DOI: 10.26485/0459-6854/2020/70.1/1 PL ISSN 0459-6854

# B U L L E T I N

DE LA SOCIÉTÉ DES SCIENCES ET DES LETTRES DE ŁÓDŹ

2020 Vol. LXX

Recherches sur les déformations no. 1

pp. 11–41

*Julian Ławrynowicz*, *Małgorzata Nowak-Kępczyk, Osamu Suzuki*
*in collaboration with Mohd Fauzi Othman*

## BINARY AND TERNARY STRUCTURES OF THE EVOLUTIONS IN THE UNIVERSE ($2 \times 3 \times 2 \times \cdots$ -WORLD) III

### THE GALOIS THEORY OF LANGUAGES AND THE ANTHROPIC PROBLEM IN PHYSICS

**Summary**

(1) The non-commutative Galois theory of languages is presented and the universal language of natural languages is constructed. (2) The Galois theory for natural languages is given. (3) The Galois theory for the formal language theory is given. (4) Finally, we find intimate connections between language and physics and discuss the anthropological problem in physics from the point of view of our language theory. (5) In Appendix we give a virtual language defined by Fibonacci and Tribonacci sequences.

*Keywords and phrases:* the universal language, formal language theory, Turing machine, the evolution of the universe, non-commutative Galois theory, Fibonacci sequence, Tribonacci sequence

## Introduction

This paper is the third part of papers which are written under the same title. In ([18]) and ([19]) a survey on the evolution of the universe is given in terms of binary and ternary extensions. In this paper we will discuss the evolution of languages in more details and point out its intimate connection to physics.

At first we shall find the structure of a non-commutative Galois theory for languages. Then we can find the concept of the "universal language" which has been introduced by N. Chomsky ([2]) and we can discuss natural languages and computer languages in a unified manner. We notice that we can discuss the possibilities of the communication (translation) between different languages, intelligence and memories in terms of languages. This will be discussed in our next paper. Finally, we are going to the intimate connection between language and physics. We can obtain the following results:

**(1)** We can construct the Galois theory of the universal language which can describe the hierarchy structure of the language. Then we see that the hierarchy structure can determine sentences of natural languages strictly. Namely, we can observe basic sentences in any natural language, which are common in English as follows:

$$S+V, \quad S+V+O, \quad S+V+C, \dots$$

**(2)** We can discuss the possibility of communication in languauges and intelligence in terms of the universal language (in our next paper ).

**(3)** We introduce the Shannon entropy of natural languages and give the grammar which judges wheather the sentence is correct or not ([21]). Moreover, we can describe memories in terms of the entropy. Then the Boltzmann principle for Shannon entropy can tell why the memories become weaker when time passes (in our next paper).

**(4)** We can discuss languages of other types: for example animal languages, primitive human languages, for example: pidgins and kleole and computer languages in a unified manner. We can treat them in terms of the concept of "level" of sentences which can make the differences between these languages and compare their intelligencies (in our next paper).

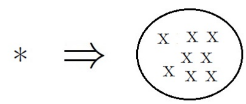
**(5)** Finally we will describe the connections between language and physics. The present orthodox trend in physics is the reductionism. But, recentely we have No-Go-Theorem in physics. In fact, we can not observe smaller lengths of time and distance than the Planck time and distance respectively ([1]). Also, the reductionism makes the materials in the reference finer and finer. But we have very big difficulties in integrating the divided materials to the originally given materials. This difficulity appears in the unification problem of 4 kinds of interactions. It asks how we can control from the small size of atoms, $10^{-33}$, to the big size of the universe, $10^{22}$, (meter, second, for example) in a unified manner. In the evolutions of biology or geography the difference in these sizes are not surprise in the usual research. Here we shall introduce an evolutional method for language. Then we can find remarkable similarities in the evolution in both physics and in language (the comparison table will be given in Section 5). This similarity indicates us a concrete approach to "anthropic principle" in physics ([1], etc.). This will be discussed in another paper in a more realistic manner.

## 1. The Galois theory of evolutional system (Binary and ternary extensions)

Here we recall the evolutional method of generations of systems ([18], [19]). The generation is performed in the following steps.

### (I) The big explosion (Step 1)

We denote the origin of the evolution by *. Then we have a big explosion and obtain "seeds "of the evolution. We denote the seeds by "x...x ":

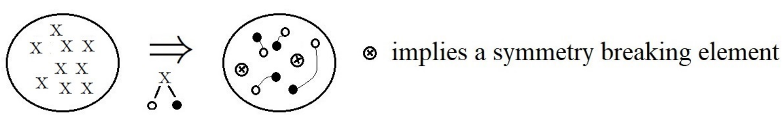


We assume that seeds make a simple random walk. The entropy of the states of the seeds is called the entropy of the evolution.

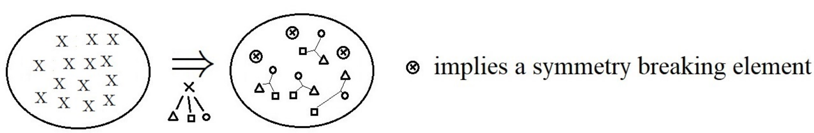
### (II) The binary and ternary extensions

The system is generated by the binary and ternary extensions successively.

**(1) Binary extension:** The seeds create a set of pairs which are called conjugate to each other.




**(2) Ternary extension:** The seeds create a set of triples which are called conjugate to each other.




**Remark:** In the both extensions, not necessarily all seeds create pairs or triples. Such seeds are called "symmetry breaking elements".

### (III) BTBB-structure

The evolutional system is called to have a BTBB structure, when it evolutes in the following process:

**(1)** The first binary extension happens (Step 2).

**(2)** The ternary extension happens (Step 3).

**(3)** The second binary extension happens (Step 4).

**(4)** The final binary extension happens and the the entropy is introduced and the direction of evolutions is determined (Step 5).

**Remark.** By step 5, we create the evolutional system $X_{in}$ and its ambient system $X_{out}$. We notice, that when the entropy $S_{in}$ of $X_{in}$ decreases, the entropy $S_{out}$ of $X_{out}$ increases automatically (Boltzmann-principle).

### Explicit construction of evolutions

Following the evolution scheme, we can give the explicit construction in Fig. 1.

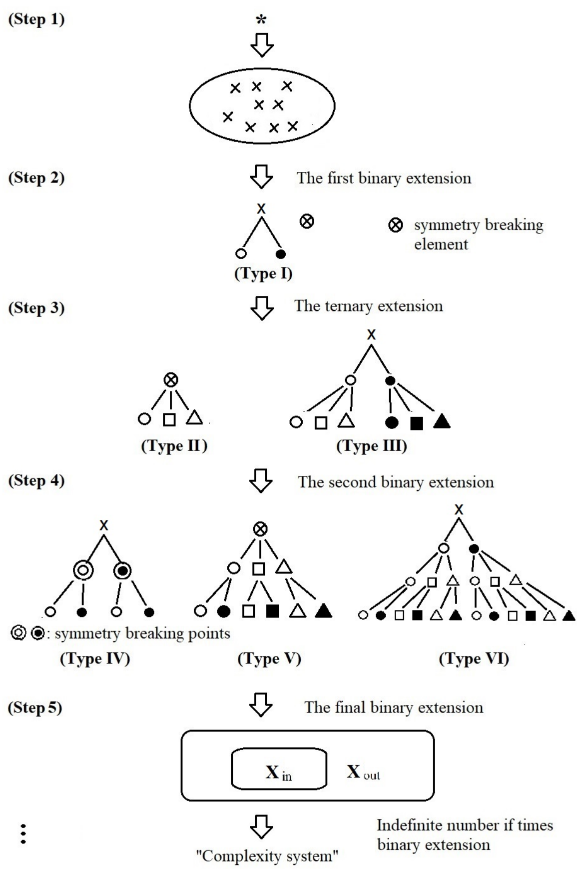



Fig. 1. Explicit construction of evolutions.

At this stage, the BTBB-system is constructed. Hence the basic system is obtained. Then we can obtain a much more complicated system - "Complexity system".

From this system we can derive chaotic systems and complex systems. This will be discussed in Part IV of our paper.

**The total hierarchy structure of evolutions**

The repetition of the generations of the BTBB system and the complexity system create the total hierarchy structure of the evolutional system:

**(1)** We denote the set of seeds by $\mathscr{L}_0$.

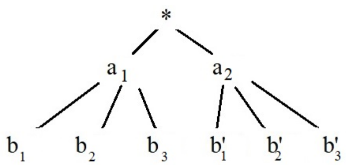
**(2)** We denote the system which is generated by the BTBB-structure by $\mathscr{L}_1$.

**(3)** Replacing $\mathscr{L}_0$ with $\mathscr{L}_1$, we follow the process (1), (2). Then we obtain the system $\mathscr{L}_2$.

**(4)** In the same manner we can obtain $\mathscr{L}_3$ from $\mathscr{L}_2$. Repeating this process we can obtain $\mathscr{L}_n$ $(n = 1, 2, \ldots)$. We call the system $\mathscr{L}_n$ evolutional system of level $n$.

**Permutation of elements in evolutional system**

In the Galois theory of extensions, we have a concept of permutations between elements of extensions which make a group. This is called Galois group ([23]). Here we introduce a conceptof permutations between elements of the system. The permutations are neccessary to create question forms from sentences and in translations of sentences trom one natural language to another. We describe it by a simple example.




**Example (Small permutation)** The permutation on each end of the branch of the extension, for example, the permutation in $\{b_1, b_2, b_3\}$ or $\{b'_1, b'_2, b'_3\}$ is called a small permutation.

**Example (Big permutation)** The permutation $\{a_1, a_2\}$ is called a big permutation because it gives rise to permutations $\{b_1, b_2, b_3\} \Rightarrow \{b'_1, b'_2, b'_3\}$ automatically.

By this example, we see that the big permutation gives a big change of sentences.

**Non-commutative Galois theory for an evolutional system**

Here we make a comment on the mathematical theory of the evolutional system. The classical Galois theory tells that the group of permutations of the roots of a general algebraic equation is solvable. Moreover, if they include not only binary extension but also other extensions, then it has the following sequence of extensions ([23]):

$$\sqrt{\phantom{x}} \Rightarrow \sqrt[3]{\phantom{x}} \Rightarrow \sqrt{\phantom{x}} \Rightarrow \sqrt{\phantom{x}}$$

i.e. the extension structure has the BTBB-structure. Applying this theory, we may prove the following theorem:

**Theorem.** *When an evolutional system is generated by successive non-commutative Galois extensions, we can prove the following assertion: When the system has not only binary extensions but also other type extensions, for example, ternary extensions, then we see that the system has the BTBB-structure.*

The proof of Theorem will be given in the part V of the series of this paper.

## 2. The universal language

We introduce a concept of the universal language. We will show that we can derive natural languages from the universal language (Section 3). We notice that we can describe the universal language independently from some especially chosen local natural language, for example, English. We follow the scheme of generations of evolutional systems.

### The birth of the universal language.

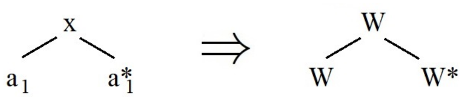
We can choose the origin of the universal languauge which is denoted by *. We take words which are finite sequences of arbitrary alphabets, for example: $x$, &, $y$, %, ... and consider a free algebra which is generated by words. The algebra of the words is denoted by W. We may choose the seeds $\{x\}$ as words.

Next we introduce concepts of binary and ternary and their succesive extensions on "words" and obtain sentences of the universal language.

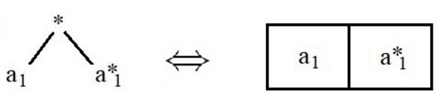
### (Step 1). The first binary extension

Introducing the conjugate algebra W* (resp. W) of W (resp. W*), we can define the first binary extension and obtain a sentence.

We call the sentence Type I sentence. We denote this as follows:




We write the scheme in the following manner

**(Type I)**


$(a_1 \in W, \quad a_1^* \in W^*)$

Here the right side is called "the box representation of the sentence".

**Remarks.** (1) The sentence given in the above corresponds to Type 1 sentence of the basic five sentences: $S + V$, where $S$ is the subject, $V$ is the verb in a natural language, and (2) We may assume that symmetry breaking elements may exist.

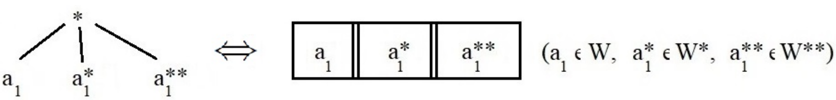
### (Step 2) The ternary extension

Next we proceed to the ternary extension. As in the binary extension, we consider the triple W, W*, W** for the words W which are ternary conjugate to each other. Namely, there exists a ternary involution $s$:

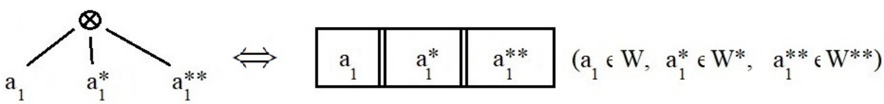
$$s : W \to W^*, \quad s : W^* \to W^{**}, \quad s : W^{**} \to W,$$

with $s^3 = 1$. In the same manner to the binary extension we prepare the origin * of the extension and the seeds W, W*, W**. We introduce a ternary sentence in the following diagram:

**(Type II)**




The right side is called "the box representation of the sentence". When we make the ternary extension for the symmetry breaking element $\otimes$ we can also consider the box representation

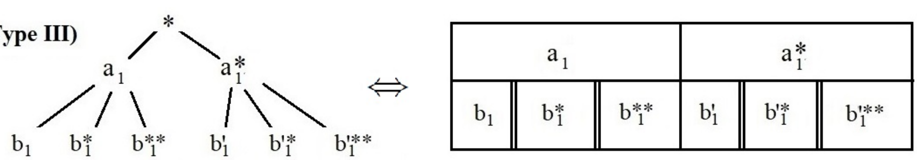



### (Step 3) The final binary extension (The generation of the basic sentences)

Next we proceed to considering the succesive extensions of binary and ternary extensions and obtain basic sentences for the universal language by the following succesive extensions (Type III), ... , (Type VI):

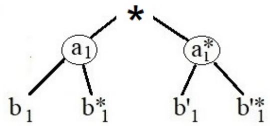
**(1)** We begin with Type III (Binary extension $\Rightarrow$ Ternary extension) sentence. Here we consider the extension which begins with origin * and making the succesive extensions of binary and ternary extensions, we have the sentence:

**(Type III)**




Next we proceed to the Type IV (Binary extension $\Rightarrow$ Binary extension) sentence.

**(Type IV)**



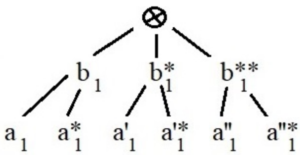
$\Longleftrightarrow$

| $a_1$ | | $a^*_1$ | |
|---|---|---|---|
| $b_1$ | $b^*_1$ | $b'_1$ | $b'^*_1$ |

Here $a_1$ and $a^*_1$ are symmetry breaking elements for the ternary extension ([19]).

Next we proceed to the Type V (Ternary extension $\Rightarrow$ Binary extension) sentence. Here we consider the extensions which we begin with origin * and making the succesive extensions of ternary and binary extensions:

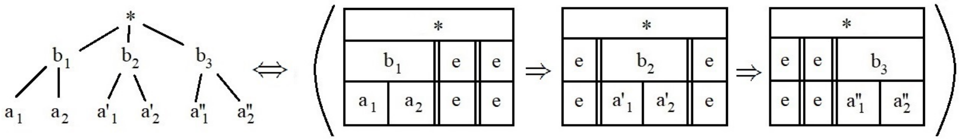
**(Type V)**



$\Longleftrightarrow$

| $b_1$ | | $b^*_1$ | | $b^{**}_1$ | |
|---|---|---|---|---|---|
| $a_1$ | $a^*_1$ | $a'_1$ | $a'^*_1$ | $a''_1$ | $a''^*_1$ |

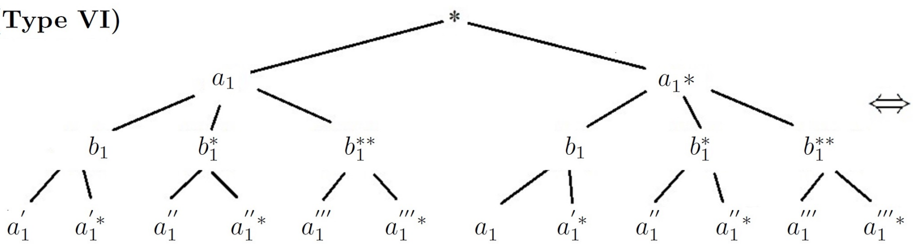
**Remark.** We may consider the partial extension of the above extension and realize it in terms of the succesive extension of the partial extensions.



Here we mean e as the empty element. Each permutation on the right hand side is called a partial extension. We see that any extension can be realized as a succesive partial extensions.

Finally we treat the general extension Type VI (Binary extension $\Rightarrow$ Ternary extension $\Rightarrow$ Binary extension).

**(Type VI)**



| $a_1$ | | | | | | $a_1*$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $b_1$ | | $b_1^*$ | | $b_1^{**}$ | | $b_1$ | | $b_1^*$ | | $b_1^{**}$ | |
| $a_1^{'}$ | $a_1^{'}*$ | $a_1^{''}$ | $a_1^{''}*$ | $a_1^{'''}$ | $a_1^{'''}*$ | $a_1$ | $a_1^{'}*$ | $a_1^{''}$ | $a_1^{''}*$ | $a_1^{'''}$ | $a_1^{'''}*$ |

### (Step 4) Introduction of entropy

To complete the construction of BTBB-structure, we proceed to the construction of the final binary extension. Here we introduce the entropy. The entropy is Shannon entropy. This gives the separation of sentences into correct sentences and incorrect sentences and describes the process of the creation of sentences. We notice that this entropy gives the grammar of the language. When a given sentence is acceptable, then entropy attains the minimum, because it needs no more information ([21]).

### The grammar of the universal language

The grammar of the universal language is given as follows:

A sequence of words is acceptable for the grammar if and only if the two conditions are satisfied:

(1) The sequence constitutes the binary and ternary and their successive extension structure,
(2) Permutations may happen.

### Complex sentences

Making indefinite times binary extensions, we can create much more complex sentences. This can be analysed in the total hierarchy structure of the universal language.

### The total hierarchy structure of the universal language

Finally, we make the total set of sentences of the universal language. The total set of sentences which are constructed as in Section 1 is called the level one sentence and are denoted by $\mathscr{L}_1$. We denote the set of words by $\mathscr{L}_0$.

Replacing $\mathscr{L}_0$ with $\mathscr{L}_1$, and following the scheme of generation of sentences for $\mathscr{L}_1$, we make the set of sentences which is denoted by $\mathscr{L}_2$. Repeating this precess, we can obtain the total set of sentences:

$$\mathscr{L}_0,\ \mathscr{L}_1, \dots, \mathscr{L}_k, \dots$$

### The classification of sentences

(1) The sentences $\mathscr{L}_1$ which are created in the BTBB-generations from $\mathscr{L}_0$ are called "basic sentences".

(2) The other sentences in $\mathscr{L}_k$ $(k > 1)$ are called "complex sentences of level $k$.

## 3. Natural languages

We will derive natural languages from the universal language. Here we describe it in terms of English. We notice that the same discussions hold for other languages. We follow the generation scheme of the universal language. Here we notice that we inlude the empty word "e" as a word.

### (Step 1) The birth of natural languages

This step is almost the same as in the universal language. We treat the sentences in the following order:

$$\text{Type I} \Rightarrow \text{Type II} \Rightarrow \text{Type V} \Rightarrow \text{Type IV} \Rightarrow \text{Type III}.$$

In the case of English, we choose English alphabets and make words W which is called "non-ending words" (we may add $e$ (empty word)).

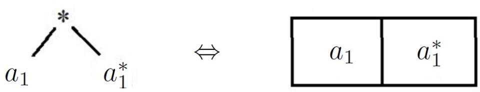
### (Step 2) The first binary extension

Introducing "ending words W*" as the conjugate words, we have

$$\widetilde{W} = W \cup W^* \quad \text{(W: non-ending words, W*: ending words).}$$

We can create the sentences of the following type:

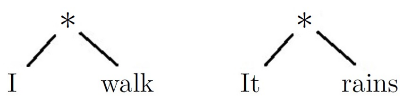
**(Type I)**




$(a_1 \in W \quad a_1^* \in W^*)$

This sentence is then so called S+V sentences.

**Examples**




Here we notice that the symmetry breaking between W and W* always happens: a dog runs, a dog sleeps, a dog comes, a cat runs, a rat runs.

**Remark (Natural languages in biology and in physics)**. We make a comment on the language structures in biology and physics. We can find an intimate analogy between natural languages and biology, physics. This will be discussed in our next paper.

**(1)** In molecular biology, RNA and DNA are tapes which are written by 4 words: $\{A, T, G, C\}$, $\{A, U, G, C\}$, respectively. Hence we may take

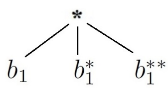
$$\text{W}=\{A, T, G, C\} \text{ for RNA, W=W*}=\{A, T, G, C\} \text{ for DNA, respectively.}$$

We have the duality T ⇔ A, C ⇔ G between W and W* in DNA. Hence we have no symmetry breaking. DNA can be regarded as the binary extension on RNA through identification of C with G. Proteins can be regarded as the ternary extension on RNA. Then we may expect to obtain the languages by the successive binary extensions. The acceptable sentences can be discussed from the body constructions. The Galois group can be treated as mutations. These topics will be discussed in Part IV.

**(2)** In the theory of elementary particles, we have W ⇔ particles, W* ⇔ anti-particles as binary extension. The symmetry breaking creates mass of particles. Here we notice that we have the duality between Wand W* by q ⇒ q* + $\gamma$, where $\gamma$ is the photon. The ternary extension creates the colors of quarks. These will be discussed in Part IV of our paper.

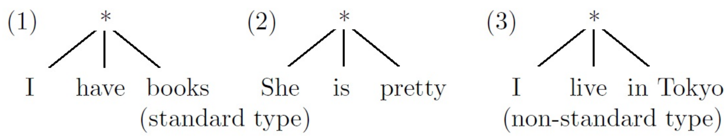
### (Step 3) The ternary extension

Following the scheme, we introduce a concept of ternary conjugate triples W, W*, and W** and we introduce the following types of sentences

**(Type II)** 

$\Leftrightarrow \boxed{b_1}\boxed{b_1^*}\boxed{b_1^{**}} \quad (b_1 \in W,\ \ b_1^* \in W^*,\ \ b_1^{**} \in W^{**})$

We have the following two types: (1) S+V+O, S+V+C (standard type) (2) S+V+A (non-standard type).

**Examples** 


We give the background on the constructions of sentences:

### The Galois theoretic understanding on the construction of Type II sentences

At first we recall how we construct ternary sentences:

I have ⇒ "What do you have? ⇒ " I have books.

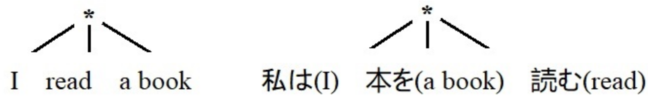
She is ⇒ "How is she?" ⇒ She is pretty.

I live ⇒ "Where do you live?" ⇒ I live in Tokyo.

Then we see that the sentences can be constructed by the ternary generations. Namely two words, for example, "I + have" are not enough and the entropy is not minimum and demands more words. Then we choose a book and put "I+have+a book". Then the entropy is minimized and complete the sentence: I have a book. In the case of other languages, we may make permutations, if we need:

$$b_1,\, b_2,\, b_3 \Rightarrow b_1,\, b_3,\, b_2 \Rightarrow \dots \quad (b_1 \in W,\ b_2 \in W^*,\ b_3 \in W^{**}).$$

**Examples**

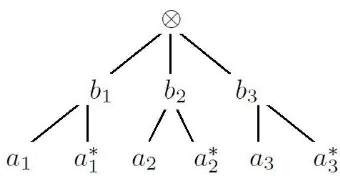



This shows that we need the Galois group.

### (Step 4) The successive extensions

We begin the succesive extensions (Ternary extension $\Rightarrow$ Binary extension).

**(Type V)**




$\Leftrightarrow$

| $b_1$ | | $b_2$ | | $b_3$ | |
|---|---|---|---|---|---|
| $a_1$ | $a_1^*$ | $a_2$ | $a_2^*$ | $a_3$ | $a_3^*$ |

$$\left(\ b_1 \in W,\ \ b_2 \in W^*,\ b_3 \in W^{**},\ a_1,\ a_2,\ a_3 \in W',\ a_1^*,\ a_2^*,\ a_3^* \in W'^*\ \right)$$

We see that the following sentences can be realized by this successive extension:

(i) S+V+(O+O), (ii) S+V+(O+C).

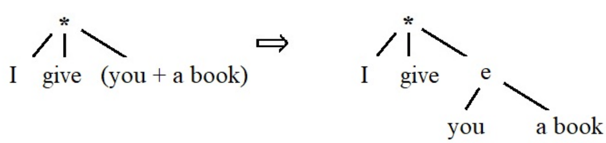
**The Galois theoretic understanding on the construction of Type V sentences**
**(i) S+V+(O+O)**

We may see that the sentence "I give you a book" is the combination of the following two ternary sentences:

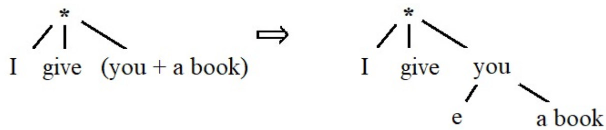
$$\left\{\begin{array}{l} I\ give\ you \\ + \\ I\ give\ a\ book \end{array}\right. \Rightarrow I\ give\ (you + a\ book) \Rightarrow I\ give\ you\ a\ book.$$

Hence we may understand that this construction is obtained by successive extensions of ternary and binary extensions. Hence we may express the sentence in the several manners:

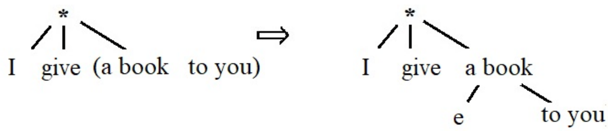
(1)



(2)




(3)



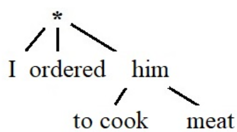

**Remark.** N. Chomsky associates only the binary-binary extension to sentences. Hence we see that we need some discussions on several possibilities of associations ([2]):
The Galois theoretic construction for the remained sentences is the same and may be omitted.

**(ii-1) S+V+O+(V+O)**
We take a sentence: "I ordered him to cook meat". We can imagine its construction as follows:

$$I\ ordered\ him \Rightarrow \begin{cases} What\ did\ you\ order\ him? & \Rightarrow\ I\ ordered\ him\ to\ cook & \Rightarrow \\ What\ did\ you\ order\ him? & \Rightarrow\ I\ ordered\ him\ meat & \Rightarrow \end{cases}$$

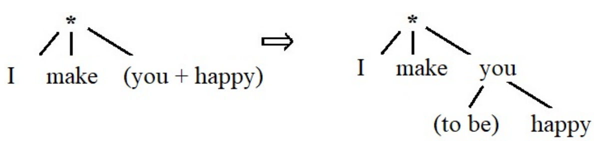
$$\begin{array}{llll} \Rightarrow & What\ cook? & \Rightarrow & meat \\ \Rightarrow & What\ with\ meat? & \Rightarrow & cook \end{array}$$

$$\begin{cases} I\ ordered\ him\ to\ cook \\ I\ ordered\ him\ meat \end{cases} \Rightarrow$$

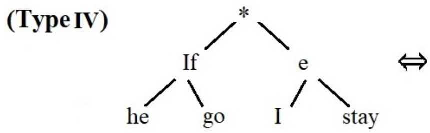



**(ii-2) S+V+O+C**
We take a sentence: "I make you happy". Then we see its construction as follows:

$$I\ make \Rightarrow \begin{cases} Whom\ do\ you\ make? & \Rightarrow & You & \Rightarrow & How? & \Rightarrow & happy \\ How\ do\ I\ make? & \Rightarrow & Happy & \Rightarrow & Whom? & \Rightarrow & You \end{cases}$$

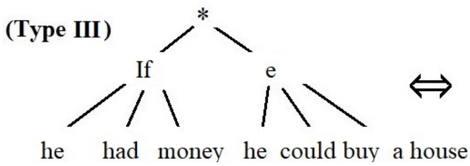



Next we give several examples of Type IV, Type III sentences.
**(Type IV) sentences** (Binary extension $\Longrightarrow$ Binary extension)




| If | | e | |
|---|---|---|---|
| he | go | I | stay |

**(Type III)** (Binary extension $\Longrightarrow$ Ternary extension)




| If | | | e | | |
|---|---|---|---|---|---|
| he | had | money | he | could buy | a house |

where e is a blank box.

**Remark.** If-sentence, when-sentence, because-sentence etc...are typical Type IV, III sentences.

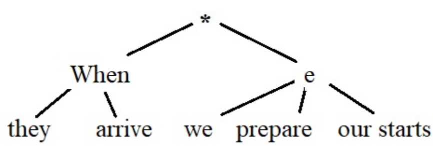
**(Type VI)** (Binary extension $\Longrightarrow$ Ternary extension $\Longrightarrow$ Binary extension $\Longrightarrow$ binary extension) This sentence is thought to be so complex that it is might not easily be constructed.

## The total hierarchy structure of a natural language

Finally we can describe the total hierarchy structure of sentences by the following generation scheme of the sentences of level $k$: $\mathscr{L}_k$ as we have given in Section 2. We give several examples:

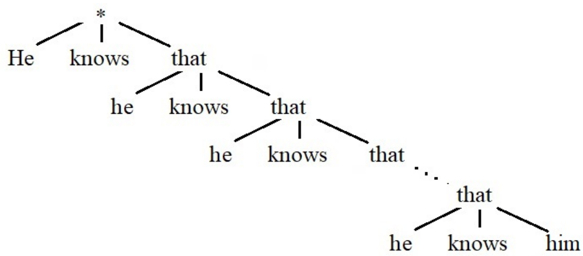
**(1)** $\mathscr{L}_2$ sentences which are not $\mathscr{L}_1$ sentences: We can include sentences of "asymmetric" type in $\mathscr{L}_2$ sentences.

**Example:** "When they arrive we prepare our starts"



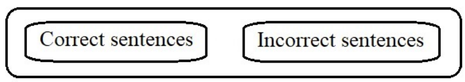

**(2)** $\mathscr{L}_k$ - sentences for arbitrary $k$: We can find sentences in $\mathscr{L}_k$ for any $k$ which are correct from grammar but not practical. We give an example:

**Example:** He knows that he knows that he knows... that he knows him.




**(Step 5) Introduction of entropy**

Finally, we introduce the final binary extension. We choose the Shannon entropy ([21]).




However, the grammar for sentences in school texts is not enough to judge wheather a given sentence is correct or not in daily life. We need help of the cognitive language theory. This will be discussed in our next paper. Here we consider in what level sentences, the effect of the entropy appears. When we speak simple sentences, we do not worry about the grammar, or entropy. In fact, children speak incorrect sentences frequently. Occasionally even adults do not speak correct sentences, for example, in pygin language. In the case of simple sentences, we have not big troubles. Hence we may assume that the essential effect of entropy appears at the later stage of BTBB-structure. As for the entropy, we will discuss in our paper Part IV.

Summary We can derive natural languages from the universal language. Then we can obtain the following results:

**(1)** The sentences of $\mathscr{L}_1$ contain basic sentences which supply enough sentences in the daily conversation. In fact, so called 5 (or 7) basic sentences in English are included in $\mathscr{L}_1$. Moreover, we see that basic sentences in other natural languages, for example, in Japanese.

**(2)** The sentences in BTBB-structures include not only basic sentences but also other useful sentences If- sentences, when-sentences, ...

**(3)** Applying Theorem in Section 1 to natural languages we can produce the basic sentences. When we have not only binary sentences (S+V) but also ternary sentences (for example, S+V+O), and S+V+O+O. S+V+O+C sentences. Then it has the BTBB-structure, but no more other sentences, for example, S+V+O+O+O, S+V.+O+C+O,... cannot exist.

## 4. Computer language

In this section we will discuss the evolution of the computer languages. At first we recall the basic formal languages and give several examples of computer programming languages ([15]). Then we proceed to the evolution of formal languages and realization of computer languages in the formal languages and discuss the hierarchy structures. Finally, we will notice that the compile is nothing but the realization of computer languages in the context of free language.

### The hierarchy structure of the formal language theory

In the formal language theory we have the following hierarchy structure:

**(1)** The regular language: $\mathscr{F}_1$

**(2)** The context free language: $\mathscr{F}_2$

**(3)** The context sensitive language: $\mathscr{F}_3$

**(4)** The general language (Turing machine): $\mathscr{F}_4$

We have:

$$\mathscr{F}_1 \subsetneq \mathscr{F}_2 \subsetneq \mathscr{F}_3 \subsetneq \mathscr{F}_4.$$

We can describe the same hierarchy structure in terms of computer machines. Corresponding to the hierarchy structure of the formal language, we have

**(1)'** Finite automaton

**(2)'** Push-down automaton

**(3)'** Linear bounded automation

**(4)'** Turing machine

We notice that (1) $\Leftrightarrow$ (1)', (2) $\Leftrightarrow$ (2)', (3) $\Leftrightarrow$ (3)', (4) $\Leftrightarrow$ (4)'. Hence we see that the formal language is directly connected to mathematics ([15]).

### The computer programming languages

We have many computer programming languages. Here we make a classification of the programming languages and state some basic properties: (i) Lower level language (ii) Higher level language:

**(i) Lower level languages.** The languages which are directly connected to computer systems are called of lower level languages.

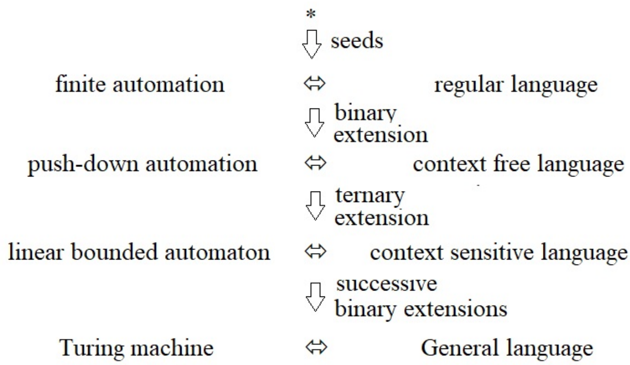
**Examples** (1) Machine language (2) Assembly language

**(ii) Higher level language** The language which is constructed for practical uses. To perform this language, we have to transform (compile) the language to a lower level language.

**Examples** (1) FORTRAN, BASIC, COBOL, (2) Pascal. C-language, PL/1, (3) LISP, Scheme, MI. Prolog (4) C++, Smalltalk, Java, C#, PHP, Perl, TD,...

### The evolution scheme of the formal languages

We give the evolution of the formal languages.




**Remarks: (1)** We may expect that this evolution can be described by non-commutative Galois extensions directly. Moreover, we see that the evolution of a language, even if it is a natural language, has a mathematical character. This is the background philosophy of this paper. N. Chomsky has already observed this philosophy and established his language theory ([2]). Unfortunately, he has not found the universal language. He has described in terms of a proper natural language, English. This is thought to be a weak point of his theory and this causes misunderstandings on his philosophy. We can complement his theory by replacing English with our universal language.

**(2)** We make a comment on the grammar on the formal language. We may choose the Montagne grammar as the grammar of the formal language. N. Chomsky established only the formal language theory, but he has not entered into the grammatical structure. It seems that the grammatical structure depends on culture, history, characters of peoples who use the language. This has indicated the necessity of the introduction of cognitive language.

### The universal computer programming language

We proceed to find the universal computer programming language. We have seen that we have the universal language $\mathscr{F}^*$ for a natural language $\mathscr{F}$ and the realization $f : \mathscr{F} \Rightarrow \mathscr{F}^*$. Here we will find the universal computer programming language PL* for a computer programming language PL and its realization. Since any PL can be described in the formal language, we can choose a Turing machine as its universal language. We see that the so called compiling is one of the realizations in the context free language.

## 5. The method of language theory to physics

Here we recall the evolutional methods in physics and we will find the same hierarchy structure as in the language theory. Hence we may assert that this fact gives a method of language theory to physics.

### The evolution of the universe

We recall the results on the evolution of the universe. Then we can find the BTBB-structure and its complexity systems.

We assume that the birth of the evolution is given by explosion (for example, Big-Bang) of the origin (for example the Penrose-Hawking singularity). Then we have a fluctuation in the initial state. Next the self-organization performs 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 descr?bed by the successive extensions of the following type:

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

where $\{0\}$ is the initial state and $B_{(*)}$, $T_{(*)}$ are the binary and ternary extension respectively and $\Rightarrow$ implies the successive extension. We notice that the ternary extension appears only one time and other extensions are binary extensions.

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

$$B_{(1)} \Rightarrow T_{(2)} \Rightarrow B_{(3)} \Rightarrow B_{(4)} \Rightarrow \ldots \Rightarrow \{\infty\},$$

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

**(E-III) The total evolution**
The total evolution is generated by successive operations of (E-I) and (E-1I) which create a fractal structure and finally a chaotic structute.

### The language method for physics

We will state the following problems and find the language method for physics.

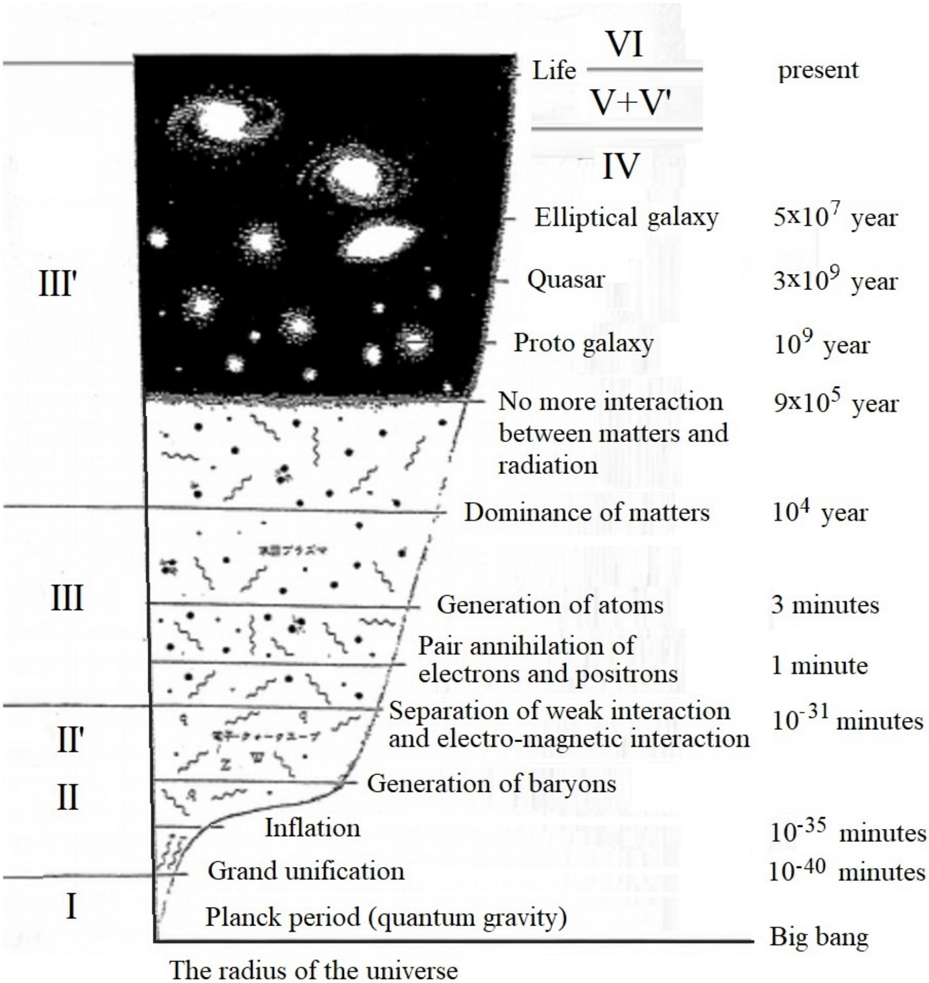



Figure 2. The evolution of the universe

**Problems:**

**(1)** Can we describe the evolution in terms of language?
**(2)** Is there no phenomena which cannot be described in terms of language?

We will consider the problems in the followirg steps:

**Step 1:** We recall the evolution of the universe which is given in Part I ([18]). We can summarize the evolution in the Figures 1. Then we can observe the evolution processes E-I, E-II, E-III.

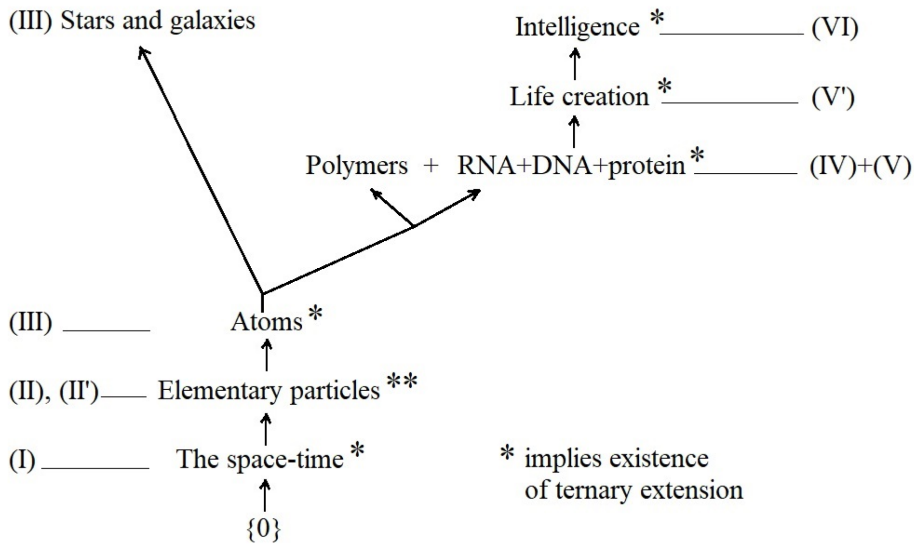



Figure 3. The Total Evolutionary Tree

**Step 2:** We consider the evolution in the language. We can observe also the evolution processes E-I, E-II, E-III.

**Step 3:** Then we compare the both evolutions. We have introduced the concept of the level of the evolutions. We compare the evolution of the universe with that of language in each level $k$ (see p. 9, 13). We can give the results in Table 1.

Then we can observe the following facts:

**(1)** We see that the generations of the universe and that of sentences have the same characters i.e. the BTBB- structure and the complexity systems.

**(2)** In each evolution stage, we can find only one ternary extension and other extensions are binary extensions. Hence, finding the ternary extension, we can divide the evolution process into each stage of the evolution (see Figure 3).

## The anthological problems in physics

With these observations, we will discuss the problems. The motivation of the consideration on the problems can be stated as follows:

**(1)** Can other animals describe or understand this universe as human being? It seems that they cannot discuss the evolution of the universe, because their language ability is too poor to describe it.

**(2)** We know that we (want to) describe the universe in our way. We do not know whether our language ability is perfect or not. If not, we can have only the incomplete knowledge on the universe.

**(3)** If there would exist life things, we may call "hyper human being", who have hyper ability, then they can understand the universe much more exactly. Then we see that there exist unknown phenomenon forever, for us.

Table 1. The comparisons of $\mathscr{L}_k$ structures in language and physics.

| generation | language | physics | remark |
|---|---|---|---|
| $\mathscr{L}_1$ | (0) Alphabets (or words)<br>(1) binary sentence<br>(S+V)<br>(2) ternary sentences<br>(S+V+O, S+V+A)<br>(3) basic sentence<br>(S+V+O+O, S+V+O+A) | (0) photons<br>(1') quarks and anti-quarks<br>(q and q*)<br>(2') quarks with colors<br>(q(r), q(b), q(y))<br>(3') quark family<br>t, b, s, c, u, d | BTBB-structure |
| | (4) complex sentences | (4) statistical particles | complexity structure |
| $\mathscr{L}_2$ | (0') $\mathscr{L}_1$-sentences<br>(1) Binary $\mathscr{L}_1$-sentences<br>$(\mathscr{L}_1 + \mathscr{L}_1)$<br>(2) Ternary $\mathscr{L}_1$ sentences<br>$(\mathscr{L}_1 + \mathscr{L}_1 + \mathscr{L}_1)$<br>(3) $\mathscr{L}_1$ basic type sentences<br>$(\mathscr{L}_1 + \mathscr{L}_1 + (\mathscr{L}_1 + \mathscr{L}_1))$ | (0') proton and neutron<br>(1') $H_2$, $H_4$ (Gamov process)<br><br>(2') He+He+He=C<br>(Salpter process)<br>(3') a-process, b-process<br>generation | BTBB-structure |
| | (4) $\mathscr{L}_1$-complex sentences | (4') Generation of stars | complexity structure |
| $\mathscr{L}_3$ | (0) $\mathscr{L}_2$-sentences<br>(1) Binary $\mathscr{L}_2$-sentences<br>$(\mathscr{L}_2 + \mathscr{L}_2)$<br>(2) Ternary $\mathscr{L}_2$ sentences<br>$(\mathscr{L}_2 + \mathscr{L}_2 + (\mathscr{L}_2 + \mathscr{L}_2))$<br><br>(3) $\mathscr{L}_2$ basic type sentences<br>$(\mathscr{L}_2 + \mathscr{L}_2 + (\mathscr{L}_2 + \mathscr{L}_2))$ | (0') The equilibrium state of matters and emissions<br>(1') Light stars (M≤4Ms)<br>(Gamov process)<br>(2') Heavy stars (M≥13Ms)<br>(Salpter process)<br>(3') Hyper Nova (M≥13Ms) | BTBB-structure |
| | (4) $\mathscr{L}_2$-complexity structure | (4') The creation of galaxies and black holes | complexity structure |

We give some explanations on the table. Here we give intimate analogies between physics and language theory

**(1)** S+V $\Leftrightarrow q + q^*$

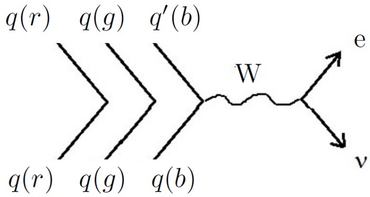
**(2)** S+V+O, S+V+C $\Leftrightarrow q(r) + q(g) + q(b),\ q^*(r) + q^*(g) + q^*(b)$

**(3)** S+V+O+O', S+V+O+C can be seen as the "resonance" of two sentences: S+V+O+O' $\Leftrightarrow$ (S+V+O)+(S+V+O'), S+V+O+C $\Leftrightarrow$ (S+V+O)+(S+V+C), For example

$$\text{I give you books} \Leftrightarrow (\text{I give you}) + (\text{I give books})$$
$$\text{I grow up him to be a doctor} \Leftrightarrow (\text{I grow up him}) + (\text{I grow up to be a doctor})$$

This phenomena can be observed in physics:

$$q(r) + q(g) + q(b) + \text{ weak boson W} \Leftrightarrow q(r) + q(g) + q'(b)$$




$q(b)$ and $q'(b)$ make a resonant state.

Repeating this process, we can obtain the generation of the quark family:

$$(q(r) + q(g) + q(b)) + (q'(r) + q'(g) + q'(b)) \Leftrightarrow (q''(r) + q''(g) + q''(b))$$

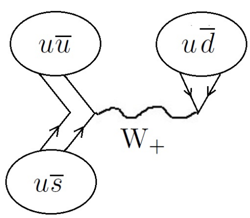
Hence we can understand that the both baryons make a resonance state by a weak boson W. We can rewrite the above sentences in a physical manner:

$$\text{I give you} + \text{I give books} \Leftrightarrow \text{I give you books} + \text{emitted entropy}$$

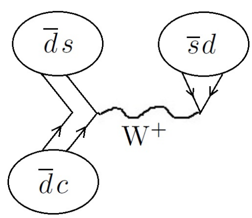
We can see that the role of weak bosons and leptons is emitting the entropy compensating the decrease of the entropy for the self organizations.

**(4)** We give other examples of binary resonances:

(1) $\mathrm{K}^+$- decay ($\overline{s} \Rightarrow u$)



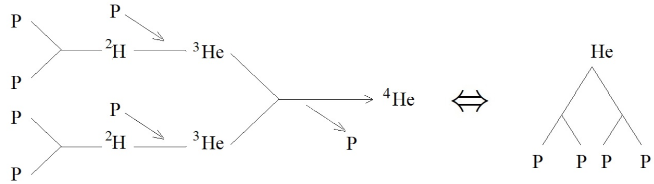

(2) $\mathrm{D}^+$- decay ($c \Rightarrow \overline{s}$)

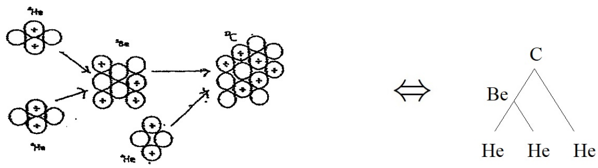



The corresponding sentences might be the change of S, V: S + V $\Leftrightarrow$ S'+V':

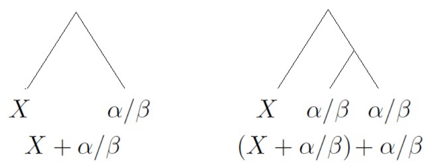
I walk $\Leftrightarrow$ I will walk, I walk $\Leftrightarrow$ He walks.

**(5)** We can associate $\mathscr{L}_2$ - generations for Gamov process and Salpeter process. We can associate these process to Type I sentence (S+V-sentences) and Type II sentence (S+V+O sentences)




**(6)** We can associate successive $\alpha$-process and $\beta$-decay process to the following tree structures;




**Remark.** By these observations, we can see intimate relationships between physics and languages. We may complete the following table:

| Physics | Language |
|---|---|
| W-boson | Change of tense |
| | Change of subjective, objective |
| Lepton | post-positional particle |
| Photon, neutrino, lepton | Junk sentences |

**Remark:** Linguists have paid attentions only to correct sentences, but not incorrect sentences or junk sentences. The research of molecular biology tells that junks in DNA play very important hidden roles for the life activity. They keep their freedom of the choices for survives. In the linguistics, we have the same analogy: Namely such sentences make the freedom of the human beings. We can not observe the freedoms directly. It lives in the information space and we can measure them in terms of the Shannon entropy. Hence we should consider not only the correct sentences but also non-correct sentences, junk sentences as the origin of the language. Hence by the step 5 (introduction of entropy) in the evolution process of the language, the final binary extension creates the separation of the correct sentences and incorrect sentences. We may say that Chomsky has discussed only on the logical side, or mathematical structure but not on the emotional side. On the base of this observation we may propose an ambitious proposal on the research on the dark matter, dark energy:

$$\left\{\begin{array}{l}\text{Light matters}\\ \text{dark matter}\end{array}\right. \Leftrightarrow \begin{array}{l}\text{correct sentences}\\ \text{non-correct sentences}\end{array}$$

## Appendix: Fibonacci language (Language defined by Fibonacci and Tribonacci sequences)

We introduce the Fibonacci/Tribonacci sequence and construct a natural language by these languages ([8]).

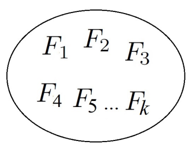
### Fibonacci and Tribonacci Fibonacci sentences

The following sequences are called Fibonacci sequence/Tribonacci sequence, respectively, when

$$F_{n+2} = F_n + F_{n+1} \ \ (F_1 = F_2 = 1),$$

$$G_{n+3} = G_n + G_{n+1} + G_{n+2} \ \ (G_1 = G_2 = 1, \ \ G_3 = 2).$$

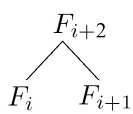
At first we consider sentences which are generated by the Fibonacci sequence. We assume the existence of the origin of the evolution which is denoted by *. We choose the seeds of evolution as elements of the Fibonacci sequence:

$* \ \Rightarrow$ 


We assume that they are floating and make a simple random walk: Then the first binary extension happens and create following pair which is called Fibonacci pair:

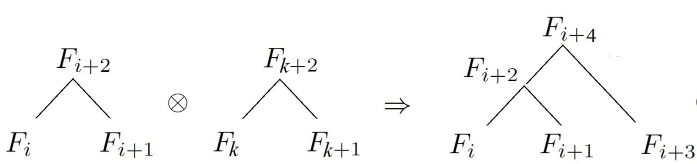
$$\{F_i, \ F_{i+1}\}, \ \ (i = 1, 2, \ldots).$$

We introduce the simplest binary sentence by




$(i = 1, 2, \ldots)$

From these pairs, we will introduce the "general Fibonacci sentence" by the tensor product:

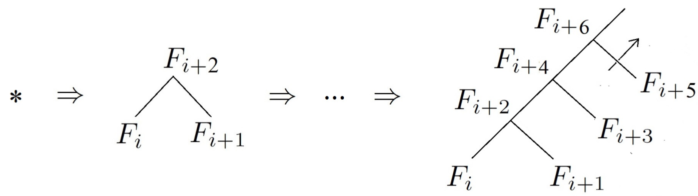



$(k = i+2)$

Otherwise ($k \neq i+2$) we have a direct product of two pairs which are called symmetry breaking pair. More generally we take a sequence of pairs

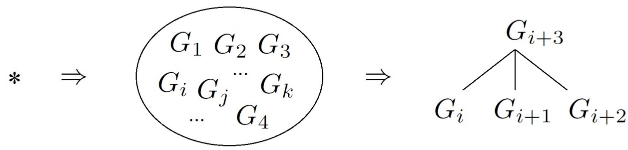
$$\{F_i,\ F_{i+1}\} \Rightarrow \{F_{i+1},\ F_{i+2}\} \Rightarrow \{F_{i+2},\ F_{i+3}\} \ldots$$

and we can define general sentences by the successive extensions:

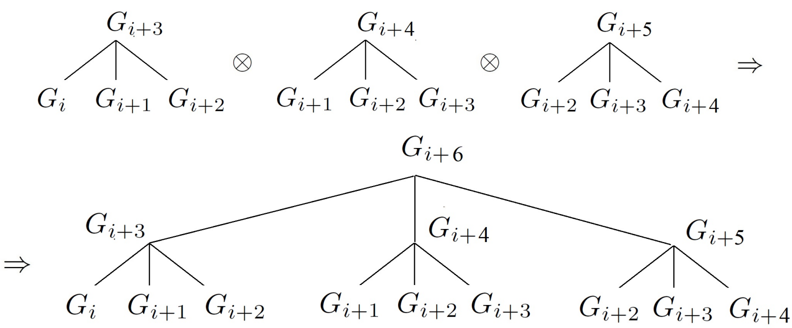



"Going up construction"

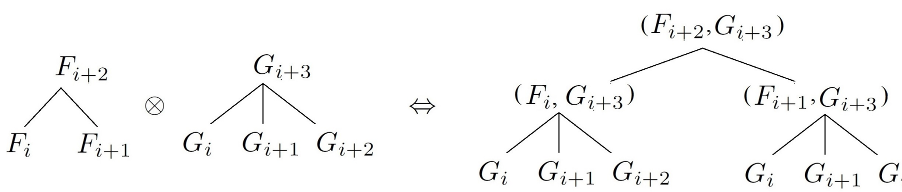
Next we consider the Tribonacci sequence $\{G_i\}$. In the same manner, we have the explosion:




Then we have the ternary sentences. In a similar manner, we have the successive temary sentences:



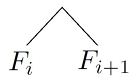

We introduce sentences which are created by the successive binary and ternary extensions



Following the converse process we have the transcription mechanism.

## The group theoretic generation of Fibonacci and Tribonacci sequences

We introduce a concept of the group structure for the generation of the Fibonacci sequences at first. For the generation of basic binary sentences, we associate a vector by




$$\Leftrightarrow \quad \begin{bmatrix} F_{i+1} \\ F_i \end{bmatrix}$$

Then we can generate a tower of binary sentences by the Galois group operation defined by

$$\begin{bmatrix} F_{i+2} \\ F_{i+1} \end{bmatrix} = \mathscr{F} \begin{bmatrix} F_{i+1} \\ F_i \end{bmatrix}, \quad \mathscr{F} = \begin{pmatrix} 1 & 1 \\ 1 & 0 \end{pmatrix}.$$

In fact, we have

$$\begin{bmatrix} F_{i+3} \\ F_{i+2} \end{bmatrix} = \mathscr{F} \begin{bmatrix} F_{i+2} \\ F_{i+1} \end{bmatrix} = \mathscr{F}^2 \begin{bmatrix} F_{i+1} \\ F_i \end{bmatrix}.$$

In order to extend the product to the group structure, we have to extend the Fibonacci sequence with negative index by the condition: $F_{i-1} = F_{i+1} - F_i$ $(i < 0)$. Then we have the Fibonacci sequence to the negative degree

$$F_{-i-1} \;\; F_{-i} \;\; F_{i+1} \;\; \ldots \;\; F_{-1} \;\; F_0 \;\; F_1 \;\; F_2$$

Hence we have

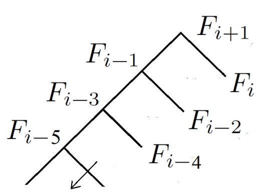
$$\ldots\ldots -21 \;\; 13 \;\; -8 \;\; 5 \;\; -3 \;\; 2 \;\; -1 \;\; 1 \;\; 0 \;\; 1 \;\; 1 \ldots$$

For this sequence we can define $F_n$ $(n \leq -1)$ as follows:

$$\begin{bmatrix} F_i \\ F_{i-1} \end{bmatrix} = \mathscr{F}^{-1} \begin{bmatrix} F_{i+1} \\ F_i \end{bmatrix}, \quad \mathscr{F}^{-1} = \begin{pmatrix} 0 & 1 \\ +1 & -1 \end{pmatrix}.$$

In an analogous manner we generate sentences with negative indices:

$$F_{i+1},\; F_{i-1},\; F_i,\; F_{i-3},\; F_{i-2},\; F_{i-5},\; F_{i-4}, \ldots$$




(Going down generation)

Next we proceed to the generation of ternary Tribonacci sentences in terms of the Group generation. For a ternary Tribonacci sequence $\{G_n\}$ we introduce the Group structure

$$\begin{bmatrix} G_{i+5} \\ G_{i+4} \\ G_{i+3} \end{bmatrix} = \mathscr{G} \begin{bmatrix} G_{i+2} \\ G_{i+1} \\ G_i \end{bmatrix}, \quad \mathscr{G} = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 0 \end{pmatrix}.$$

Then we can generate the ternary sentences by

$$\mathscr{G}^n \begin{bmatrix} G_3 \\ G_2 \\ G_1 \end{bmatrix}.$$

In a completely analogous manner, we introduce the inverse ternary sentences by

$$(\mathscr{G}^{-1})^n \begin{bmatrix} G_3 \\ G_2 \\ G_1 \end{bmatrix}.$$

Then we can make the "going-up generation" and "going-down generation" of ternary sentences. The sentences given by successive extension sentences become

$$\ldots \mathscr{F} \times \mathscr{G} \times \mathscr{F}(\,|* > \ \otimes |* >) = \begin{bmatrix} F_2 \\ F_1 \end{bmatrix} \otimes \begin{bmatrix} G_3 \\ G_2 \\ G_1 \end{bmatrix}.$$

Hence we can obtain the sentences by operating the group operations.

### Galois theory of Fibonacci and Tribonacci sequences

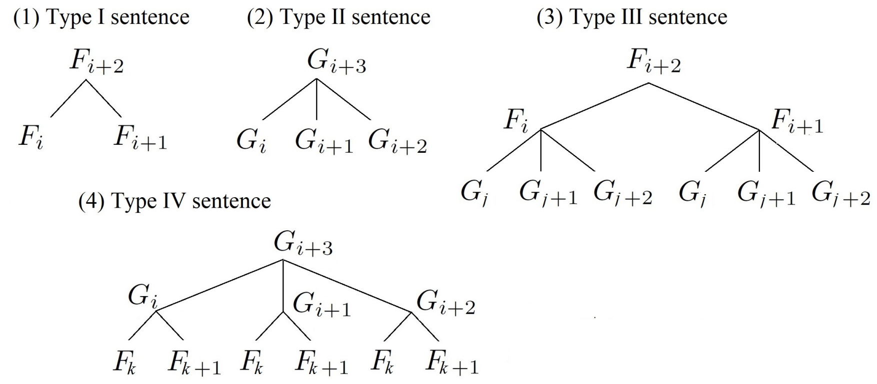
We can give the Galois theory for the tower of tensor products. From the sequence of tower generation, we have the tower of Galois groups. For this we will introduce permutations for Fibonacci pairs and Tribonacci triples: $F_i \Leftrightarrow F_{i+1}, G_i \Leftrightarrow G_{i+1} \Leftrightarrow G_{i+2}$. Then we can introduce the tower structure of successive extensions and construct the Galois theory for the tensor products of the generations. When we assume that the total Galois group is a solvable group, we can find the BTBB structure.

### Fibonacci Tribonacci language and their biology

With these preliminaries, we will construct the Fibonacci-Trigonacci language and their biology:

**(1) Fibonacci-Trigonacci language**

Here we will find a virtual natural language of Fibonacci and Trigonacci sequences. Following the generation scheme of several types of sentences of a natural language, we will produce sentences. We will give the first four types of sequences. The remained sequences can be given in an analogous manner:




Type III, IV sentences are given by the tensor product: $G_j \times F_i \; |* >$, $F_k \otimes G_j \otimes F_i \; |* >$, respectively. Other sentences can be given in terms of tensor products.

**(2) Fibonacci and Trigonacci biology** Here we will give the DNA sequence of Fibonacci sequence: DNA constitutes with two RNA sequences:

$$3' - \text{RNA} - 5' \text{ sequence}: \; \ldots\ldots F_{-6} \;\; F_{-4} \;\; F_{-2} \;\; F_0 \;\; F_2 \;\; F_4 \;\; F_6 \;\; \ldots\ldots$$

$$5' - \text{RNA} - 3' \text{ sequence}: \; \ldots\ldots F_{-7} \;\; F_{-5} \;\; F_{-3} \;\; F_{-1} \;\; F_1 \;\; F_3 \;\; F_5 \;\; \ldots\ldots$$

with the duality: $F_{2n-1} \Leftrightarrow F_{2n}$.

Next we will construct the transcription mechanism for Fibonacci-Tribonacci sequence. For this we prepare the tensor products of the Fibonacci sequence and Tribonacci sequence $F_i \otimes G_j$ and $F_i \otimes G_j \otimes F_k$, successively. Here we have the tensor product in the vertical direction:

$$\begin{array}{ccccccccc}
\ldots\ldots & F_{-6} & F_{-4} & F_{-2} & F_0 & F_2 & F_4 & F_6 & \ldots\ldots \\
 & \otimes & \otimes & \otimes & \otimes & \otimes & \otimes & \otimes & \\
\ldots\ldots & G_{-3} & G_{-2} & G_{-1} & G_0 & G_1 & G_2 & G_3 & \ldots\ldots
\end{array}$$

$\Rightarrow$

$$\begin{array}{ccccccccc}
\ldots\ldots & F_{-6} & F_{-4} & F_{-2} & F_0 & F_2 & F_4 & F_6 & \ldots\ldots \\
 & \otimes & \otimes & \otimes & \otimes & \otimes & \otimes & \otimes & \\
\ldots\ldots & G_{-3} & G_{-2} & G_{-1} & G_0 & G_1 & G_2 & G_3 & \ldots\ldots \\
 & \otimes & \otimes & \otimes & \otimes & \otimes & \otimes & \otimes & \\
\ldots\ldots & F_{-7} & F_{-5} & F_{-3} & F_{-1} & F_1 & F_3 & F_5 & \ldots\ldots
\end{array}$$

$\Leftrightarrow$

$$\begin{array}{cccccccccc}
 & \ldots\ldots & F_{-6} & F_{-4} & F_{-2} & F_0 & F_2 & F_4 & F_6 & \ldots\ldots \\
 & \ldots\ldots & F_{-7} & F_{-5} & F_{-3} & F_{-1} & F_1 & F_3 & F_5 & \ldots\ldots \\
 & & & & & & & & & \\
+ & \ldots\ldots & G_{-3} & G_{-2} & G_{-1} & G_0 & G_1 & G_2 & G_3 & \ldots\ldots
\end{array}$$

This process can be identified with the inverse process of the tensor product. Remark: The Fibonacci-Tribonacci language and biology are non-realistic virtual ones. In part VII, we will give model constructions of evolutions. Then we may survive "the lost world" or imagine "the unknown astrobiology".

## References


[1] J. Barrow, Theories of everything, Oxford University Press, 1991.

[2] N. Chomsky, Three models of the description of languages, PGIT, 2:3, 113-124, 1956.

[3] F. Ducastelle and F. Gauthier, *Generalized perturbation theory in disordered transitional alloys: Applications to the calculation of ordering energies*, J. Phys. F 6 (1976), 2039; doi: 10:1088/0305-4608/6/11/065.

[4] P. G. de Gennes, Scaling Concepts in Polymer Physics, Cornel University Press 1979.

[5] C. R. Darwin, The origin of species, 6th Ed., The world's classics, London, Oxford University Press 1872.

[6] W. Feller, An introduction to probability theory and its applications (Vol. 1) Springer Verlag, New York, Inc. (1988), John Wiley and Sons 1957.

[7] H. F. Gilbert, Basic Concepts in Biochemistry (A Student Survival Guide), McGraw-Hill, Inc. 1992.

[8] R. P. Grimaldi, Fibonacci and Catalan Numbers (An Introduction), A John Wiley & Sons, INC. Publication, 2012.

[9] J. Ławrynowicz, M. Nowak-Kę pczyk, and M. Zubert, *Mathematics behind two related nobel prizes 2016: in physics - topology governing physics of phase transitions, in chemistry - geometry of molecular nanoengines,* Bull. Soc. Sci. Lettres Łódź Sér. Rech. Déform. **69**, vol 1 (2019).

[10] J. Ławrynowicz, O. Suzuki, A. Niemczynowicz, M. & Nowak-Kępczyk, *Fractals and chaos related to Ising-Onsager-Zhang lattices. Ternary approach vs. binary approach*, Int. J. of Geom. Meth. in Modern Physics, Vol. 15, No. 11, 1850187 (2018). 01 Nov 2018, https://doi.org/10.1142/S0219887818501876 .

[11] J. Ławrynowicz, M. Nowak-Kępczyk, A. Valianti, and M. Zubert, *Physics of complex alloys - one dimensional relaxation problem,* Bull. Soc. Sci. Lettres Łódź Sér. Rech. Déform. **65**, 27–48 (2015).

[12] J. Ławrynowicz, K. Nôno, D. Nagayama, and O. Suzuki, *Non-commutative Galois theory on Nonion algebra and* su(3) *and its application to construction of quark models*, Proc. of the Annual Meeting of the Yukawa Inst. Kyoto "The Hierarchy Structure in Physics and Information Theory" Soryuusironnkennkyuu, Yukawa Institute, Kyoto 2011, pp. 145–157 [http://www2.yukawa.kyoto-u.ac.jp].

[13] J. Ławrynowicz, K. Nôno, D. Nagayama, and O. Suzuki, *A method of non-commutative Galois theory for binary and ternary Clifford Analysis*, Proc. ICMPEA (Internat. Conf. on Math. Probl. in Eng. Aerospace, and Sciences) Wien 2012, AIP (Amer. Inst. of Phys.) Conf. 1493 (2012), 1007–1014.

[14] J. Ławrynowicz, K. Nôno, and O. Suzuki, *Binary and ternary Clifford analysis vs. non-commutative Galois extensions. I. Basics of the comparison*, Bull. Soc. Sci. Lettres Łódź Sér. Rech. Déform. **62**, no. 1 (2012), 33–42.

[15] R. N. Moll, M. A. Arbib, and A. J. Kfoury: Introduction to formal language theory, Springer-Verlag, New York, 1988.

[16] R. Nevalinna, Analytic functions, Springer-Verlag, Berlin-Heidelberg-New York 1970.

[17] O. Suzuki, *Mathematical theory of symmetry breaking in binary and ternary structures*, Bull. Soc. Sci. Lettres Łódź Sér. Rech. Déform. **70**, no. 1 (2020),

[18] O. Suzuki, *Binary and ternary structure in the evolutions of the universe (*$2 \times 3 \times 2 \times 2 \times \cdots$ *world). From space-time to molecular biology*, Bull. Soc. Sci. Lettres Łódź Sér. Rech. Déform. **69**, no. 1 (2019), 13–26.

[19] O. Suzuki, *Binary and ternary structure in the evolutions of the universe (*$2 \times 3 \times 2 \times 2 \times \cdots$ *world) II. The description of further stages of the evolutions (Polymers, molecular biology, and natural language)*, Bull. Soc. Sci. Lettres Łódź Sér. Rech. Déform. **69**, no. 1 (2019), 27–34.

[20] O. Suzuki, J. Ławrynowicz, M. Nowak-Kępczyk, and M. Zubert, *Some geometrical aspects of binary, ternary, quaternary, quinary and senary structures in physics*, Bull. Soc. Sci. Lettres Łódź Sér. Rech. Déform. **68** no. 2, (2018) 109–122. DOI: 10.26485/0459-6854/2018/68.2/11

[21] C. Tsallis, Introduction to nonextensive statistical mechanics (Approaching a complex world), Springer Verlag, New York, Inc. 2009.

[22] H. Umezawa, Advanced field theory (Micro, Macro and Thermal Physics), American Institute of Physics 1993.

[23] B. L. van der Waerden, Moderne algebra 2, Berlin Verlag von Julius Springer 1937.

Julian Ławrynowicz
Department of Solid State Physics
University of Łódź
Pomorska 149/153, PL-90-236 Łódź;
Poland
E-mail: jlawryno@uni.lodz.pl

Małgorzata Nowak-Kępczyk
Institute of Mathematics and Computer Science
The John Paul II Catholic University of Lublin
Al. Racławickie 14, P.O. Box 129, PL-20-950 Lublin
Poland
E-mail: gosianmk@wp.pl

Osamu Suzuki
Department of Computer and System Analysis
College of Humanities and Sciences, Nihon University
Sakurajosui 3-25-40, Setagaya-ku, 156-8550 Tokyo
Japan
E-mail: osuzuki1944butterfly@gmail.com

Mohd Fauzi Othman
Department of Electronic Systems Engineering
Malaysia-Japan International Institute of Technology
Universiti Teknologi Malaysia Kuala Lumpur
Jalan Sultan Yahaya Petra
54100 Kuala Lumpur, Wilayah Persekutuan
Malaysia
E-mail: mdfauzi@utm.my

Presented by Julian Ławrynowicz at the Session of the Mathematical-Physical Commission of the Łódź Society of Sciences and Arts on October 29, 2019.

## STRUKTURY BINARNE I TERNARNE W EWOLUCJI WSZECHŚWIATA (ŚWIAT $2 \times 3 \times 2 \times \cdots$ WYMIAROWY) III

### TEORIA GALOIS JĘZYKÓW I PROBLEM ANTROPICZNY W FIZYCE

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

(1) Przedstawiamy nieprzemienną teorię języków Galois i skonstruowano uniwersalny język języków naturalnych. (2) Przedstawiamy teorię Galois dotyczącą języków naturalnych. (3) Przedstawiamy teorię Galois dla formalnej teorii języka. (4) Wreszcie znajdujemy bliskie powiązania między językiem a fizyką i omawiamy problem antropologiczny w fizyce z punktu widzenia naszej teorii języka. (5) W Dodatku podajemy wirtualny język zdefiniowany przez sekwencje Fibonacciego i Tribonacciego.

*Słowa kluczowe:* binarna struktura fizyczna, ternarna struktura fizyczna, kwaternarna struktura fizyczna, kwinarna struktura fizyczna, sennarna struktura fizyczna, stop, pentacen, polimer, białko, paptyd, aminokwas, rozszerzenie Galois, powierzchnia Riemanna.