

# The Ultimate External Reality

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## Abstract

Since ancient time our perception of the ultimate external reality evolves as our investigation produces more knowledge by expanding the related disciplines. This phenomenon is illustrated by our vision of space and time, while they were treated separately in antiquity and subsequent ages, they are unified into a continuum in modern time. Further more, the theoretical possibility of parallel universes with more than one time dimension are considered in the present age. In this paper, a theory is developed to precisely treat reality along with its associated concepts that arise from the modern scientific investigations. This treatment contributes to a quotient set of realities with five equivalence classes and a qualitative measurement of our current ultimate external reality with its possible evolution based on the related scientific theories and their consequences.

## I INTRODUCTION

The ultimate external reality<sup>1</sup> is a relativistic concept which depends on the intellectual status (the collection of ideas, traditions and beliefs) of the observer, so the ultimate external reality has evolved from the simple paradigms of ancient civilizations through the Aristotelian and Copernican paradigms to our current parallel universes and multiverses perceptions. In this monograph, we will measure our ultimate external reality<sup>2</sup>, so after elaborating on the nature of the reality in section II, we will discuss the completeness and abstraction of our ultimate external reality in section III and IV. In section V we will measure the correctness distribution of the candidate types of our reality.

## II THE MATHEMATICAL NATURE OF REALITY

Reality is a set<sup>3</sup> of entities with relations between them and relative natures with respect to an observer, so we will define the reality to be the ordered triple  $(\mathbb{E}, \sigma, \rho)$ , where  $\mathbb{E}$  is a set of entities,  $\sigma$  is their sense relation<sup>4</sup>

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<sup>1</sup>In this paper, the ultimate external reality is not restricted to the experienced reality by a given observer or a group of observers. However, it is extended to any reality which is believed to exist by an observer or a group of observers based on rational reasoning. We will refer to the ultimate external reality by the acronym UER.

<sup>2</sup>The ultimate external reality as it is perceived currently by the supreme representatives of the related scientific community will be referred to as our ultimate external reality.

<sup>3</sup>The set, in this paper, is defined as a collection of intellectually isolated elements which allows duplications (multiset).

<sup>4</sup>The sense relation is a mapping from  $\mathbb{E}$  to  $\mathbb{E}$ , so it is a set of ordered pairs where the first component of each pair represents an entity and the second represents its nature hence it is included in the Cartesian product  $\mathbb{E} \times \mathbb{E}$ .

and  $\rho$  is the set of all relations between them<sup>5</sup>. Suppose that  $\mathcal{R}_1, \mathcal{R}_2, \dots, \mathcal{R}_i, \dots, \mathcal{R}_n$  are a collection of realities then we define their union to be:

$$\bigcup_{i=1}^n \mathcal{R}_i = \mathcal{R}_\tau = (\mathbb{E}_\tau, \sigma_\tau, \rho_\tau) \quad (1)$$

where

$$\mathbb{E}_\tau = \bigcup_{i=1}^n \mathbb{E}_i, \quad \sigma_\tau = \bigcup_{i=1}^n \sigma_i \quad \text{and} \quad \rho_\tau = \bigcup_{i=1}^n \rho_i \quad (2)$$

hence the union of a collection of realities is again a reality and further more any set of realities is also a reality since the underlying intellectual isolative attributes for all realities are the same<sup>6</sup>. A reality  $\mathcal{R} = (\mathbb{E}, \sigma, \rho)$  is said to be “abstract” or “complete”, respectively, if it satisfies the following conditions:

$$\sigma = \mathbb{E}^2 \quad \text{or} \quad \rho = \mathbb{E}^3 \quad (3)$$

If the reality is both abstract and complete then it is called “perfect reality”, so if  $\mathbb{E}$  is a set of entities then, by definition, its perfect reality  $\mathcal{R}_\pi$ <sup>7</sup> will be:

$$\mathcal{R}_\pi = (\mathbb{E}, \mathbb{E}^2, \mathbb{E}^3) \quad (4)$$

If a reality is not abstract but complete, we call it “semi-perfect reality” and if it is abstract but not complete, it is said to be “semi-deficient reality”. However,

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<sup>5</sup> $\rho$  is a collection of binary relations (any higher order relation can be reduced to a binary relation), so each of its element is a mapping from  $\mathbb{E}^2$  to  $\mathbb{E}$  and hence it is a subset of the Cartesian product  $\mathbb{E} \times \mathbb{E} \times \mathbb{E}$ .

<sup>6</sup>If a set consists of elements that have the same intellectual isolation (the common attribute) then forming a new set by grouping these elements into distinct sets does not change the original set.

<sup>7</sup>In this paper, we use the subscript Greek letter  $\pi$  to denote the perfect reality.

if it is neither abstract nor complete, it will be dubbed “deficient reality”. A reality  $\mathcal{R}$  which consists of a set of realities is said to be “closed” if there exists a subset  $A = \{\mathcal{R}_1, \mathcal{R}_2, \dots, \mathcal{R}_n\}$  of this set with cardinality<sup>8</sup> 2 or more so that<sup>9</sup>:

$$\forall e_1, e_2, e_3 \in \mathcal{R} \exists \mathcal{R}_i, \mathcal{R}_k \in A \quad (5)$$

such that

$$(e_1, e_2) \in \mathcal{R}_i \text{ and } (e_1, e_2, e_3) \in \mathcal{R}_k \quad (6)$$

**Theorem II.1.** *A reality is closed if and only if it is perfect.*

*Proof.* Suppose that  $\mathcal{R} = \{\mathcal{R}_1, \mathcal{R}_2, \mathcal{R}_3, \dots, \mathcal{R}_n\}$  is a reality, so by definition we have:

$$\mathbb{E} = \bigcup_{i=1}^n \mathbb{E}_i, \quad \sigma = \bigcup_{i=1}^n \sigma_i \text{ and } \rho = \bigcup_{i=1}^n \rho_i \quad (7)$$

but since  $\mathcal{R}$  is closed, for any arbitrary entities  $e_1$  and  $e_2 \in \mathcal{R}$ , we would have  $(e_1, e_2) \in \mathcal{R}$  and further more there must be an entity  $e_3 \in \mathcal{R}$  such that  $(e_1, e_2, e_3) \in \mathcal{R}$  and hence  $\mathcal{R}$  is perfect. On the other hand, if we suppose that  $\mathcal{R}$  is a perfect reality and assume that  $\mathcal{R} = \mathcal{R}_i = \mathcal{R}_k$  then the closeness conditions are satisfied by definition.  $\square$

If only the second condition [i.e.  $(e_1, e_2, e_3) \in \mathcal{R}_k$ ] of closeness is satisfied, we call the reality “semi-closed”. However, if only the first condition [i.e.  $(e_1, e_2) \in \mathcal{R}_i$ ] is satisfied, the relating reality is called “semi-open”, but if both of them are not satisfied the reality will be designated as “open reality”.

**Corollary II.1.1.** *A reality is semi-closed, semi-open or open if and only if it is semi-perfect, semi-deficient or deficient, respectively.*

*Proof.* If we assume that a given reality is semi-closed or semi-open then the related property (either completeness or abstraction) will follow from the first part of the proof of the previous theorem. However, if the reality is open both properties will not be satisfied (by the same part of the proof). The reverse direction can be proven similarly by the second part of the proof of the previous theorem.  $\square$

If  $\mathcal{R}_1$  and  $\mathcal{R}_2$  are two realities, we say that they are “joint” if one of the following conditions is satisfied:

$$\mathbb{E}_1 \cap \mathbb{E}_2 \neq \emptyset, \quad \sigma_1 \cap \sigma_2 \neq \emptyset \text{ or } \rho_1 \cap \rho_2 \neq \emptyset \quad (8)$$

If two realities are not joint then they are “disjoint”. If we have two realities  $\mathcal{R}_1$  and  $\mathcal{R}_2$  that are joint and if  $A = \{e_1, (e_1, e_2), (e_1, e_2, e_3)\}$  is any arbitrary set of an entity, nature and relation such that:

$$A \in \mathcal{R}_1 \Rightarrow A \in \mathcal{R}_2 \quad (9)$$

<sup>8</sup>We will refer to the cardinality of a set or reality using the vertical lines  $| \cdot |$ , so the cardinality of  $A$  is  $|A| = n$ .

<sup>9</sup>If  $\mathcal{R} = (\mathbb{E}, \sigma, \rho)$  is a reality such that  $e_1 \in \mathbb{E}$ ,  $(e_1, e_2) \in \sigma$  and  $(e_1, e_2, e_3) \in \rho$  then we say  $e_1, (e_1, e_2)$  and  $(e_1, e_2, e_3) \in \mathcal{R}$ .

then we say that  $\mathcal{R}_1$  is included in  $\mathcal{R}_2$  or  $\mathcal{R}_2$  contains  $\mathcal{R}_1$  and refer to that by the notation “ $\mathcal{R}_1 \subset \mathcal{R}_2$ ”. If the reverse of the preceding implication is also hold, that is:

$$A \in \mathcal{R}_2 \Rightarrow A \in \mathcal{R}_1 \quad (10)$$

then the two realities are identical and we say “ $\mathcal{R}_1$  is equal to  $\mathcal{R}_2$ ” or symbolically “ $\mathcal{R}_1 = \mathcal{R}_2$ ”.

**Theorem II.2.** *If  $\mathcal{R}_1, \mathcal{R}_2$  and  $\mathcal{R}_\pi$  are semi-deficient, semi-perfect and perfect realities, respectively, that have the same set of entities  $\mathbb{E}$  then we have:*

$$\mathcal{R}_1 \subset \mathcal{R}_\pi \text{ and } \mathcal{R}_2 \subset \mathcal{R}_\pi \quad (11)$$

*Proof.* Since  $\mathcal{R}_1, \mathcal{R}_2$  and  $\mathcal{R}_\pi$  have the same entities  $\mathbb{E}$  then by the definition of the perfect reality we would have:

$$\sigma_1 \subset \sigma_\pi (\mathbb{E}^2) \text{ and } \rho_1 \subset \rho_\pi (\mathbb{E}^3) \quad (12)$$

and also

$$\sigma_2 \subset \sigma_\pi (\mathbb{E}^2) \text{ and } \rho_2 \subset \rho_\pi (\mathbb{E}^3) \quad (13)$$

and hence the result follows by the definition of inclusion.  $\square$

**Corollary II.2.1.** *Any deficient reality is included in a perfect reality.*

*Proof.* Since the deficient reality is incomplete, it has the property of the semi-deficient reality that entails its nature inclusion and also since it is non-abstract it possesses the aspect of the semi-perfect reality that proves its relation inclusion hence the proposition holds.  $\square$

**Corollary II.2.2.** *If  $\mathcal{R}_{\pi_1}$  and  $\mathcal{R}_{\pi_2}$  are two perfect realities such that  $\mathbb{E}_{\pi_1} \subset \mathbb{E}_{\pi_2}$  and if  $\mathcal{R}$  is any arbitrary reality then we have:*

$$\mathcal{R} \subset \mathcal{R}_{\pi_1} \Rightarrow \mathcal{R} \subset \mathcal{R}_{\pi_2} \quad (14)$$

*Proof.* Since  $\mathbb{E}_{\pi_1} \subset \mathbb{E}_{\pi_2}$ , it follows that:

$$\sigma_{\pi_1} (\mathbb{E}_{\pi_1}^2) \subset \sigma_{\pi_2} (\mathbb{E}_{\pi_2}^2) \quad (15)$$

and

$$\rho_{\pi_1} (\mathbb{E}_{\pi_1}^3) \subset \rho_{\pi_2} (\mathbb{E}_{\pi_2}^3) \quad (16)$$

so we have  $\mathcal{R}_{\pi_1} \subset \mathcal{R}_{\pi_2}$  and hence the result holds.  $\square$

Since any arbitrary non-trivial reality (consists of more than one element), by its very definition, can be decomposed into a group of realities, we refer to the image of the highest nesting level by the canonical mapping  $N$ , that preserves the decomposition order,<sup>10</sup> the frequency  $\nu$  of that reality. The level corresponds to zero is called the “reference nesting level” and any frequency below it is a “negative frequency” by definition.

<sup>10</sup>The canonical mapping  $N$  is a bijective mapping, that preserves the order of the decomposition, from the set of all nesting levels of a given reality to a subset of integer numbers  $Z$  which includes zero and with cardinality equals to the number of these levels.

**Theorem II.3.** *If  $\mathcal{R}^*$  is a non-trivial reality with cardinality  $|\mathcal{R}^*| > 1$  and non-zero frequency  $\nu$  then there exist realities  $\mathcal{R}_1$  and  $\mathcal{R}_2$  of frequencies  $\nu - 1$  and  $\nu + 1$ , respectively, such that:*

$$\mathcal{R}_1 = \mathcal{R}^* = \mathcal{R}_2 \quad (17)$$

*Proof.* From the properties of  $\mathcal{R}^*$  and since all realities have the same intellectual isolative attributes, decomposing the realities (dropping the sets indicators) in any arbitrary nesting level of the reality  $\mathcal{R}^*$  or constructing new realities by combining the realities in the that level (introducing sets indicators in it) will, respectively, produce the realities  $\mathcal{R}_1$  or  $\mathcal{R}_2$  which is the desired result.  $\square$

**Corollary II.3.1.** *Any reality  $\mathcal{R}$  with frequency  $\nu$  can be reduced to a lower frequency back to a reality of frequency zero.*

*Proof.* The decomposition process of the preceding theorem can be performed recursively starting from the highest nesting level back to an appropriate nesting level to produce a reality with the required frequency.  $\square$

**Corollary II.3.2.** *Any reality  $\mathcal{R}$  with frequency  $\nu$  can be increased to a maximum frequency equal to the cardinality of its lowest nesting level.*

*Proof.* Suppose that  $\mathcal{R}$  is the lowest nesting level of a given reality that contains  $n$  elements (realities). We can create nesting sets from these elements by including only one element in each subsequent nesting set. However, this is the maximum number of nesting sets that could be created from these elements (realities) which is equal to the cardinality of the lowest nesting level.  $\square$

Let  $\mathcal{R} = \{\mathcal{R}_1, \mathcal{R}_2, \mathcal{R}_3, \dots, \mathcal{R}_n\}$  be a sequence of realities, we define the superior reality  $\mathcal{R}_{sup}$  of this sequence (which may not be included in the sequence) as the reality of the least frequency that satisfies the following condition:

$$\mathcal{R}_1, \mathcal{R}_2, \mathcal{R}_3, \dots, \mathcal{R}_n \subset \mathcal{R}_{sup} \quad (18)$$

**Theorem II.4.** *If  $\mathcal{R}_{sup}$  is the superior reality of a set of realities  $\mathcal{R} = \{\mathcal{R}_1, \mathcal{R}_2, \dots, \mathcal{R}_i, \dots, \mathcal{R}_n\}$  and there exists another reality  $\mathcal{R}^*$  such that:*

$$\mathcal{R}_1, \mathcal{R}_2, \mathcal{R}_3, \dots, \mathcal{R}_n \subset \mathcal{R}^* \quad (19)$$

*then we would have*

$$\mathcal{R}_{sup} \subset \mathcal{R}^* \quad (20)$$

*Proof.* By the definition of the superior reality,  $\mathcal{R}_{sup}$  must have lower frequency than  $\mathcal{R}^*$  (otherwise they would be identical) and hence the result follows.  $\square$

If the reality  $\mathcal{R}_\epsilon^{11}$  is the superior reality of any sequence of realities then we call it an “elucidated reality”.

<sup>11</sup>The Greek letter  $\epsilon$  (appears as a subscript) will be used to denote the elucidated reality.

**Theorem II.5.** *The elucidated reality  $\mathcal{R}_\epsilon$  is unique.*

*Proof.* Suppose the  $\mathcal{R}_\epsilon$  and  $\mathcal{R}_\epsilon^*$  are two elucidated realities, so from their definitions (as elucidated realities) we have:

$$\mathcal{R}_\epsilon \subset \mathcal{R}_\epsilon^* \quad \text{and} \quad \mathcal{R}_\epsilon^* \subset \mathcal{R}_\epsilon \quad (21)$$

and hence

$$\mathcal{R}_\epsilon = \mathcal{R}_\epsilon^* \quad (22)$$

which is the required result.  $\square$

**Corollary II.5.1.** *The elucidated reality is abstract and complete hence it is a perfect reality.*

*Proof.* Let  $\mathbb{E}_\epsilon$  be the entity set of the elucidated reality  $\mathcal{R}_\epsilon$ , and assume that  $\mathcal{R}_\epsilon^* = \{\mathbb{E}_\epsilon, \mathbb{E}_\epsilon^2, \mathbb{E}_\epsilon^3\}$ , so if  $\mathcal{R}_\epsilon$  is non-abstract and/or incomplete then we would have:

$$\sigma_\epsilon \subset \mathbb{E}_\epsilon^2 \quad \text{and/or} \quad \rho_\epsilon \subset \mathbb{E}_\epsilon^3 \quad (23)$$

however, in any combination of these cases, we would get:

$$\mathcal{R}_\epsilon \subset \mathcal{R}_\epsilon^* \quad (24)$$

which is a contradiction by definition.  $\square$

If  $\text{Aut}(S)$  is the set of all automorphisms<sup>12</sup> on a subset  $S$  of a given reality then it constitutes a group under the operation of composition as proven in the following theorem.

**Theorem II.6.** *The set  $\text{Aut}(S)$  of all automorphisms on the set  $S$  is a group under composition.*

*Proof.* Let  $\varphi$  be an element of  $\text{Aut}(S)$  and define  $I(e) = e$  for all  $e \in S$  then it is obvious that  $I \in \text{Aut}(S)$  and we have:

$$\varphi^{-1} \circ \varphi = \varphi \circ \varphi^{-1} = I \quad \text{and} \quad I \circ \varphi = \varphi \circ I = \varphi \quad (25)$$

where  $\varphi^{-1}$  is the inverse of  $\varphi$ , but if we assume that  $\varphi_1, \varphi_2$  and  $\varphi_3 \in \text{Aut}(S)$  then from the related definitions, we would have also:

$$\varphi_1 \circ (\varphi_2 \circ \varphi_3) = (\varphi_1 \circ \varphi_2) \circ \varphi_3 \quad (26)$$

however, since the composition of any two automorphisms in  $\text{Aut}(S)$  is again an automorphism in  $\text{Aut}(S)$  then  $\text{Aut}(S)$  is closed under the operation of composition which completes the proof.  $\square$

We call  $\text{Aut}(S)$  the symmetry group of  $S$ . The action of  $\text{Aut}(S)$  on the set  $S$  is defined as the mapping  $\psi : \text{Aut}(S) \times S \rightarrow S$  such that:

$$\psi[\varphi_1, \psi(\varphi_2, e)] = \psi(\varphi_1 \circ \varphi_2, e), \quad \psi(I, e) = e \quad (27)$$

for all  $\varphi_1$  and  $\varphi_2$  in  $\text{Aut}(S)$  (where  $I$  is the identity automorphism). It is straightforward to show from the definition that the action is an equivalence relation that partitions its set into equivalence classes each of which

<sup>12</sup>The automorphism is a bijective mapping from a set to itself that preserves the relations between its elements.

we call an “orbit”. If the orbits are non-trivial (contain more than one element) then the relations between their elements (we will refer to them as the relations between the related orbits) are called the “laws” of the reality involved ( $S$  in our discussion). The higher the cardinalities of the orbits involved in a law the more general is it and the more symmetrical is the reality. If the set of all orbits  $O$  has a symmetry group  $\text{Aut}(O)$  then the action of this group on it is called a “nesting orbit” with frequency one. If this process is repeated  $n$  times, then the resulting nesting orbit is said to be an orbit with frequency  $n$ . It is obvious that the more the frequencies of the orbits the more fundamental is the law associated with them. For a given reality we call the laws between its orbits that have the highest frequencies the “fundamental laws” of that reality and the laws associated with the orbits with the second highest frequencies the “effective laws” of it. For any number  $n$  of orbits with arbitrary frequencies, the “initial condition” is defined as the  $n$ -tuple of values (a sequence of  $n$  elements) whose components have a one-to-one correspondence with these orbits.

Any nesting reality with uniform cardinality  $n$  (having the same number of realities  $n$  in each nesting level) is called a “fractal reality” with cardinality  $n$ . In a given system of nesting realities, the reference reality (the origin which is conventionally assigned a frequency of zero) is called a “parallel universe” with zero frequency (the reference parallel universe) while all the nesting realities which are below the parallel universe are called realities with negative frequencies. Any reality that consists of a set of parallel universes with identical frequencies is again a parallel universe.

**Theorem II.7.** *There are infinitely many parallel universes with all possible frequencies.*

*Proof.* Let  $\mathcal{P}_\phi$ <sup>13</sup> is the reference parallel universe then we could construct the following reality:

$$\mathcal{P}^* = \{\mathcal{P}_{\phi_1}, \mathcal{P}_{\phi_2}, \mathcal{P}_{\phi_3}, \dots, \mathcal{P}_{\phi_n}\} \quad (28)$$

so, from the definition,  $\mathcal{P}^*$  is a parallel universe with unit frequency. However, the parallel universe  $\mathcal{P}^*$  can be used to construct a parallel universe with 2 frequency. In principle, this procedure can be repeated as many time as required hence the proposition holds.  $\square$

Any isolated set of parallel universes which have the same fundamental laws, but their orbits with the highest frequencies have different initial conditions are called “alternative histories”. A collection of parallel universes with identical or distinct frequencies is called a “multiverse”.

**Corollary II.7.1.** *A multiverse that consists of parallel universes with identical frequencies is a parallel universe with higher frequency.*

<sup>13</sup>The Greek letter  $\phi$  will be used as a subscript to denote the reference parallel universe.

*Proof.* Suppose the  $\mathcal{M}$  is a multiverse with frequency<sup>14</sup>  $\nu$  then starting from the reference parallel universe, the iteration mentioned in the previous theorem could be performed until the prescribed multiverse  $\mathcal{M}$  is produced.  $\square$

**Theorem II.8.** *Any set  $\mathcal{M}$  of multiverses is again a multiverse with a frequency of the multiverse in  $\mathcal{M}$  that has the highest frequency.*

*Proof.* Let  $\mathcal{M} = \{\mathcal{M}_1, \mathcal{M}_2, \mathcal{M}_3, \dots, \mathcal{M}_n\}$  be a set of multiverses, so when each of these multiverses is decomposed into its parallel universes, we would get:

$$\mathcal{M} = \{\{\mathcal{P}_1, \dots\}, \{\mathcal{P}_2, \dots\}, \{\mathcal{P}_3, \dots\}, \dots, \{\mathcal{P}_n, \dots\}\} \quad (29)$$

however, since the intellectual isolative attributes for each subset of parallel universes are the same (each of them is a reality) then we could drop the set indication and hence we will be left with  $\mathcal{M}$  consisting only of parallel universes which is, by definition, a multiverse. Now since any of the original multiverses has the frequency of its parallel universe that has the highest frequency (by definition) then  $\mathcal{M}$  will have the frequency of its multiverse which has the highest frequency.  $\square$

**Theorem II.9.** *The set of all realities is identified with the  $\mathcal{R}_\epsilon$ .*

*Proof.* If we suppose that  $\mathcal{R}^*$  is the set of all realities, it follows that if  $\mathcal{R}$  is any reality then  $\mathcal{R} \subset \mathcal{R}^*$ . However, this is exactly the definition of  $\mathcal{R}_\epsilon$  hence  $\mathcal{R}^* = \mathcal{R}_\epsilon$ .  $\square$

Let we define a relation  $\mathcal{R}$  on the set  $\mathcal{R}_\epsilon$  such that for any  $\mathcal{R}_1, \mathcal{R}_2 \subset \mathcal{R}_\epsilon$  we have  $\mathcal{R}_1 \mathcal{R} \mathcal{R}_2$  if  $\mathcal{R}_1$  and  $\mathcal{R}_2$  have the same attributes of abstraction and completeness. However, if we let  $\mathcal{R}_1, \mathcal{R}_2$  and  $\mathcal{R}_3$  be any arbitrary three realities in  $\mathcal{R}_\epsilon$  then we would have:

$$\mathcal{R}_1 \mathcal{R} \mathcal{R}_1 \quad \text{and} \quad \mathcal{R}_1 \mathcal{R} \mathcal{R}_2 \Rightarrow \mathcal{R}_2 \mathcal{R} \mathcal{R}_1 \quad (30)$$

also we have

$$\mathcal{R}_1 \mathcal{R} \mathcal{R}_2 \quad \text{and} \quad \mathcal{R}_2 \mathcal{R} \mathcal{R}_3 \Rightarrow \mathcal{R}_1 \mathcal{R} \mathcal{R}_3 \quad (31)$$

and hence this relation is reflexive, symmetric and transitive, so it is an equivalence relation which divides  $\mathcal{R}_\epsilon$  into five equivalence classes. We call them collectively the quotient set of  $\mathcal{R}_\epsilon$  by  $\mathcal{R}$ :

$$\mathcal{R}_\epsilon / \mathcal{R} = \{\bar{\mathcal{R}}_\delta, \bar{\mathcal{R}}_{\bar{\delta}}, \bar{\mathcal{R}}_{\bar{\pi}}, \bar{\mathcal{R}}_\pi, \bar{\mathcal{R}}_\epsilon\}^{15} \quad (32)$$

The equivalence class  $\bar{\mathcal{R}}_\epsilon$  contains only one element which is the elucidated reality  $\mathcal{R}_\epsilon$  and any other imagined reality is included in one of the other four classes (each of them has infinite number of elements). The main question of this research is to which equivalence class, does our ultimate external reality belong. The answer of this main question will be developed in the following sections of the research.

<sup>14</sup>The frequency of the multiverse is defined as the highest frequency of its parallel universes plus one, notice that more than one of these parallel universes may have this frequency.

<sup>15</sup>We refer to the deficient, semi-deficient and semi-perfect realities by the subscripts  $\delta, \bar{\delta}$  and  $\bar{\pi}$ , respectively. The bar above each reality indicates that it is an equivalence class.

### III THE COMPLETENESS OF OUR ULTIMATE EXTERNAL REALITY

The vast majority of the data that we have collected about our universe was obtained through the electromagnetic radiation. The analysis of these data revealed that our universe is expanding at an accelerated rate (Linder E. V. 2003). This evidence along with the fact that light (electromagnetic radiation) propagates in space with a constant speed  $c$ <sup>16</sup> led to the dogma that the last observable surface from earth is the so called the “surface of the last scattering” from which the cosmic microwave background radiation (CMB) originates (Bolejko K. 2011). The spherical region surrounding an observer with a radius equals to the distance between him and his surface of the last scattering is called his “Hubble volume”, so we will take the Hubble volume to be the parallel universe with zero frequency.

According to the standard models of modern physics, any constituent of the universe can be regarded as a member of one of four classes of entities: matter, energy, space and time (Haharov et al. 2018), so these classes constitute the orbits of the highest frequencies in our universe and hence the relations between them form by definition the fundamental laws of our parallel universe as an isolated system. These laws as described by relativity and quantum theories led to the emergence of the first accurate models of our universe<sup>17</sup> by scientific standards. However, the most acceptable models of our universe that agree with observations were based on the Big Bang theory as a paradigm for its origin. This theory is strongly accepted for its elegant explanations of the CMB, the abundances of the light elements (through primordial nucleosynthesis) and Hubble’s law<sup>18</sup> along with other phenomena such as Olbers’ paradox<sup>19</sup> (Tytler et al. 2001). The notion that our parallel universe was initially packed in a very small region (based on this theory) along with the relations between the orbits with the highest frequencies in our parallel universe (the fundamental laws of physics) produced as logical consequences the problems of flatness, horizon, and smoothness among other cosmological problems (Linde et al. 1994). These problems can be solved in one fell swoop by the theory of inflation<sup>20</sup> (Singh et al. 2016).

<sup>16</sup>The speed of light  $c$  is a physical constant which is found by celestial and terrestrial measurements to accurately have the value 299792.458 km/s.

<sup>17</sup>In our discussion the two terms: our parallel universe and our universe will be taken to mean our Hubble volume.

<sup>18</sup>Hubble’s law states that the perceived velocities by which galaxies receding from an observer are proportional to their distances from him (the constant of proportionality is called Hubble constant).

<sup>19</sup>Olbers’ paradox refers to the contradiction results from the conflict between the assumption of infinite space filled with matter and the darkness of the night sky since the former assumption entails a night sky as bright as the sky during the day. It is named in honor of the German astronomer Heinrich Olbers who was the first one to describe it.

<sup>20</sup>Inflation is an epoch of exponential expansion of space that dilutes away monopoles (superheavy particles) and other debris

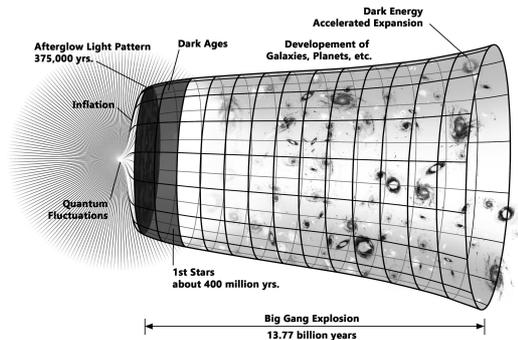


Fig. 1. The development of our parallel universe with zero frequency (our Hubble volume) from the Big Bang through the inflation period to the current epoch of our cosmological history. This expansion is governed by the metric of the cosmological model and the metric of the concordance model of cosmology is called the Robertson-Walker metric.

This fact, nominates inflation as the most plausible explanation of the cosmological problems (see Fig. 1). On the other hand, there are accumulated evidences that our zero frequency parallel universe is embedded in an infinite space with sufficiently uniform distribution of matter (Tegmark M. 2003). This fact combined with the assumption that our fundamental laws are valid through out this space lead (in the realm of the Big Bang paradigm) to the inevitable conclusion that it must be composed of infinitely many parallel universes with zero frequencies (Hubble volumes) each of which has its own Big Bang. However, from the unitary of the fundamental laws of physics and the randomness of the quantum fluctuations, each of these parallel universes has different  $n$ -tuple of values (initial condition) corresponds to its orbits of the highest frequencies, so by definition these parallel universes constitute alternative histories to which we refer collectively as the “Level I multiverse” (a multiverse of zero frequency). This means that the entire possible histories (including all copies of us having infinitely many variations of histories) are included in this multiverse (Tegmark M. 2003).

It is a rational and common practice in science to accept all the predictions of a given theory if it has falsifiable predictions that have been proven experimentally to be true (the more it predicts and the more these predictions agree with observation the more rationally plausible to accept its other predictions). For instance, the black hole notion was accepted by the scientific community when the general relativity which predicts its existence had been established to be correct in a number of experimentally inspected situations<sup>21</sup> (Celotti et al. 1999).

and hence producing flat and smooth space. It also magnifies the quantum fluctuations which are manifested as the seed fluctuations responsible of the origin of all structures in our parallel universe.

<sup>21</sup>The three traditional evidences of the validity of the general relativity were its predictions of the precession of Mercury’s orbit, the gravitational deflection of light and the gravitational redshift, all of which have been established experimentally with astonishing agreements between predicted and observed values.

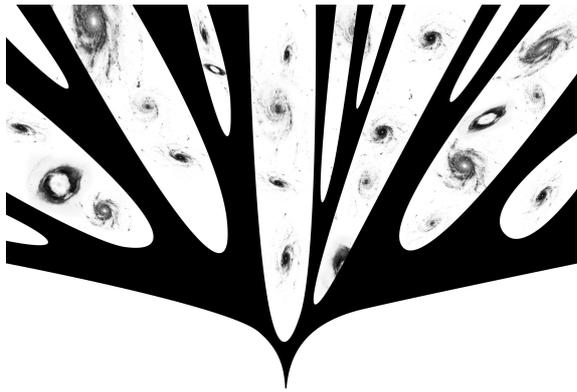


Fig. 2. A depiction of part of the post-inflationary bubbles which constitute the level II multiverse (a multiverse with one frequency). The inflation is triggered by these bubbles through quantum fluctuations in the spacial regions between them producing a perpetual exponential growth of them.

Although this practice is rational on its own, there is another reason that justifies its employment. It is very common in the scientific reasoning and calculations that we encounter a situation in which we have to assume a theoretical framework to accomplish these processes and hence the previous practice provide a rational criterion to select the appropriate framework to work with.

In the light of this fact and since inflation has been proven to have many predictions that agree neatly with observations (Guth & Steinhardt 1984), it is adopted as a main feature of the concordance model of cosmology<sup>22</sup> and many other theories of elementary particles. One of the widely accepted models of the latter is the so called “chaotic inflation”. Under the umbrella of this model, the inflation of the space occurs eternally by a process in which a ceased inflating region called a “post-inflation bubble” produce “inflating bubbles” by quantum fluctuations in a chain reaction that grows exponentially (Linde A. 1997). This process has far consequences since there are many convincing evidences that the relations between the orbits with the appealingly highest frequencies (the laws of physics as we know them) are just low-energy limits of more fundamental relations between orbits with higher frequencies (more fundamental laws) that obtained at tremendously high temperatures, so these laws are in fact the effective laws of our parallel universe which results from breaking the higher symmetry in such a way that produces the physical constants, the 3+1-dimensional spacetime and the elementary particles which we perceive today in our universe. However, the randomness of the driving quantum fluctuations causes each post-inflationary bubble to randomly break the symmetry and so to have different physical constants, dimensionality and particle contents (Tegmark M. 2003). The latter physical mechanism produces infinitely many post-inflation bubbles with all possible

<sup>22</sup>The concordance model of cosmology is the currently accepted model that is used as a base of the theoretical works and calculations related our universe. It is currently the The  $\Lambda$ CDM (Lambda cold dark matter) model.

sets of effective laws of physics including our own level I multiverse, so each of these bubbles constitutes the set of all possible alternative histories (Fig. 2) that by definition have the same relations between their orbits of the second highest frequencies (the effective laws). We call each bubble a “level II parallel universe” (a parallel universe with one frequency) and the entire set of all bubbles the “level II multiverse” (a multiverse with one frequency).

In the traditional perception based on classical mechanics the relations between the orbits with the second highest frequencies representing space and time are described by the position vector of the particle involved and its derivative with respect to time (the particle’s velocity vector), but assuming a continuous magnitudes of these vectors in the microscopic scale, as in the atomic model of Rutherford (Lakhtakia A. 1996), produced a contradiction between predictions and observations. This led to the abandonment of continuity in this scale and replacing it with discrete values of these magnitudes where Bohr model of the hydrogen atom represents one of its manifestations (Hetteima H. 1995). However, the sequence of evidences that led to the emergence of Heisenberg’s uncertainty principle (Sen D. 2014) eliminated the possibility of the precise measurements of the particle’s position vector and its momentum at the same time (in microscopic scale). These accumulated developments terminated in the invention of quantum mechanics by Schrodinger to reconcile the predictions with observations. The atomic model based on this theory is know as the “quantum mechanical model of the atom” in which the electrons occupy discrete spatial orbits depending on their energies called “orbitals” with probability distributions governed by their wavefunctions (Garofalo A. 1997).

The wavefunction which describes the probability distribution of a physical quantity (e.g. position and velocity) for a given particle evolves according to the Schrodinger equation (a linear partial differential equation). The set of all wavefunctions form with the complex field ( $\mathbb{C}, +, \times$ ) an infinite-dimensional inner-product space<sup>23</sup> which is called a “Hilbert space”, so for any arbitrary isolated system (including the entire universe) the wavefunction which depicts its quantum status is called the wavefunction of that system. This wavefunction determines the dynamical history of the system, so in the case of the universe where the latter governed the gravitational clustering that produced the galaxies, stars and planets, its wavefunction specifies our entire history including life (Hartle & Hawking 1983). Although the theory of quantum mechanics precisely described the quantum phenomena explain-

<sup>23</sup>An inner-product space is a vector space with inner-product structure that is a collection of objects which is close under addition and multiplication of vectors (objects) and also under multiplication by scalars (numbers) from the associated field (which is the complex field in the case of wavefunctions). The inner-product is a mapping from the Cartesian product of the vector space to the associated field that is symmetric, linear and positively defined.

ing the atomic structure and the elementary particles behaviors and interactions, it led naturally to the principle of quantum superposition<sup>24</sup> which results in contradictions when interpreted in the realm of the orthodox line of thought. This is so because quantum superposition entails that an entity can be in two different positions or states at the same time (Einstein A. 1935). The celebrated thought experiment devised by Schrodinger which depicts the latter situation is known as the “Schrodinger’s cat paradox”. In this experiment a machine operated by quantum decay of a radioactive element is configured to kill a cat when an event of a decay is registered. However, the quantum superposition states that both status of decaying and not decaying should occur with probability determined by the element’s wavefunction, so the cat should be dead and alive at the same time (Schrödinger & Trimmer 1980).

The traditional argument adopted to resolve this conflict between predictions and observations is called the “Copenhagen interpretation” which states that the wavefunction collapses into a deterministic classical value whenever an observation is made (Camilleri K. 2009). There are numerous interpretations of quantum mechanics that explain away this conflict. However, the most common interpretation which is increasingly becoming popular is the so called the “many-worlds interpretation” introduced by Hugh Everett. The many-worlds interpretation explains away this paradox by emphasizing that the apparent contradictions arise from the process of realizing all the possible quantum outcomes by branching (Fig. 3) with probability distribution dictated by the wavefunction of the system (De Witt B. S. 2004). In the light of this interpretation, all of the quantum fluctuations that produce the entire set of the level II parallel universes, for any arbitrary level I multiverse, will be realized by branching with probability distribution precisely identified with that predicted by its wavefunction. In spite of its success, the many-worlds interpretation arose two problems related to branching. These complications are the mechanisms by which the involved branches prevented from being cross observed and isolated in Hilbert space. Both of these problems have been shown to be solved by an effect called “decoherence” (Joos et al. 2013) which has withstood its harsh experimental inspection since it has been proposed.

Assuming the time-evolution of wavefunction is unitary which is strongly suggested by “string theory” (Barrow et al. 2004), the previous reasoning indicates that the level II multiverse is totally repeated with different distribution through splitting the reality by superposition. We call the assemblage of all of these redistributed branches of level II multiverses, the “level III multiverse” (a multiverse with two frequencies).

<sup>24</sup>The principle of quantum superposition states that a valid quantum state is obtained by the addition (superposition) of two quantum states and also a given state can be decomposed into several distinct states. This principle results from the wave nature of the wavefunctions.

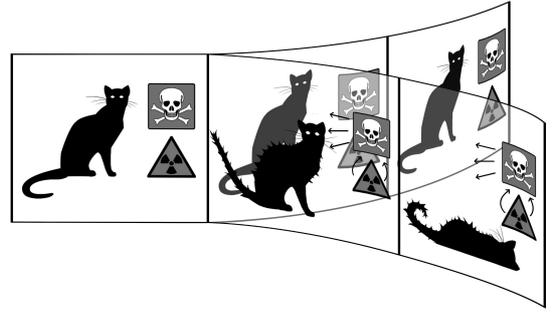


Fig. 3. In the many-world interpretation of quantum mechanics all the possible histories of a system are realized by splitting (which appears as superposition) with probability distribution determined by its wavefunction.

The accumulated evidences that support the existence of orbits with frequencies higher than those related to our observable universe as an isolated reality led to the believe on more fundamental laws which constitute the relations between these orbits. The different level I multiverses (the post-inflationary bubbles) have distinct initial conditions for them and hence constitute alternative histories which together form the level II multiverse to all of its possible distributions, we refer as the level III multiverse. These fundamental laws, know collectively as the “theory of everything” (TOE), can be used in principle to deduce the entire history of the level II multiverse. However, extrapolation led to the speculative suspicion that there may exist other orbits with even higher frequencies whose relations are the fundamental laws and the TOE is just an effective law which is a reflection of a particular initial condition for these orbits. These fundamental laws are called the “mathematical structures” and their assemblage (which is a multiverse with 3 frequencies) is referred to as the “level IV multiverse” (Tegmark M. 2008).

Corollaries (II.3.1.) and (II.3.2.) entail, as a logical consequence, that any arbitrary element belongs to a given equivalence class of the quotient set  $\mathcal{R}_c/\mathcal{R}$  can be represented as a multiverse of 2 or 3 frequencies imitating the level III or the level IV multiverses. However, if we assume that the realities  $\mathcal{R}_a = (\mathbb{E}_a, \sigma_a, \rho_a)$  and  $\mathcal{R}_b = (\mathbb{E}_b, \sigma_b, \rho_b)$  represent the level III and the level IV multiverses, respectively, and if  $\mathcal{R}_a = \{\mathcal{R}_{a_1}, \mathcal{R}_{a_2}, \dots\}$  and  $\mathcal{R}_b = \{\mathcal{R}_{b_1}, \mathcal{R}_{b_2}, \dots\}$ , then according to the preceding well established scientific predictions each of these sub-reality (parallel universe) is an alternative history, so it has the same entities of the related multiverse and we would have:

$$\mathbb{E}_{a_1} = \mathbb{E}_{a_2} = \dots = \mathbb{E}_a \quad \text{and} \quad \mathbb{E}_{b_1} = \mathbb{E}_{b_2} = \dots = \mathbb{E}_b \quad (33)$$

However, each of these multiverses includes the entire set of its alternative histories, so there exist subsets of  $\mathcal{R}_a$  and  $\mathcal{R}_b$  with cardinalities of 2 or more that satisfy the conditions of semi-closeness. Therefore, both of them by definition are complete and hence the level III and the level IV multiverses are at least semi-perfect realities (see Fig. 4).

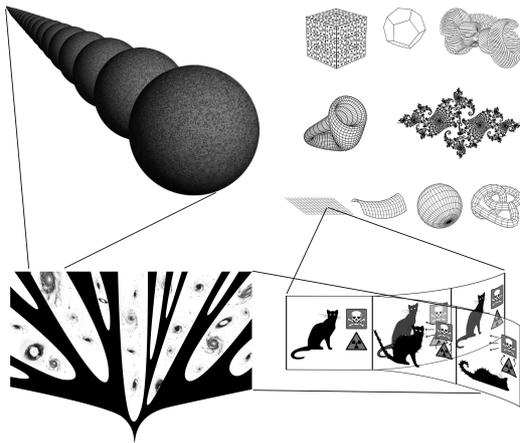


Fig. 4. It follows from the predictions of a number of experimentally verified theories with wide applications that our ultimate external reality forms a nesting reality with 2 or 3 frequencies.

#### IV THE ABSTRACTION OF OUR ULTIMATE EXTERNAL REALITY

In our parallel universe as an isolated system, the orbits of the highest frequencies classify its contents into five classes: personality<sup>25</sup>, matter, energy, space and time. These classes along with their relations constitute our reality (Ferreira et al. 2017). Personalities describe the attributes acquired by the different concepts relative to a given observer, so they are in fact the natures of the different forms and relations that the four physical contents of the universe can have with respect to that observer. The orbits of the personalities can be decomposed into two sub-orbits with lower frequencies corresponding to the sensational and non-sensational personalities<sup>26</sup>. However, psychophysics has shown that the sensational personalities are relativistic phenomena that depends on the constitutional structure of the observer (Marks L. 2014). The latter produces what is referred to as the “internal reality” of the observer which is a virtual space created by the interaction of the senses in his sensory system<sup>27</sup>. If we take a human setting in a room as an example of an orthodox observer, the colors of the objects surrounding him are just the interpretations created by his brain of the interactions of his retina with electromagnetic radiations (visible light) of different frequencies (Moutoussis & Zeki 2000). The different sounds exist in his room are

<sup>25</sup>Personality is any concept that cannot be reduced to the four main types of the physical constituents of the universe (matter, energy, space and time).

<sup>26</sup>The sensational personality for an observer is defined as the personality that is perceived by any of his senses. If a personality cannot sensorially be perceived by that observer then it is a non-sensational personality relative to him.

<sup>27</sup>For any orthodox observer the sensory system is composed of the ordinary five senses (vision, hearing, smell, taste and touch). However, the developing environment of a given observer may endowed him with more or less senses which may be of different natures. We refer to this type of observer as a heterodox observer.

in fact longitudinal mechanical waves with several frequencies that propagate in air and vibrate his eardrum according to these frequencies which are translated by the auditory cortex in his brain as the familiar sounds he hears (Lewis et al. 2004). The gaseous molecules present in the room interact with the olfactory epithelium in his nasal cavity sending electrical pulses to the olfactory bulb which are processed to produce the variant odors fabricated by his brain (Stevenson & Wilson 2007). The flavors of the mixture of compounds which he drinks are created by his gustatory system as a result of processing the electrical signals generated in response to the contact of his taste receptors with the molecules of these compounds (Rolls E. T. 2015). The feeling of the movement of the air molecules, their pressure and the judgment of the nature of its temperature are processed in the primary sensory cortex and the sensation is created by his nervous system (Rolls E. T. 2010), so the preceding discussion emphasizes that the essence of the internal reality is created by the nervous system of the orthodox observer. However, the informational contents of the nervous system which exist as language, knowledge and beliefs constitute the non-sensational personality sub-orbit of the internal reality of the observer and determine the patterns of his reasoning and hence his judgment whether something is true or false (Evans et al. 1993).

Although it is true that the internal reality, with its structure and content, represents the natures of the entities with respect to an observer, it could be infected by illusion (sensational deception), omission (sensational defects) or addition (hallucination) or any combination of them, also it must be censored to avoid any non-realistic contributions (such as dreams), interpolated (between unconscious periods such as sleeping) and extrapolated (incorporate concepts that exist beyond the horizon of the observer). Treating the previous defects and performing the processes of censorship, interpolation and extrapolation create a common reality accepted by a group of observers which is called the “consensus reality” (Tegmark M. 2003). Our consensus reality is the common reality accepted by all sapient human which is also the reality accepted by the scientific community.

The fact that the natures of the entities which constitute the internal reality (consensus reality) are fabricated by the constitutional structure of the observer deprives these entities of any absolute meaning. The collection of these abstract entities with their relations are referred to as the “external reality”<sup>28</sup>. On the other hand, the relativistic nature of the structure and content of the internal reality (consensus reality) means, at least in principle, that for any given external reality there are corresponding internal realities (consensus realities) with appropriate structures and contents that rationalize it and vice versa. We call the latter

<sup>28</sup>The external reality, according to this definition, coincides with the definition of reality without the sense relation.

statement the “generic anthropic principle”<sup>29</sup>, so (as in our previous treatment) if we let  $\mathcal{R}_a$  and  $\mathcal{R}_b$  refer to the level III and level IV multiverses, respectively, then by the latter principle which implies, along with their inclusion of the entire alternative histories, the existence of all possible natures of any arbitrary entity and hence:

$$\sigma_a = \mathbb{E}_a^2 \quad \text{and} \quad \sigma_b = \mathbb{E}_b^2 \quad (34)$$

Therefore,  $\mathcal{R}_a$  and  $\mathcal{R}_b$  are abstract, so since they also complete (as we have shown in the preceding section) then each of the level III and level IV multiverses constitutes at least a perfect reality and hence belongs to one of the equivalence classes  $\bar{\mathcal{R}}_\pi$  and  $\bar{\mathcal{R}}_\epsilon$ .

## V MEASURING THE CORRECTNESS OF THE ELEMENTS OF $\mathcal{R}_\epsilon/\mathcal{R}$

Based on the previous analysis and the diverse sample of the cited literature, a discrete pattern is produced in the abstraction-completeness continuum<sup>30</sup> (Fig. 5). Appealing to the locations of the points in the continuum, the correctness distribution of the equivalence classes of reality is measured qualitatively in accordance with the classification of the related scientific theories ramifications as mainstream, controversial or highly controversial (see Table 1 below)<sup>31</sup>.

Table 1. The distribution of the correctness of realities.

$\mathcal{R}_\epsilon/\mathcal{R}$	$\bar{\mathcal{R}}_\delta$	$\bar{\mathcal{R}}_{\bar{\delta}}$	$\bar{\mathcal{R}}_{\bar{\pi}}$	$\bar{\mathcal{R}}_\pi$	$\bar{\mathcal{R}}_\epsilon$
Plausibility	H	VL	L	HL	EL

Since the plausibility of the  $\bar{\mathcal{R}}_\delta$  reality is currently high, our ultimate external reality is a deficient reality with zero frequency. While this ultimate external reality remained the same since Aristotelian paradigm, the degrees of abstraction and completeness increased significantly. If this trend continues and the developments of the related scientific disciplines lead gradually to the inclusion of more extreme ramifications in the mainstream class then our ultimate external reality would gradually approach the  $\bar{\mathcal{R}}_\pi$  reality (Tegmark reality). However, solving the elucidation problem<sup>32</sup> by adpoting the principle of plenitude<sup>33</sup> (in its wider sense)

<sup>29</sup>This principle asserts that any reality is comprehensible by some observer (either orthodox or heterodox) while the weak and strong anthropic principles in the cosmological literature state that the reality should be designed to be conceivable by a sapient observer and the sapient observer should be developed in an appropriate way to be capable to comprehend the reality, respectively.

<sup>30</sup>This continuum is defined as a single integrated spectrum in which all the reality components are captured.

<sup>31</sup>In this table H, VL, L, HL and EL refer to high, very low, low, highly low and extremely low, respectively.

<sup>32</sup>This problem arises from the fact that any proposed reality cannot be explained completely unless it contains all the possibilities.

<sup>33</sup>The principle of plenitude emphasizes that all possible forms of existence are actually exist.

would transcend our UER to the  $\bar{\mathcal{R}}_\epsilon$  reality which is the superior reality of the ultimate external reality for any possible orthodox or heterodox observer.

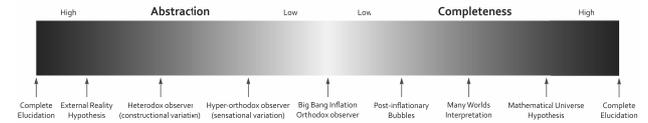


Fig. 5. The abstraction-completeness continuum describes the entire spectrum of reality. As each end of the continuum is approached, the degree of controversiality increases continuously (this is depicted in the figure by the gradual increase in the intensity of shading toward those ends).

## VI CONCLUSION

We have developed a theory to describe reality with all of its aspects mathematically, the theory unified the features of the possible realities that emerge as direct or far consequences of Big Bang, inflation, chaotic inflation, quantum and string theories along with our current established psychophysical perspectives. The analysis leads to the quotient set  $\mathcal{R}_\epsilon/\mathcal{R}$  which reduces all types of realities into five classes. As it has been shown, our ultimate external reality is  $\bar{\mathcal{R}}_\delta$ . However, based on the sense of the scientific developments, it tends to approach  $\bar{\mathcal{R}}_\pi$  reality and ultimately  $\bar{\mathcal{R}}_\epsilon$  reality which realizes the principle of plenitude.

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