewolucji. Wprowadzając pojęcia rozszerzeń binarnych i ternarnych opisujemy strukturę hierarchiczną (BTBB) i systemy złożoności ewolucji wszechświata w jednolity sposób. Główny rezultat tej pracy to drzewo ewolucyjne, które konstruujemy w Paragrafie 3. Na koniec odnosimy się do zasadniczych problemów teorii ewolucji.

Słowa kluczowe: binarne struktury fizyczne, ternarne struktury fizyczne, kwinarne struktury fizyczne, senarne struktury fizyczne, pentacen, polimer, ewolucja, wszechświat, rozszerzenie binarne, rozszerzenie ternarne, nieprzemienne rozszerzenie Galois