

COMPLEX LOGIC

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Abstract

Complex logic is a novel logical framework, which formalizes the semantics of the categories of matter, space, and time in a system of logic that operates with complex logical objects.

A complex logical object represents a superposition of a logical statement and its logical negation positioning any statement co-relatively to its logical negation.

In the system of logical notations, where S is a logical statement and $Not S$ is its logical negation, complex logic includes co-relative logical positions of S and $Not S$ with the probabilities of their truth within the scale $0 \dots 1$, excluding the boundary values of 0 and 1 , into a single logical superposition. Thus, the logical superposition, summing up the probabilistic positions of S and $Not S$, has an invariant truth value equal to 1 . In this context, *complex logic* proves to be invariant to reality, offering a *unified* logical interpretation of reality, spanning from quantum to cosmological scales.

By defining the nature of matter and reality as a complex two-format processual essence with corresponding logical consequences, complex logic enhances our concept and understanding of reality.

1 An Introduction to Complex Logic

Let us symbolically denote a certain statement as S , and its logical negation as $Not S$, denoted as S' , to avoid overloading logical constructs. Thus, the double negation operator $Not Not S$ will look like S'' or $S'(2)$, and the n -fold negation of S will look like $S'(n)$.

Thus, $S'(0) = S$. Indeed, S has no negation (zero negations), and that is the statement S itself.

It should be noted that in complex logic, the statement and the logical object are logical synonyms.

Let us denote the logical superposition as the formalized union of the logical statement S (logical position S) and its logical negation S' (logical position $Not S$) into a complex logical

object of the form $/ S + S' /$, where the logical positions S and S' (*Not S*) have probabilistic values in the range of the truth-value scale $0 \dots 1$, excluding boundary values:

$$/ S + S' / = 1 \quad (0)$$

The given relation is a logical equation that reflects the equivalence of the logical superposition $/ S + S' /$ (where S and S' have probability representations) to the truth value equal to 1 . The equivalence of the superposition to 1 as a truth value reflects its invariance to reality. Hence, relation (0) will be further referred to as the invariance relation, invariance equation, or simply as equation (0), or referred to as an invariant. Accordingly, logical positions S and S' (*Not S*) are also represented simply as positions S and S' (*Not S*) without explicitly naming them as logical.

In the superposition notation $/ S + S' /$ the logical negation S' follows the logical statement S , but not vice versa, as negation is positioned in a *co-relative* manner to the statement it negates, emphasizing a strict sequence where one follows *co-relatively* to the other since negation is only possible for something that has been asserted.

Right-slanting slash brackets are used to represent the superpositional state of the probability positions S and S' (*Not S*).

The addition operator, represented by the symbol "+" (plus), signifies the operation of adding summands that exist in a state of co-relative simultaneity at a single moment. In this logic, this applies to all mathematical operators, such as subtraction, multiplication (exponentiation), division, and so on. Mathematical symbols of relations, such as equals (equivalent), less than, greater than, and so on, also represent arguments in a state of simultaneity.

As the symbol of equivalence, we will use the sign "=" which is also conventionally referred to as the equality sign.

From equation (0), it follows that the truth probability measures of S and S' are expressed by the relations $0 < S < 1$, $0 < S' < 1$.

As noted, S and S' do not take on the extreme values of 0 and 1 ; instead, they are present in the relation (0) in such a way that if one numerically changes, the other changes accordingly. However, their sum constitutes an invariant unit.

In other words, S and S' are linked by probability measures between the state of actuality (S) and the state of virtuality (S'). The probability measure implies mathematical probability, i.e., the measure of the probabilistic presence of an object or event. Actuality refers to a state of an object (event) that can be somehow fixed or measured, unlike a virtual state, which lacks the option of measurability (fixability). Thus, the concept of "virtuality" is encompassed within the concept of reality and is not defined outside of reality. Actuality and virtuality exist in superposition as co-relative facets of a unified reality.

Consequences from the invariance relation (0)

1.1 Impossibility of Absolute Truth

$S \neq 1$. This implies that there are no undeniable statements (*absolutely true*).

Any statement is conditioned by the current circumstances and does not exist outside of these circumstances as absolutely independent from them.

The truth recognized as absolute by consensus or definition, such as an axiom or postulate, does not imply that it holds true in complex logic and, consequently, in reality.

$S \neq 0$. This implies that there are no absolutely false statements (*absolutely untrue*). An absolutely false statement is essentially the same as an absolute truth, but located on the opposite side of the truth scale.

Thus, no matter how senseless or trivial a statement may appear, it nonetheless possesses some "potential for truth", distinct from zero. This reflects the *impossibility of "zero" reality*

or the absence of an *absolutely* empty state of reality. In other words, there is no "breakthrough" or exit from reality. The impossibility of the existence of anything *absolute* implies that every aspect of reality is inherently *co-relative*, *two-sided* in nature, or, in other words, *two-format*.

From $S \neq 0$, it follows that matter is indestructible (as it does not assume a zero value) - therefore, matter undergoes changes (transforms) in forms of presence, signifying that matter is a *procedural* essence.

1.2 Two Formats of Logic

If we assume that S and *Not S* *exclusively* take the extreme truth values of 1 and 0 , then complex logic is reformatted into two-valued mathematical logic. In two-valued logic, truth values are absolutized into the boundary values of 1 or 0 , whereas in complex logic, truth values vary within the bounds of the truth scale $0 \dots 1$, excluding the extreme values.

Assuming, in the invariant $S + S' = 1$, that $S' = 0$, then complex logic transforms into formal logic, where $S = 1$ is normatively true. If $S' = 1$, then $S = 0$ is normatively false.

1.3 Principle of Co-Relativity

Superposition reflects two aspects of reality: the fixity in the statement S of some aspect of reality and the negation of this fixity in the logical negation *Not S*. Therefore, a logical object is defined *co-relatively* to its logical negation. This is ***the principle of co-relativity*** in complex logic: ***any logical object (event) is positioned co-relatively to its own logical negation.***

Logical negation implies the presence of an object, as negation is possible only for what is definitely present in reality. If there is no statement, there is no logical negation of it, and vice versa; logical negation is possible only in the presence of a statement. Therefore, the co-relativity between a statement and its negation can only be *momentary*.

Momentary is the determining condition *for the state of co-relativity*. If two states are not momentary, then they are defined as *relative*, either in terms of spatial relativity, or in terms of temporal relativity. Thus, co-relativity, implying the possibility of spatio-temporal relativity, is two-format.

The interconnectedness or entanglement of positions (objects) in complex logic implies their co-relative momentary simultaneity. This momentary co-relative entanglement includes the position of logical negation, *Not S*, and the position of S in the same reality. In other words, the position of *Not S* is as real as the position of S .

The statement S and its logical negation, *Not S*, being co-relative, constitute a single logical superposition. Thus, *superposition is a manifestation of the principle of co-relativity*.

The co-relative interdependence of a logical object and its logical negation reflects the *process of co-relativity* between two logical formats as an *invariant process* inherent in reality. Therefore, the nature of reality is fundamentally dual-formatted. In other words, the criterion for the correspondence of any statement (or abstraction) to the nature of reality is the dual formatting of that statement (abstraction).

The consequence of the principle of co-relativity is the impossibility of the existence of truth (logical object) in an absolute form that excludes the possibility of its logical negation.

1.4 Negation of Fixity

Any logical statement, S , exists within the bounds of its fixed values (meanings), determined by the context. In the logical negation, *Not S*, the boundaries that define (fix) S are nullified.

Thus, the logical negation of any statement, S , means a transition into the *co-relative* semantic aspects of *Not S*, representing the logical negation of the semantic values established (fixed) in S .

Let us clarify this as follows. The form of a circle on a plane (*position S*) fixes the area of the

circle (content bounded by the circle) relative to the unbounded external plane (*position NotS*), having no fixed limits in terms of form or content.

Thus, any statement, *S*, *fixes* the content of that statement. In the negation, *Not S*, the content in *S* is denied, meaning its *fixity is negated*.

Content reflects attributivity, i.e., the inherent nature of properties or qualities in an object or phenomenon. The inalienability of the properties inherent in an object means that these properties are fixed for that object. An object outside of these properties is not a given object. Therefore, the determining factor in negation is the negation of the *fixity of certain attributes* in an object or phenomenon.

Hence, the definition of logical negation is:

The logical negation of a statement S in the form Not S or S' is the negation of the fixity of certain attributes (properties) fixed (affirmed) in S. (1)

From (1), it follows that a statement formulated in the negative form does not have an unambiguous truth value. Thus, an axiom or postulate cannot be formulated in the form of logical negation, as logical negation does not involve an unambiguous fixity of axiomatic principles accepted as true by definition or consensus.

1.5 A Category of Ambiguity

Every object has two aspects: quantitative and qualitative. These aspects are interconnected. The qualitative aspect of an object is quantitatively measurable, representing an actual quantity. The *qualities* of an object are manifested in its actual (fixed) *attributes*. Therefore, the actual attribute of an object is the correspondence of a specific property (quality) of the object to its specific quantitative content. If certainty in the quantitative aspect of the object "disappears", correspondingly, the certainty of the qualitative aspect of the object "disappears" as well. The "disappearance" of certainty in the quantitative aspect of the object entails the "disappearance" of measurability of this aspect, meaning that the qualitative aspect of the object also becomes "unmeasurable".

The unmeasurability of something means that it cannot be measured *unambiguously* and does not have an *unambiguous* quantitative fixity (and, accordingly, a fixed qualitative attributivity). Thus, the qualitative *attributivity* of an object reflects the *unambiguous measurability of its quantitative aspect*. If in the quantitative aspect, an object cannot be measured unambiguously, that is, becomes *quantitatively ambiguous*, then the *qualitative attributivity of the object also becomes ambiguous*.

Thus, the *ambiguity of the attributivity* of an object means *ambiguity in its quantitative measurement*. *Measurement of quantity* is the *fixity of that quantity*; therefore, the *unmeasurability of quantity* is the *negation of its fixity*.

Thus, if there is an object *S* with attribute *a*, then the negation of this object *S'* is the negation of its attributivity *a'*. The negation of attributivity in *a'* means that in *a'* lacks the fixity of the unambiguity present in the original attributivity of *a*. In other words, the attributivity in *a'* has become ambiguous, corresponding to the ambiguous quantitative aspect of *a'*.

Thus, we introduce the category of ambiguity:

The category of ambiguity reflects the unmeasurability of the quantitative aspect of an object, phenomenon or event and is the result of a logical negation of the measurability of a given object, phenomenon or event.

Complex logic represents any object as a complex logical object in the form of a superposition of a given object and the corresponding logical negation of that object.

The superposition of an object and its logical negation constitutes an invariant equivalent to reality. Therefore, *the category of ambiguity, as an integral aspect of logical negation, is an inherent aspect of reality.*

From this conclusion, it follows that all physical constants are not absolute; each constant has its range of ambiguity.

1.6 Probabilistic Interpretation of S and $\text{Not } S$

The truth values of S (*single value*) and $\text{Not } S$ (S') (*ambiguous value*) vary within the truth value scale $0 \dots 1$ in a coordinated manner, ensuring that their combined truth value in superposition always equals 1 , making it invariant.

To illustrate the variability of truth values in the components of a superposition, let us use the example of the number π .

Invariant relation for π :

$$/ \pi + \pi' / = 1$$

In this case, $S = \pi$, $S' = \pi'$.

Suppose we assert that π , as an option, is 3.14 . Then π' as the negation of this statement represents a set with an unfixed number of elements (values): 3.141 , 3.1415 , 3.14159 , etc.

Thus, $\pi = 3.14$ (*a fixed value*), and π' , as a *non-fixed set of values* (3.141 , 3.1415 , etc. to infinity), together constitute all the variants (or variations) of the number π . In a probabilistic representation, *the sum of π and π' has an invariant value equal to 1.*

Let, for example, the statement S has the value "it is a terrier". Accordingly, the logical negation S' has the value "it is not a terrier". The latter means that S' does not contain everything but specifically negates the singularity of the terrier. Therefore, S' relates to the *set of all possible dog breeds except for the terrier*. In other words, S' is a **multi-valued** choice that includes all elements of the *set of dog breeds, excluding the "terrier" breed*.

The choice regarding the elements of *the set represented by S' is ambiguous (uncertain)*.

The probability measure of truth S is a measure of the invariance (correspondence) of a given statement to reality. Truth, as the concept of invariance in reflecting reality, has a conditioned nature, meaning it exists within real circumstances and does not exist absolutely (outside of circumstances).

1.7 Component Attributivity

Consider the act of tossing a coin. In a binary logic system, this coin toss is confined to statistically equivalent outcomes of either heads or tails, each with a probability of $1/2$. In complex logic, the process takes on a different aspect.

The coin is thrown into the air, spinning, and ultimately lands on a surface, settling in one of two fixed values: heads or tails. These fixed values, in complex logic, signify *component attributivity*.

The attributive components as *co-relative* opposite fragments inherent in a single object - the coin - align with the definition of superposition. Consequently, it can be inferred that the superposition, as represented by a coin in this instance, embodies an attribute-component relationship.

Therefore, *in complex logic, superposition is represented in two configurations: attributive negation and component-attributive negation*. In the first case, the *attributivity* of the *object* is denied, while in the second case, *attributivity* is negated *within the object*, that is, in the *componential configuration* of attributivity. In the first case, **Not S lacks an unambiguous attribution of S** ; in the second case, **Not S lacks a component-equivalent attribution of S** , that is, the attributions **within Not S** and **within S** are **not equivalent in the component configuration**.

Thus, the co-relativity of superposition has a two-format configuration: an externally-formative (inter-formative) and an internally-formative (componential). These configuration

formats of superposition constitute a procedural unity.

Indeed, superposition is a procedural amalgamation of statement S and its logical negation $Not\ S$. As a compositional structure, a statement can be negated both a composition as a whole and in any of its component parts. Since a logical statement is a formative logical object in complex logic, all categories, concepts and representations in this logic are two-formatted.

Thus, the logical objects S and $Not\ S$ are two-formatted, meaning each of them has two options: the option of "external" negation and the option of "internal" (component) negation.

Let us return to the coin toss.

While rotating in the air ($3D$ space), the coin (as a conditionally point-like object) has 3 degrees of freedom and exists in a superposition state. Upon reaching the plane of incidence, the $3D$ rotation superstate, with 3 degrees of freedom, collapses and the coin is updated in the $2D$ space with 2 degrees of freedom. The paired component state, which was superpositional in $3D$ rotation, collapses and splits into two fragments: "upper" and "lower", thereby actualizing one of the two fragments of the pair: heads or tails. These fragments of the pair are antipodes. If the upper fragment is heads, then the lower one is anti-heads (or tails), and vice versa: if the upper is tails, then the lower is anti-tails (or heads).

The fragments of the pair constitute a unified attribution inherent to the coin as an object. The rotation of a coin in the air is a superstate of component attribution with ambiguity of the component attributive choice.

Let us clarify the definition of logical negation (I) as formulated in point 1.4 (*Negation of Fixity*):

*The **negation of the fixity** of attributivity of an object **implies the negation of unambiguity** in the choice of the form of attributivity of the object, thereby **logical negation converts the unambiguity** in the choice of the form of attributivity of the object **into the format of ambiguity** of the attributive choice.*

Thus, in complex logic, a coin as a logical object has attributivity in two co-relative components: heads and tails. The aspect of a coin as a logical object with a specific component attributivity will be denoted by S , and the aspect of the logical negation of this specific component as $Not\ S$ or S' . These two aspects form a superposition

$$/S + S'/$$

This is a superposition with componential-attributive negation, where S can take one of the two componential values of attributivity: heads or tails, and $Not\ S$ (S'), as the logical negation of S , represents the ambiguity of choosing between heads and tails during the rotation of the coin.

Upon the coin's descent onto the surface, the state of ambiguity $Not\ S$ **collapses**, adopting one of the probabilistic values: heads or tails. The state S , being co-relatively opposite to the state $Not\ S$ (in accordance with the principle of co-relativity), takes a value opposite to the one that could have been fixed in the position of $Not\ S$ as a result of the collapse of ambiguity.

For instance, if the coin lands tails down (state $Not\ S$), then the state of heads is fixed in S . And vice versa. Every time the state $Not\ S$ is "lower", and the state S is correspondingly "upper".

Thus, the *collapse of superposition* signifies the *collapse of the state of logical negation: the state $Not\ S$ converts from a state of ambiguity to a state of unambiguous probabilistic choice, while remaining in a state of superposition.*

That is, the superposition changes the configuration: $Not\ S$ converts from attributive negation (external attributive configuration) to componential-attributive one (internal attributive configuration).

Mathematically, this means that the **collapse of the $Not\ S$ position alters the relationship between the probabilistic values of S and $Not\ S$ in the superposition**. Initially, these probability values are in the relation $0 < S < Not\ S < 1$, and the collapse of the $Not\ S$

ambiguity sets the relation $S = \text{Not } S = 1/2$.

Any object is *component-attributed*. The negation of a component attribute converts it into a *component anti-attribute*.

Consider the attribute $A (a1, a2, a3, \dots)$ and the anti-attribute $\text{Anti } A (\text{Anti } a1, a2, a3, \dots)$, where the component $\text{Anti } a1$ is the logical negation of the component $a1$. An attribute with homogeneous components $A (a1, a2, a3, \dots)$ is considered more stable in comparison with an anti-attribute with heterogeneous components $\text{Anti } A (\text{Anti } a1, a2, a3, \dots)$, as a structure with compatible components is more robust than a structure with conflicting (incompatible) components.

If we introduce a *category with a classification based on types of elements* - homogeneous and heterogeneous - then in this category, elements of the same type are considered equivalent, while elements of different types are not. A set with equivalent elements, according to the equivalence criterion, is equivalent to a set with a single element. A set with one element has one state option. A set with two or more elements has a greater variety of states compared to a set with one element.

The variability of a system is the ability of the system to change its state, that is, all states of the system determine its variability. The variability of a system reflects its instability. Thus, the variability of a system reflects its states, which differ in terms of the stability criterion.

Consequently, a system with heterogeneous and incompatible elements has greater variability and, accordingly, less stability relative to a system with homogeneous elements.

It should be noted that equivalence does not imply *absolute* equality; that is, equivalence is conditional within ranges of variable applicability. Within these ranges, equivalence is determined with variations of deviations, that is, variably.

The equality $A = B$ means that A is equivalent to B according to a certain criterion (or criteria), the accuracy of which corresponds to the accuracy of the equality.

If a system with *one element* is denoted as S , then a system with a larger and *indefinite number of elements* should be denoted as $\text{Not } S$. These systems are in superpositional probabilistic relation $S < \text{Not } S$, meaning the variability of $\text{Not } S$ exceeds the variability of S , which means greater *systemic* stability of S .

Thus, any object, as a fragmentarily attributive one, can contain both homogeneous (conditionally equivalent) and heterogeneous (conditionally non-equivalent) components, with the presence of anti-components. If we designate matter with anti-component presence as antimatter, then antimatter will prove to be less stable due to the conflicting interactions of heterogeneous (non-equivalent) components.

1.8 Asymmetry of superposition

In probabilistic truth values, $S < \text{Not } S$, as the probability of a single event S is less than the probability of multiple events represented by $\text{Not } S$. Thus, events S and $\text{Not } S$ are not equivalent in the probabilistic dimension; therefore, $\text{Not } S$ is an asymmetric probabilistic reflection of the state S .

The symbol S represents a certain statement with a *fixed* value. $\text{Not } S$ is the *logical negation of this fixed value* of S . Consequently, $\text{Not } S$ contains *non-fixed values*. Therefore, *the value of S , negated in $\text{Not } S$ as fixed, is contained in $\text{Not } S$ as non-fixed*. This leads to the *irreversibility* of the negation operation, signifying the impossibility of unambiguously returning the initial value of S from the operation of double negation, $\text{Not } \text{Not } S$, since the logical negation $\text{Not } S$ does not contain the initial value of S in a *fixed form*.

In other words, the initial value of S is not extracted from $\text{Not } S$ by a single-cycle procedure (double negation) due to their asymmetric variability. Extracting S from $\text{Not } S$ is thus a multi-cycle (iterative negation) procedure, as the possibility of extracting the initial value of S occurs *spontaneously*.

The inability to return the initial value of S from the logical negation operation $\text{Not } S$

through a one-cycle procedure signifies the asymmetry of the logical negation operation.

Thus, *the asymmetry of logical negation is a consequence of its irreversibility.*

Indeed, if logical negation involves ambiguity (uncertainty), it is not possible to unambiguously "extract" something predetermined from that uncertainty. This can be illustrated with the following example.

From a closed box with numbered balls, it is not possible to extract balls predeterminedly with specific numbers. Pulling out a ball with a specific number is a game of chance with a certain probability (in the case of a fixed number of balls in the box). The possibility of occasionally drawing predetermined balls represents realized (or actualized) randomness.

Thus, the double negation *Not Not S* does not predeterminedly return the initial value of *S*, which can be expressed as *Not Not S* \neq *S* or $(S)'\neq S$ or $S''\neq S$.

The asymmetry between positions *S* and *Not S* implies the asymmetry of superposition. Superposition is a manifestation of the principle of co-relativity. Therefore, *asymmetry is a consequence of the principle of co-relativity.*

The principle of co-relativity reflects the dual (two-format) nature of reality; therefore, the nature of reality is fundamentally asymmetric.

Asymmetry is the negation of symmetry in accordance with the principle of co-relativity. That is, asymmetry and symmetry manifest superpositionally. Since asymmetry is inherent in *Not S*, the negation of the object *S*, symmetry is therefore inherent in the object *S* (matter). Consequently, symmetry as a concept of structural invariance of an object (system) in transformational translations is an intrinsic property of matter, reflecting its internal (component) interdependence. This internal interdependence of attributive matter is twofold: co-relative and relative. In the co-relative interdependence of the components of attributive matter, asymmetry predominates in the form of *attributive antisymmetry*. This co-relativity of matter components manifests itself as the superposition of attributive positions: *A* and *Anti A*. *Both positions A and Anti A are attributive*, meaning they have attributive fixity inherent to the corresponding co-relative components.

Regarding some components, objects can be component-identical, while, regarding other components, objects can be component-co-relative, that is, superpositional. As an example, one can consider the electron and positron, having attributively co-relative (asymmetric) positions with respect to certain properties (components), such as charge. Regarding other attributive positions, the electron and positron are componentially equivalent.

One should draw a distinction between the concepts of *co-relativity* and *relativity* in the logical aspect.

Co-relativity is a substantive (essential) relationship between objects, while relativity is considered as a relation (interaction) between the actual forms of objects. In other words, *co-relativity emphasizes the substantive or essential relationship between objects, represented as logical entities*, and *relativity emphasizes the relationship between external forms or external relationships of objects presented as material entities.*

2 Superposition in Numerical Form

The statement *S*, as a logical representation of a certain object or phenomenon, involves the fixity or the possibility of unambiguous fixity of various aspects of *attributivity* of *S*. In the logical negation of *S'*, this fixity or the possibility of unambiguous fixity of attributivity of *S* is negated.

Thus, to denote *S*, we will use the symbol *a* (indicating the option of attributivity), and for *S'*, respectively, Δa , where the symbol Δ (delta) denotes a range of ambiguity in the values of *a*, since logical negation converts the unambiguity of *S* into the ambiguity of *S'*.

The superposition $/ S + S' /$ in this case takes the form $/ a + \Delta a /$ and consists of two parts: the fixed part *a*, which has a quantitative measurement in real numbers, and the non-fixed part Δa , which does not have a measurement in real numbers (but has the possibility of such

an option).

Let us represent the superposition as a complex logical object in the form of a complex number in algebraic notation: $a + b * i$,

where a is a real number, b is a real number, $*$ denotes multiplication, and i is the imaginary unit defined by the relation $i^2 = -1$.

The algebraic form of logical superposition is not the sole mathematical representation. The numerical representation of superposition is defined by the correspondence of the logical content to the mathematical form as a complex of real and imaginary parts.

3 Zero and Infinity in the Category of Ambiguity

Zero and infinity, as mathematical concepts, signify the *absence of a fixed quantity*. The former denotes the absence of any quantity, while the latter represents the absence of a limit to quantity. It is impossible to establish a minimum numerical value beyond which absolute zero follows or a maximum numerical value that concludes in infinity.

Conceptually, zero and infinity signify, in one case, the idea of an *infinite decrease* in quantity, and in the other, the idea of an *infinite increase* in quantity. They represent the concept of a process of changes in quantity, presented in opposite directions.

From the definition of logical negation (1), it follows that the result of logical negation is the non-fixity of attributivity, meaning the absence of its unambiguous measurability. The absence of measurability is synonymous with the ambiguity of measurability.

Zero and infinity lack fixed numerical boundaries; they are not unambiguously measurable. Consequently, they are ambiguous. Therefore, due to the non-fixability (ambiguity) of limiting numerical values, zero and infinity are equivalent in the category of ambiguity. If infinity represents the ambiguity of the presence of a maximally limiting value, then zero represents the ambiguity of the presence of a minimally limiting value.

The concepts of zero and infinity reflect the quantitative continuity of matter as an unbounded essence.

Regardless of how minimal the quantity is, it does not alter the qualitative characteristic of zero as an endless process of minimizing quantity. Similarly, no matter how maximum the quantity is, it does not alter the qualitative characteristic of infinity as an endless process of maximizing quantity.

Hence, the concepts of zero and infinity are qualified as processually equivalent in the category of ambiguity. In other words, zero as a process and infinity as a process are equivalent in the classification within the category of ambiguity.

This equivalence reflects that matter, defined by having no fixed boundaries or interruptions, is inherently processually continuous. That is, ambiguity is a condition for the continuity of matter (reality).

In accordance with the principle of co-relativity, ambiguity and unambiguity are co-relative concepts: unambiguity exists within certain (fixed) limits, while ambiguity extends beyond these limits, negating the boundaries of unambiguity.

As noted in point 1.3, *the Principle of Co-relativity* posits that the nature of reality is two-format.

This dual-format nature manifests in all aspects of reality representation. In this case, it is confirmed in the category of ambiguity (or uncertainty), revealing the two-format nature in the equivalent ambiguity of zero and infinity.

Thus, ambiguity (or uncertainty) is two-format.

4 Two Formats of Matter

Following the principle of co-relativity, it can be concluded that in complex logic all categories are positioned co-relative to their logical negation. Now, let us establish the invariance relation for the superposition of the category of matter:

$$/ M + \text{Not } M / = 1$$

where M is a symbolic representation of the category of matter.

In this case, the symbol M represents the attributively fixed form of matter. As follows from the definition of logical negation, $\text{Not } M$ represents the negation of attributive fixity in the classification of the category of matter. Thus, $\text{Not } M$ is in the form of ambiguity, indicating that the category of matter has two formats: the attributive format, or attributively fixed, and the non-attributive format, or attributively non-fixed. More precisely, the non-attributive format lacks unambiguous fixity, unlike the attributive format (which has unambiguous fixity). In other words, considering the probabilistic nature of reality, we can infer that the category of matter exists in two format options: attributive and non-attributive. The attributive option has fixity of properties (parameters) of material objects, while the non-attributive option lacks fixity of properties (parameters) of material objects.

The non-fixity of an object's attribute in the actual form (i.e., the lack of unambiguous measurement of the object's property) reflects the probability of non-fixable attributivity.

An object in a superposition exists in two formats: attributive and non-attributive. Therefore, an object has attributive measurement if there is a certain minimum measure of attributivity (minimally limiting measure of attributability) sufficient for such measurement.

5 Category of Space

Let us formulate the invariance relation for the superposition of the category of space, considering its three-dimensionality:

$$/ 3D \text{ Space} + \text{Not } 3D \text{ Space} / = 1$$

where $\text{Not } 3D \text{ Space}$ represents the logical negation of $3D \text{ Space}$, i.e., the three-dimensional space of the Universe.

The logical negation $\text{Not } 3D \text{ Space}$, by definition, is the negation of the fixed nature of space as three-dimensional. As follows from the category of ambiguity, logical negation means that the dimension of space in the $\text{Not } 3D \text{ Space}$ format does not have an unambiguous fixity.

Therefore, the $\text{Not } 3D \text{ Space}$ format represents spaces of multiple dimensions. Since the $\text{Not } 3D \text{ Space}$ format lacks unambiguous fixity, it implies an indefinite number of spaces with various dimensions. More precisely, spaces of various dimensions form a set with an unfixed number of multidimensional spaces (elements of the set).

Non-fixed quantity means the absence of quantitative restrictions. The inability to fix the number of spaces in the $\text{Not } 3D \text{ Space}$ format is equivalent to the mathematical concept of infinity within the category of ambiguity. Infinity and zero also have equivalent ambiguity. Hence, within the category of ambiguity, the $\text{Not } 3D \text{ Space}$ format is equivalent to the representation of space with "zero" dimensionality.

Thus, the logical negation $\text{Not } 3D \text{ Space}$ is equivalent to the format of space with "zero" dimensionality. In this format, definitions of motion trajectory and distances are nonexistent. The speed of interactions is indeterminately infinite, i.e., instantaneous. From this, it also follows that interactions in the "zero" format of space, corresponding to the non-attributive format of matter, are non-deterministic or ambiguously deterministic. Ambiguous determinism means that determinism is present, but is spontaneous, lacking fixed characteristics. Spontaneity is due to the fact that in the category of ambiguity, the multi-dimensionality of space is equivalent to the zero dimensionality of space. The multi-dimensionality of space determines multi-temporal determinism, because each n -dimensional space has its own time component. Otherwise, two different dimensional spaces would merge into a single space.

This multi-temporal determinism in the format of zero space manifests itself as spontaneity (spontaneous determinism).

Therefore, spontaneity as a qualifying characteristic of the category of time is determined by the category of space. This conclusion reflects the inextricable relationship (entanglement

or cohesion) between the categories of space and time. It means that space and time together constitute a single spacetime category. In other words, space and time form an inseparable spacetime continuum, where time is the temporal dimension of space and is determined by space.

The speed of light, representing a constant, is the maximum speed of interaction propagation in the attributive format of matter. In the non-attributive format of matter, the propagation of interactions is represented as instantaneous. This representation is not contradictory because the non-attributive format of matter is characterized by "zero" dimension of space. In this format, there is no definition of distance. In mathematical terms, distances are considered equivalent to zero. Zero distance is covered instantly at any speed, especially at the speed of light. Thus, the speed of light as a fundamental constant is unchanged in both formats of matter.

As a result of considering the category of space, we can reasonably assume that reality is represented by attributive Universe and non-attributive Multiverse. Our Universe has a stable minimum dimensional *3D Space* co-relative to Multiverse, consisting of unstable multidimensional spaces. Unstable multidimensional spaces, each with its own time course, are categorically equivalent to zero space with spontaneous time component.

The instability of multidimensional spaces as Multiverse has consequences noted in section *Attributive Format of Matter*.

6 Category of Time

The invariance relation for the superposition of the category of time is represented by:

$$/ T + \text{Not } T / = 1$$

where T is the symbol for the category of time.

The irreversibility of the logical negation operation results in three consequences for the category of time.

1. Time functions as a negation operator, demonstrating equivalence in irreversibility with the logical negation operation.
2. Time exhibits a unidirectional nature due to its irreversibility.
3. The irreversibility is a consequence of ambiguity, and within the category of time, ambiguity corresponds to the spontaneity of the passage of time.

It should be noted that the logical negation of an object as the negation of its fixity presupposes the possibility of spontaneous changes in the object. Indeed, the object is included in the time continuum, meaning that changes in the object occur continuously. Continuity of change implies that an object, while retaining its identity, is simultaneously undergoing continuous transformation.

Thus, time in the classification of the category of ambiguity manifests itself in the form of spontaneity of the passage of time. The full manifestation of the spontaneity of the passage of time occurs in the non-attributive format of matter.

In the attributive format of matter, the passage of time is fixedly stable. The format of attribute fixity assumes component fixation. The component nature in the category of time (in the attributive format of matter) manifests itself as the *option* of uneven progression of time in *specific* local circumstances. The unevenness of the passage of time refers to the uneven fixity of time intervals. It is important to distinguish the unevenness of the passage of time from the spontaneity of the passage of time, as spontaneity lacks the attribute of fixity. This is the difference between the uneven passage of time and the spontaneous passage of time.

Considering the above, let us clarify the category of ambiguity in relation to time:

The ambiguity of measurability arises from the instability of unambiguity. The instability of unambiguity in relation to time means that the passage of time has the character of

*spontaneity (in non-attributive format of matter) and the **option** of uneven progression of time (in **specific** circumstances of the attributive format of matter).*

Analyzing the category of ambiguity in the categories of space and time reveals *two aspects*: quantitative ambiguity (*unfixability of quantity*) and qualitative ambiguity (*unfixability of quality* as a consequence of spontaneity in the quantitative aspect). Spontaneity in relation to time manifests itself as the indeterminacy of time.

Time is characterized by both continuity and discontinuity, or continuous quantization. In the attributive format of matter with fixed circumstances, the passage of time is fixed and unambiguous. In the non-attributive format of matter with unfixed circumstances, time manifests itself as unfixed, exhibiting spontaneity. The transition from fixability to non-fixability and vice versa in relation to time is characterized by both continuity and discontinuity. This means that quantization of time does not have a fixed or ultimate minimum. All limiting values in relation to time seem to possess spontaneity, characterized by a spontaneous fixity. The spontaneity of time is a condition for the continuity of reality and matter.

In addition, it should be added that the unidirectionality of time (arrow of time) follows from the concept of the continuum of reality (discussed in the next section).

If time had more than one *fixed* direction, then the "point of divergence" of time would determine the "break" in the continuum of reality. However, the spontaneity of time makes such a "point" unfixable, meaning it lacks *continuous* fixation. Time reversal is possible as spontaneous and local (due to the unity of space-time). The possibility of the reverse course of time (in spontaneous locality) is a negation, as an absolute truth, of the absolute fixation of the arrow of time.

The category of time, like all other categories, exists in two formats.

7 Continuum Concept

Reality forms a continuum or continuity in the sense that reality does not have "disconnections" in the form of "breaks", "holes" or "voids".

The continuum, as the continuity of reality, implies an unbroken interconnection of possible attributive options in the non-attributive format of matter. The continuum of reality is represented as the *continuum of attributive options* or the *continuum of optional attributivity* (abbreviated as the *optional continuum*). Each discrete option of attributivity represents the possibility of actualizing attributivity in some form. In the non-attributive format, this option exists in an ambiguous state, forming a continuum concatenation.

The ambiguity of the passage of time, as follows from the category of time, is manifested in its spontaneity. The spontaneous passage of time, combined with the continuity of the option continuum, realizes the possibility of choosing one or another option for the development of events. The spontaneity of time (in the non-attributive format of matter) actualizes one or another option of attributivity from the optional continuum.

The spontaneity of time discretizes the option continuum, actualizing one or another attributivity option. Therefore, the spontaneity of the passage of time, as a reflection of its ambiguity, is manifested in its discreteness. The discreteness of time means its quantization. Since the ambiguity of the nature of time is manifested in its spontaneity, unambiguously measuring or representing the minimum quantum of time seems impossible due to the instability and non-repeatability of such unambiguity.

The actualization of attributivity in the option continuum can be interpreted by analogy with photographs "cut" from a video footage. Video recording represents a continuous stream of snapshots that are not individually fixed within the video stream. It is a kind of continuum, meaning the video is presented as a single (indivisible) whole.

At the same time, this video sequence can be "quantized" - selecting pictures with the shortest possible periods of time. These photos will represent a sampling of the video, meaning they will create a continuous series of photos. Thus, each photograph represents a

minimal component of the video sequence, but has no separate relevance in the video stream, since it is not uniquely distinguished from this stream of photographs. In this sense, video appears as the ambiguity (connectedness) of photographs - a kind of continuum of options, where each option implies certain photograph or photographs.

Photographs with their attributes (signs) constitute a streaming video, corresponding, by analogy, to the attributive format of matter. In this format, photographs can be compiled in any order to create photo books and albums (photo genres), forming structured attributive forms (systems) that possess both their own and component attributivity.

If each photograph is fragmented into small pieces and all the fragments are placed in a container, then the content of the container would represent a non-attributive format of video (analogous to the non-attributive format of matter).

Indeed, an individual fragment of a photograph does not represent the entire photo, but only a part of it; that is, it appears to be a fragment of the photograph's attribute. As fragmentary parts of a complete photograph, these photographic fragments represent its attributive options. Assembling a complete photo from these fragments can only be achieved through a process of selection and arrangement. That is, the process of creating any full-length photograph is variable, ambiguous, and spontaneous, involving a different number of time steps (cycles) for each photo.

Thus, time in the non-attributive format of matter reveals the nature of ambiguity in the form of spontaneity. The spontaneity of time is an expression of its discreteness, or quantization. That is, time is inherently spontaneously discrete (spontaneously quantized). The discreteness of time triggers the actualization of the spontaneously selected attributive option. In other words, time interrupts the continuum of ambiguity and actualizes a certain option of attributivity (or quantum of attributivity). Attributivity is an expression of unambiguity. Therefore, the spontaneity of time converts the format of ambiguous attributivity into the format of unambiguous attributivity. Mathematically, this implies that the product of two ambiguities - the spontaneity of time and the ambiguity of matter - is equivalent to unambiguity. Considering the ambiguities (or uncertainties) from different "origins" are categorically equivalent, the uncertainty to the second power (i.e., squared) is equivalent to unambiguity. Thus, the product of two ambiguities is transformed into unambiguity through a process of "merging and mutual absorption".

Conclusion:

The Product of Two Ambiguities (Uncertainties) is Equivalent to Minimum Unambiguity (Certainty).

Or: The product of two Ambiguities is Unambiguous.

This conclusion from complex logic corresponds to the principle of uncertainty in quantum physics.

The ambiguity of time in the non-attributive format of matter manifests itself in spontaneous discreteness. The spontaneous discreteness of time converts the ambiguities of the non-attributive format of matter into the unambiguity of the attributive format, quantifying the format of ambiguity into the format of unambiguity, acting as negation operator (or format reformatting operator).

Discreteness and non-discreteness, or discontinuity and continuity, are in superposition (entanglement). The consequence of such entanglement is the discrete spontaneity of time. This manifests in the entanglement of quantum objects, where their quantum states are *co-relatively (superpositionally)* entangled.

By definition, a continuum is continuous. This means that the continuum is not interrupted under any circumstances. The uninterrupted nature of a continuum implies the impossibility of its disruption. The impossibility of breaking the continuum, in turn, means that there is no fixed possibility of interrupting the continuum. That is, any interruptibility of the continuum is an ambiguous (uncertain or unfixable) possibility.

The continuity of the continuum is explained by the absence of fixity of the minimal discreteness of matter. This is possible under the condition that the minimum discrete states of matter do not create interruptions in matter, in the sense that they do not establish an *absolute minimum* as a limit to the presence of matter. This means that the minimal discreteness of matter does not have an unambiguous fixity (as a stationary state). The minimal fixations of matter are ambiguous, manifesting as the continuity of matter.

Thus, ambiguity is an inherent aspect of the continuity of matter and reality.

The continuum manifests the duality of its nature: the continuity in defining the continuum is a discontinuity that lacks stationary fixity.

Therefore, the concept of continuum is a superposition of discontinuity and continuity. The discrete discontinuity within the continuum does not disrupt its continuity, as it is *not fixed* or defined on a minimal scale.

As a complex logical object in the form of a superposition of discontinuity and continuity (or discreteness and non-discreteness), the concept of continuum is invariant to reality.

Indeed, the superposition of object *A* is always true or invariant. The reality of object *A* is represented by continuous series of superpositions, when one superposition of object *A* continuously becomes the next. Any operations involving invariance, whether addition or multiplication, are also invariant. Therefore, the object is a process that is invariant to reality.

If object *A* is in a position or state with probability $P(A)$, determined by the relation $0 < P(A) < 1$, this means:

The object has a continuum of possibilities. Fixation of the true state of the object is expressed by a fractional probability value, meaning the object is fixed processually.

The processual fixability of an object (matter) is created by the total interconnectedness of matter. Matter in the format of total interconnectedness forms a network of total entanglement, representing a continuum. Thus, the object (matter) is in a state of probabilistic entanglement. In this case, the *probabilistic values* of finding the object (matter) in one state or another are *processual values*. These values are inseparable from each other and are in a *processual state within the continuum* (superstate).

We consider ambiguity in the non-attributive format of matter. Since ambiguity has a procedural aspect, therefore, the non-attributive format is a procedural format. Matter in the non-attributive format is in a superstate, characterized by ambiguity in the parametric characteristics (signs) of matter.

Thus, an object (matter) is a process, and:

1. The object does not vanish because $P(A) \neq 0$.
2. The object does not leave the process of interactions (does not assume a constant state), because $P(A) \neq 1$.

Therefore, an object as matter is indestructible. The indestructibility of matter means that matter does not leave the process of interactions. The process of interactions has no interruptions or stops. The latter means that the process of interactions in matter forms a continuum of matter and reality.

Matter is indestructible as a processual essence, meaning it exists in a continuous process of transformation. Thus, matter exists as a *continuum of processes*. That is, processuality and continuity (uninterruptedness) are equivalently interrelated concepts. Processuality is continual, i.e., uninterrupted, and continuity is processual, i.e., unbroken.

8 The Concept of Determinism

The speed of light in a vacuum is the ultimate speed of interactions in the attributive format of matter. Interactions in this format of matter have a cause-and-effect nature, meaning they are deterministic. Exceeding the ultimate speed of interactions implies that interactions in matter become non-deterministic, and the format of matter becomes non-attributive. Thus, the meaning of the speed of light in a vacuum as a fundamental constant is that it is the

limiting speed of determinism in matter - namely, the ultimate speed of *fixation* of the attributive features of matter.

The attribute *A* of an object cannot be present in the attribute *B* of another object with probability $P = 1$ because, in this case, it would be the same object. That is, the attribute *A* is part of the attribute *B* with a probability $P < 1$. This represents an option (possibility) of attribute *A* within attribute *B*. The variability of matter in this case represents the multiplicity of probabilistic values of option *A*. With a vanishingly low probability of any attributivity, it is impossible to measure (fixate) the attributivity. However, this attributivity is nevertheless present in an ambiguous (non-fixable) format, that is, in the format of attributive ambiguity. The presence of an attributive option of one object in the attribute of another object is equivalent to the presence of the objects themselves within each other.

Matter reveals the interconnectedness (entanglement) of various forms and structures, manifesting as the interdependence of states of matter.

Matter is two-format. A possibility in the attributive format (state of unambiguous measurability) is realized deterministically, while in the non-attributive format (state of ambiguity), it is realized non-deterministically.

As noted in the *Category of Ambiguity*, the "disappearance" of the certainty of the quantitative aspect of an object is the "disappearance" of measurability of that aspect. This implies that the qualitative aspect of the object has also become "unmeasurable".

Determinism is inherent in actual attributivity. Actuality is a measure of the probabilistic presence of an attribute, determined by the gradations of features (qualities) of that attribute. Quality (features) manifests itself as a quantitative gradation. Quantity as a category has fixed and non-fixed values. Thus, determinism is determined by gradations that have quantitative unambiguity or fixity of some attributivity. Indeterminism does not have such unambiguity, meaning it reflects the quantitative ambiguity of attributivity.

That way the concept of determinism shows its two-format nature.

9 The Attributive Format of Matter

In the context of matter, attributivity or the attributive format of matter is stable due to two factors: the fixed discreteness of matter and the ultimate speed of interactions. If attributivity was not discrete, it would represent an indivisible continuum. At instantaneous speed of interactions, all matter would also be "entangled" into an indivisible continuum.

The attributivity of matter begins with the minimal discreteness of matter as quantum discreteness, that is, it has two states: actual and non-actual. The term "actual" is relevant to the phrase "having actual or stabilized attributivity" and in this context means "unambiguity (stability) of acts (tacts) in the course of time". Spontaneous time is discretized by quantum acts that form stabilized clock series as a quantum timeline.

From the connectedness of space and time into a single space-time continuum, it follows that the birth of matter quanta manifests itself as a discretization of the space-time continuum. Space is discretized in the smallest possible form with relevant time discretization; these forms of space-time quantization, as minimal ones, do not have fractionality (divisibility), thus constituting a quantum increment of attributivity.

Imagine, as an example, a virtual chain with links of various formats. To tear out any link that is interconnected from all sides - if these sides are countless (unmeasurable) - seems incredible. However, a link, at some point in time having the minimum number of couplings (in our view, as if located on the edge) represents an option with the maximum possibility (probability) of separation. The minimum number of connections in the spontaneous (non-fixed) nature of connections is equivalent to zero connections, as the minimum and non-fixed quantities have a single point of intersection - zero.

The category of ambiguity manifests as a necessary and sufficient condition for the actualization of the attributive format of matter. It is the ambiguity of space-time that gives

rise to the quantum nature of the attributivity of matter. In this aspect, the category of ambiguity reflects the fundamental nature of reality.

Space in the non-attributive format appears to be multi-dimensional. The spontaneity of time discretizes (quantizes) multidimensional spaces down to the minimum-dimensional space ($3D$ space), which has no possibility to further decompose, as the minimum is not further divided. Note that $3D$ space has corresponding spatial component parts (internal component structure): $2D$ plane, $1D$ line, $0D$ point.

If multidimensional space decomposes into the minimal $3D$ space, what are the consequences?

Since $3D$ space is stable, the spontaneous collapses of multidimensional spaces into $3D$ space lead to the "adding" of space of this minimal format. Since the collapses are spontaneous, this process ultimately does not have a constant speed, meaning it occurs at a variable rate or with an acceleration, which also appears as a non-constant quantity on cosmological time scales. Therefore, the $3D$ space of our Universe expands with variable acceleration.

The two-format nature of matter constitutes the invariant unity of reality. The unity of reality and matter means that the two formats of matter interact.

It is reasonable to assume that the observed cosmological phenomena in our Universe, explained by the effects of dark energy and dark matter, might be a consequence of such two-format interaction of matter. As inter-format interaction, this applies to the scale of the entire Universe.

10 Final Provisions

Complex logic begins with the principle of co-relativity, positioning any statement (logical object) co-relative to its logical negation. The co-relativity of a statement and its logical negation represents superpositional unity in the form of a complex logical object - a superposition - with invariant truth value, reflecting its logical equivalence to reality.

Logical superposition "entangles" the positions S and $Not S$ into a superstate of processual simultaneity. Processuality is a defining feature of the continuum's continuity. Thus, the semantic meaning of the concept of logical superposition reflects the continuity of matter and reality. It follows from this that any aspect of reality is superpositional (or co-relatively two-format).

It should be noted that the continuity or unbroken nature of reality means that it is impossible to "insert" another reality into this one. Therefore, there is no other reality. That is, reality is invariant and has the nature of processual continuity, which determines the inexhaustibility of matter and reality.

Furthermore, the inexhaustibility of matter stems from the impossibility of absolute truth as the "zero" reality (point 1.1), reflecting the impossibility of probabilistic truth values in logical statement S to take the zero value ($S \neq 0$). This means that in the nature of reality, there is nothing *absolutely* impossible that would not be conditioned by specific circumstances. Therefore, any other versions of reality become superfluous.