Chaos, Solitons and Fractals 39 (2009) 1027-1036
DOI: https://doi.org/10.1016/j.chaos.2007.04.002

Emergence of Classical Reality from a Quantum Mechanical Background

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Abstract

A model for the process of knowledge acquisition is presented that shows how naive realism emerges from a quantum mechanical background. We formalise this process of emergence and obtain in this way an illustrative insight to some of the most fundamental physical theories: GRW-theory and E^{∞}-theory.

1 Introduction

We present an epistemological view of physics. From Husserl's phenomenological method, general principles for the acquisition of knowledge are obtained that are necessary conditions for all forms of cognition.These principles can be represented by a mathematical formalism. The structure of the knowledge, that had been deduced with this formalism from empirical data, shows all the well-known characteristics of quantum mechanics. It is therefore impossible, to use this knowledge in the same way as our daily life knowledge.

In a second step, an emergence process is defined that provides from the quantum mechanical or first level knowledge, higher level knowledge with the properties we expect in our naive reality.

From elementary principles of cognition, we obtain in this way an illustrative model that satisfies the principles of quantum mechanics and demonstrates the emergence of classical mechanics reproducing all the well-known effects of decoherence.

As our considerations are obtained from minimal preconditions, they demonstrate, the insufficiency of classical logic and probability theory to understand reality. The topology of space-time cannot be fixed in advance without considering the events in that space. Our knowledge is no representation of the events in an outer reality but a presentation and thus itself part of these events.

It seems that under the demand of life for effectiveness, mankind has simplified his thinking in a way that prevents an understanding of our abundant physical experiments. On the other side, in the old Indian philosophy we find exactly the same imagination of reality that emerged from our epistemological considerations [1].

Finally we resume the essential characteristics of the presented access to physics. We find that they are completely satisfied in E^{∞}-theory ([2],[3]). As E^{∞}-theory is deduced by Mohamed S. El Naschie from a totally different viewpoint (ontology), this accordance is a strong argument for the new possibilities of E^{∞} to increase our understanding.

2 Knowledge construction based on the principal intention of physicists

2.1 Husserl's phenomenological method

Husserl's phenomenological method describes knowledge acquisition as a process of the assignment of meaning to empirical data (Vermeinen). The entities, obtained in this process (das Vermeinte), are the constituents of the knowledge or the "objects" of the constituted reality. The expression "object" is taken to mean an object as something conceived by or presented to/in a conscious mind. As consciousness cannot be comprehended with mathematical concepts, it seems at a first view, that every understanding remains subjective. But in the following, the possibility will be demonstrated, to constitute knowledge in physics in an unambiguous way that makes it independent from the special subjective mental state of the observer. Husserl's important discovery was to recognise the dependence of knowledge acquisition on the intention under which the knowledge will be constituted. Different accesses to reality are defined by different intentions which lead us to different theories for an understanding of our empirical world. Husserl was interested in determing the most primitive principles on which the concept of a theory in general is founded. He wants to discover the pure laws, based on such primitive principles, which confer unity to any theory.

The main principal intention of physicists can be summarised in the anticipation postulate:

AP: Put the knowledge in an order such that forecasts are enabled best.

2.2 The algorithm for the constitution of knowledge

The algorithm for a constitution of knowledge from empirical data under minimal preconditions is based on the assumptions:

A: Our external world is presented to us by measurement tuples $m_{n,k}, (n = 1, ..., N; k = 1, ..., K)$ (This assumption is not essential, the formalism can easily be extended to other data structures.)

B: Our relation to these measurements is specified by adjectives:

(very) great, intermediate, (very) small, etc.

These adjectives will be formalised by Fuzzy-membership functions.

C: The anticipation postulate.

With the Fuzzy adjectives, sentences can be formed, for example:

s: m_{n1} is great AND m_{n2} is intermediate AND m_{i3} is very very small.

The membership degree $s(m_n)$ of a measurement tuple m_n in a sentence s can be interpreted as the confirmation the sentence s obtains from this measurement.
Dempster-Shafer's belief theory provides us the confirmation of a sentence s by our empirical data $M = \{m_n = m_{n,k=1,...,K} | n = 1, ..., N\}$:

$$Bel(s) = \bigvee_{n=1}^{N} s(m_n) = s(m_1) \vee s(m_2) \vee ... \vee s(m_N) \tag{1}$$

where $a \vee b := 1 - (1 - a) \cdot (1 - b)$ for $a, b \in [0, 1]$ denotes a Fuzzy-or operator. The corresponding Fuzzy-and operator $\wedge$ and Fuzzy-not operator $\neg$ are defined: $a \wedge b := a \cdot b$ resp. $\neg a := (1 - a)$. It can be shown that the relations between believability degrees are independent of the selection of the Fuzzy operators (where Max and Min have to be excluded).

The relevant sentences are those sentences that were confirmed by one part of the measurements and refused by the other part. These sentences allow us to make distinctions in our world and to recognise structures. But relevance is not the unique criterion for the selection of a sentence. Very long sentences must be better confirmed than short sentences for being selected. If we construct all the sentences with a universal Turing machine than we can define the complexity of a sentence by the length of its shortest description relative to this Turing machine. We do not calculate the relevance of the sentence itself but the confirmation of the letters of the shortest text that provides a description of the sentence with this universal Turing machine. (The algorithm is explained in [4]. Using a theorem of Kolmogorov, it can be demonstrated, that the selection of very relevant sentences occurs independently of the chosen universal Turing machine.)

The knowledge obtained from empirical data will now be constructed in the following steps:

I: We collect the sentences whose description is best confirmed by the measurements M in a set S_r.

II: A point p in space-time is defined by a subset S_p of S_r whose sentences are glued together by the measurements. Unity of two sentences s_{p1} and s_{p2} signifies mathematically that s_{p1} and s_{p2} create subsets of the measurement set M:
$S_{pk+} := \{m_n \in M | s_{pk}(m_n) \approx 1\}$, $S_{pk-} := \{m_n \in M | s_{pk}(m_n) \approx 0\}$ $k = 1, 2$
and in the sense of fuzzy similarity it holds that:
S_{p1+} is similar to S_{p2+} and S_{p1-} is similar to S_{p2-}.

III: The anticipation postulate claims that forecasts are enabled best between near points. The topology of the set of points p is therefore defined by a neighbourhood relation which relates neighbourhood of points p_1, p_2 to the similarity of the defining sets S_{p1} and S_{p2}.

We denote the set of all points p with this topology by $\mathbf{W}_{opt}$. The space-time $\mathbf{W}_{opt}$ is confirmed in its totality. We have to search the description S_r of the whole space (that contains all individual descriptions S_p for the points $p \in \mathbf{W}_{opt}$) that is maximally confirmed by the measurements M in its totality. As this selection can be restricted to sentences of bounded complexity, this search is feasible (although practically extremely timeconsuming) and leads to an unambiguous result.

With the given algorithm of knowledge constitution, we obtain a known region $\mathbf{W}_{opt}$ in the space-time of the world. From this known region we can also obtain forecasts for other points outside $\mathbf{W}_{opt}$ (compare figure 1). We use for this forecasts an extension principle that is defined in two steps:

1 The most believable outer regions $\mathbf{W}_{out}$ are those for which the similarity between the points in $\mathbf{W}_{opt} \cup \mathbf{W}_{out}$ will be maximised.

2 The forecasts for a point $p*$ in $\mathbf{W}_{out}$ are those sentences S_{p*} that define $p*$ in the most believable outer region that contains $p*$.

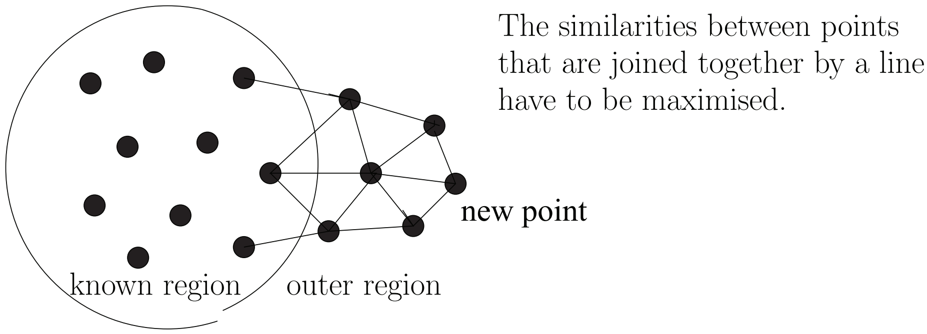

Figure 1: Continuation of knowledge to a new point in a two-dimensional region.

In our interpretation, a quantum state $|\Phi>$ consists of knowledge that allows us to assign believability degrees to possible sentences, belonging to points of outer regions $\mathbf{W}_{out}$ of space-time. These sentences refer to measurements that are defined with respect to the same experiments that constitute M. We need therefore the well-definiteness of our measurements by classical descriptions of the experiments that provide M. The assumption of well-definiteness of measurements presupposes classical measurement apparatus not only for the purpose of indicating the possession of a particular value m_{nk} but also for the purpose of realizing a set of values which thereby become available for attribution. By the measurement apparatus, the question we present to nature will be specified. As our reality depends on our intentions, it depends also on our questions to nature ([5]).

The quantum state $|\Phi>$ is the complete mathematical description of all physical phenomena. It represents the maximum knowledge one can obtain in principle from the measurements.

Time will be defined by that direction in $\mathbf{W}_{opt}$ which allows the most believable forecasts. As life depends on the capability of beings to make forecasts, it is this the direction in which life evolves.

2.3 Properties of quantum mechanical objects

2.3.1 Superposition of Properties

The measurements m_{nk}, we obtain from an experiment in quantum mechanics, don't provide us always one set $\mathbf{A}$ of noncontradicting sentences. The possibility exists that the set of believable sentences $\mathbf{A}$ is composed by a disjunct union of sets $\mathbf{A}_i, (i = 1, ..., I)$:

$$\mathbf{A} = \mathbf{A}_1 \hat{\cup} \mathbf{A}_2 \hat{\cup} ... \hat{\cup} \mathbf{A}_I \tag{2}$$

where the sentences $s_i \in \mathbf{A}_i$ contradict for $i \neq j$ to the description that is given by the sentences of $\mathbf{A}_j$. An illustrative picture of such a situation is demonstrated in Figure 2 where the two interpretations, faces and vase, contradict each other ([6],[7],[8]).

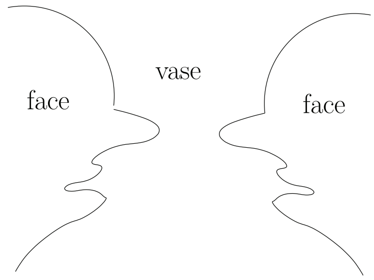

Figure 2: Faces or vase?

If equation (2) holds, we call the quantum mechanical state $|\Phi>$, which is defined by the set of sentences $\mathbf{A}$, a mixture of states $|\Phi_i>$, where each state $|\Phi_i>, (i = 1, ..., I)$ is a pure state that is defined by the sentences of $\mathbf{A}_i$. A pure state has no more, no less "physical reality" than a mixture. Both are only a mathematical tool which allows us to predict an expectation value for a new measurement that has to be determined in advance.

2.3.2 Contextualism of properties

The selection of one believable sentence s depends on the whole set of measurements M and all other selected sentences S_r. The description of every local point depends therefore on the whole context of an experiment. Properties in different parts of space-time may be "entangled". Many other properties of quantum mechanical objects can be deduced from contextualism [9].

2.3.3 Quantum mechanical entities are atomic

In this subsection, we deduce Jeffery Grupp's postulates ([10]) from the formalism of section 2.2.

As a direct consequence from our definition of knowledge, it follows that points in space-time are defined by inseparable sets of sentences. This means, that sentences which are glued together by the same subset of the measurement set M correspond to the same point. If it were possible to decompose a defining set of sentences $\mathbf{A}$ in two disjoint sets $\mathbf{A}_1$ and $\mathbf{A}_2$: $\mathbf{A} = \mathbf{A}_1 \hat{\cup} \mathbf{A}_2$,
where the sentences $\mathbf{A}_i$ are satisfied by measurements from $M_i \subset M$, $(i = 1, 2)$ with $M_1 \neq M_2$, then each set $\mathbf{A}_i, (i = 1, 2)$ would define one point by itself. As a consequence, we obtain Grupp's postulate:

G1: An entity of our knowledge is atomic, without any size.

Jeffery Grupp denominates these entities "abstract atoms" and explains ([10]):
"Quantum abstract atoms ... do not have size, and if they are going to contact or touch each other, they must exactly coincide with one another, and if that occurred then they would be coinciding points."
"Composite point-sized-quantum [entities] do not exist... Reality is composed of unrelated and unattached particles."
"Distance is a concept apprehended in the mind regarding items that do not perfectly coincide."

G2: There exist no relations [besides the topology of $\mathbf{W}_{opt}$] or connections between abstract atoms.

The formalism of subsection 2.2 provides only one relation between two points: "proximity". Proximity is defined by the topology of $\mathbf{W}_{opt}$ which is constituted by the similarity between the descriptions of that points. Every other relation between two points would strengthen the proximity between these points and in this way be included in the topology of $\mathbf{W}_{opt}$. The position in space-time is therefore the only relation that can exist between abstract atoms.

As a consequence of (G2), there exists no matter that corresponds to "the idea of a stuff" as in classical mechanics:
"There is no reason to believe that quantum atoms (electrons, gluons etc.) are material items."
Changes in the quantum world are only possible by discrete leaps, as Grupp formulates:
"If an item changes, it can only cease to exist where a new item comes into existence."

The postulates of J. Grupp correspond to the experimental results. P. Brovetto, V. Maxia and M. Salis report [11]:
"Electron is point-like in fast collisions at high energy, but is extended in low energy atomic

spectroscopy."
The second part of this statement is not astonishing, as the few structures that are available at low energies are not sufficient to precisely fix the position of an event. $\mathbf{W}_{opt}$ will appear in this case rather coarse-grained. Without any structures, space-time remains undetermined, as demonstrated in Einstein's famous hole argument ([12] page 48).

3 The meaning of 'emergence'

The word "emergence" was first introduced as a technical philosophical concept in George Henry Lewe's book: "Problems of Life and Mind". Stephan Palmquist gives a provisional definition [13]:
"Something (e.g. an object, property, or idea) can be said to "emerge" out of another thing (or level of reality) when the former somehow originates or is grounded in the latter, but displays such unique and unexpected characteristics that it takes on a "life" (i.e. a mutually interacting set of new properties) of its own."
And Samuel Alexander explains [14]:
"The emergent property is not metaphysically "nothing but" the realisation. For no merely micro physical set of properties by themselves account for the causal powers contributed by this combination of properties to individuals."

In the framework of Husserl's concept of the constitution of objects and properties in the process of the assignment of meaning, we can bring this definition into an essentially more precise mathematical form. Objects that originate from this process depend on our intentions or questions, we put to our world.

Respective to different intentions (that find their realisation in different questions), our world represents itself to us differently and with different objects. On the other side, it is important to notice that not every intention can be fundamental. There exist questions (indicating intentions) that can only be put on a higher level of cognition, when already some basic knowledge of objects and properties is available. Questions that may be enabled on one level of knowledge may lead to objects of the next higher level. Emergent properties and objects of a higher level originate wholly within the [physical] domain of the lower level yet the quantities that manifest themselves cannot be explained merely in terms of their underlying interactions in that basic domain.

Alex Rosenberg and D.M. Kaplan use this idea to explain the difference between principles from physics and from biology [15]:
"The biologist's principle of natural selection is a basic undirected law of nature, whose truth is not contingent on more fundamental laws in particular those of physical science."
In the theory of classical mechanics, where everything is predetermined, it makes no sense to claim for the "selection of the fittest".

Rosenberg and Kaplan point out that principles which enable emergence, often satisfy Dumett's substrate neutrality:
"A principle is "substrate-neutral" if it can operate on an indefinite large number of different objects, differently composed. In this case it would be true almost no matter what its underlying domain was."

The following characterisation of the process of emergence is given by Palmquist [13]:
"Emergent properties can lie dormant within lower levels and leap out at us when we examine the higher levels. "Intrinsic emergence" refers to a new property that arises unexpectedly when an old situation is viewed from a level of higher complexity."

A consequence of this characterisation is the principle:

E: Genuine evolution refers to intrinsic emergence, and this proceeds by sudden leaps-"emergencies", as if were- rather than by a step-by-step progression.

Principle (E) can be proved, using the dependence of cognition on intentionality:
Emergent objects and properties exist only respective to higher level questions, and they exist completely or not, but never in an intermediate state, and have no existence on the lower level. Emergent objects therefore leap out suddenly. It is impossible to reconstruct step by step their process of coming into being. The possibility for a new intentionality exists or does not exist, but it is never becoming. The creation of a new intentionality can never be observed. A new intentionality doesn't exist on the lower level and is the precondition for the existence of all objects that belong to the higher level.

4 Recognisability and stuff-property

4.1 The missing borderline between classical mechanics and quantum mechanics

Today in physics two different forms of thinking exist. D. Sen and S. Sengupta stress the problem which is produced by this dis-accord for our insight into the phenomena of our world [16]:
"The two theories [classical physics and quantum mechanics] are drastically different, neither the complete mathematical formalism nor the conceptual structure of one theory can be deduced from those of the other. Two different realities, therefore, seem to exist along the physical scale and the complexities of quantum-classical relationship are greatly pronounced in the boundary region. This border region is rather obtuse where elements of both the mechanics appear to be necessary for a complete description of the whole observational results."
Many ideas of our daily life, that found a correspondence in classical physics, make no sense in quantum mechanics. Sen and Sengupta wrote:
"Shape and size are macroscopic observables and can affect the outcome of various experimental results in a detectable way. But it is almost impossible to discuss such problems using quantum mechanics... Pure quantum representation cannot provide a complete description of the rigid dynamics."

This remarks demonstrate very clearly the difficulties, we have to find a borderline between classical mechanics and quantum mechanics from an ontological position. But are we really restricted to this position? In the first part of this article, we could appreciate the illustrative insight that can be obtained for quantum mechanical phenomena from an epistemological view. We shall therefore use this view to detect the missing borderline.

The basic intention of physicists (the anticipation postulate) gave us the reality of quantum mechanical objects. But exist these objects also in a classical sense?

The answer to the last question has to be "no". Classical objects can be moved in space-time and are formed by a material stuff. Properties that cannot be fulfilled by context-dependent abstract atoms. In the classical world, an apparatus should register values in a robust and permanent way and enable their amplification. In the next subsection, we will define a stability principle which allows classical objects to emerge from an underlying quantum background.

4.2 Properties of classical objects

We call an object "classical" if it satisfies the characteristics of naive realism. T. Norsen [17] defines naive realism to be the view in which "all features of a perceptual experience have their origin in a corresponding feature of the perceived object. Whenever an experimental physicist performs a "measurement" of some property of some physical system, the outcome of that measurement is simply a passive revealing of some pre-existing intrinsic property of the object."
When an observer makes a confident statement about the possessed value of a macroscopic variable, there is the implication that anyone who observes this variable will quote the same value.

These properties of naive or classical objects can be formalised in the framework of section 2.2, introducing a recognisability property:

R: A subset of points $P_S \subset \mathbf{W}_{opt}$ satisfies the recognisability property iff the set of sentences $\mathbf{A}_P$ that define P_S remains unchanged under "allowed changes" of the measurement set M.

R1: By an allowed change of M we mean an arbitrary change of all measurement tuples $m_n \in M$ not belonging to P_S and small changes of other measurement tuples.
This signifies mathematically:

R11: The membership degree of a measurement tuple m_n for P_S is defined by the expression:

$$\epsilon(m_n, P_S) := \bigvee_{s \in S_p for p \in P_S} s(m_n) \tag{3}$$

R12: A change from m_n to $\bar{m}_n$ is allowed iff the expression:

$$\neg(\bigvee_{s \in S_r} (s(m_n) \wedge \neg s(\bar{m}_n)) \vee (\neg s(m_n) \wedge s(\bar{m}_n)) \wedge \epsilon(m_n, P_S)) \text{ is true } (\approx 1) \tag{4}$$

Objects corresponding to sets $P_S \in \mathbf{W}_{opt}$ whose description $\mathbf{A}_P$ remains unchanged under allowed changes of the set of measurements are called "classical objects".
These objects "emerge under the demand for recognisability from a quantum mechanical background". K. Hornberger calls this process "the emergence of classicality in the quantum framework" ([18]).

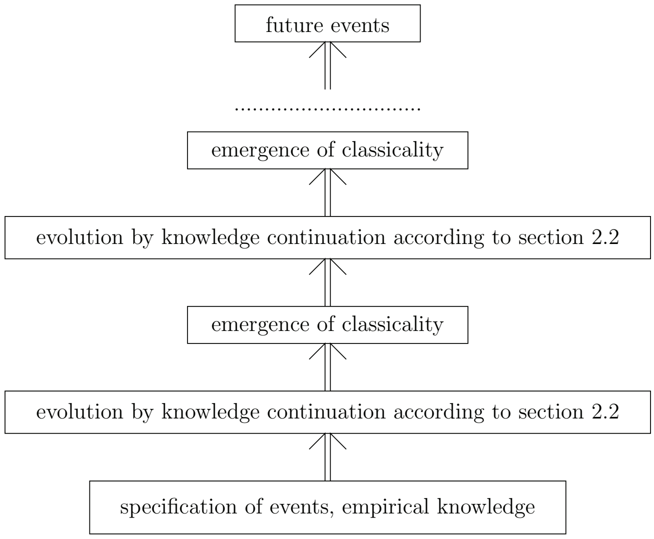

Figure 3: Forecast of future events.

By the recognisability property, very stable structures of points in $\mathbf{W}_{opt}$ are selected. The stability of these configurations is produced by the mutual confirmation the points give each other. Their descriptions S_p are mutually confirming.

The information presented by the whole structure is therefore mainly contained in its points and gives it the appearance of an object formed by a classical stuff. The whole structure appears as a continuous thing (Descartes idea of "res extensa").

In quantum mechanics, the notion of part, as a subobject up to equivalence, has a content richer than the notion of subset. A context-dependent object may come into being only as part of a whole. It seems that tunnelling is such a phenomenon that is produced by a coupling of knowledge over large distances (entanglement). On the other hand, in classical mechanics where material can be understood as composed by a stuff, objects appear as a composition of their subsets.

J. Kofler and C. Brukner resume [19]: "Classical physics and its reputed continuity emerge from a coarse-graining of the quantum world."

Stable properties, that are not effected by allowed measurement changes, correspond to values obtained by classical measurement apparatus. Once made the selection of the measurements, the specification of the meaning of the adjectives "great", "small", etc. and the determination of our intentions (section 2.2 A,B,C), it is nature, not the observer, that makes the choice of these stable properties. The choice is irreversible and will affect the entire future state of the world. What the observer does is only to analyse the "collapsed objective information" to the best of his abilities.

The recognisability property is obviously "substrate neutral" respective to the underlying quantum mechanical background. Classical objects are therefore obtained by "emergence" from this lower level. From principle (3.E) we conclude that classical measurement values leap out suddenly and can not be reconstructed step by step from laws of quantum mechanics.

4.3 Probability theory and noise

The emergence of classical objects from a quantum mechanical background constitutes these objects as an ensemble: the set of virtual measurement tuples obtained from M by allowed changes.

In our classical reality, we find therefore no superposition of contradicting views (up to a few exceptions because of incomplete observation). Uncertainty can now be described by different properties of the members of the ensemble that constitutes a classical object. Probability theory and statistical mechanics are the suitable tools for classical mechanics. Those objects, that are constituted by an ensemble of nearly indistinguishable entities, form our naive reality.

It is however important to notice, that in our understanding, classical entities and values don't refer to a statistical ensemble of measurements but to a statistical ensemble or multiplicity of possibilities to understand a finite set of actual measurements in a definite experiment.

Structures without fixed position in space-time constitute noise. On the quantum-mechanical level, each structure defines their space and time position. Noise is therefore a concept of classical mechanics.

In a very interesting experiment, M. Arndt, L. Hackermüller and K. Hornberger have demonstrated the destruction of coherence (the superposition of contradicting pictures) by noise [20]. This result is completely understandable in the framework of our considerations.

A superposition of contradictory pictures is always a consequence of symmetries in the experiment. For example the interference pattern that is obtained in the double slit experiment has its reason in the symmetries between the paths through the slits. Without symmetry it would be possible to distinguish these paths. To add noise means, that this symmetry in the context of the experiment will be disturbed. The experiment context appears now as an ensemble of unsymmetrical contexts. Our knowledge consists therefore of an ensemble of informations, each obtained from an unsymmetrical context. Coherence disappears.

5 Illustration of well-known physical concepts with the epistemological view

Most of the illustrations that had been obtained from our epistemological view are well-known concepts in physics.

The knowledge continuation from known to unknown regions (section 2.2) corresponds to the Schrödinger equation and the idea of an undisturbed time development [21].

The classical descriptions that emerge from the quantum mechanical background are called "pointer states". Wojciech Hubert Zurek defines and explains [22]:
"Pointer states remain untouched in spite of the environment, while their superpositions lose phase coherence and decohere. [Pointer states] are stable and hence retain a faithful record of and remain correlated with the outcome of the measurement in spite of decoherence. Einselection [the process of emergence] is this decoherence-imposed selection of the preferred set of pointer states that remain stable in the presence of the environment. Decoherence is the destruction of quantum coherence between preferred states associated with the observables monitored by the environment. Einselected states are distinguished by their resilience-stability in spite of the monitoring environment. Pointer states are the most "fit", they survive monitoring by the environment, to leave "descendents" [stable classical information] that inherit their properties. The objectivity of a state can be qualified by the redundancy with which it is recorded throughout the universe."

Zurek calls the strategy "to seek that states that are best in retaining correlations with other systems "the predictability sieve" and explains [22]:
"A predictability sieve shifts all of Hilbert space [all quantum mechanical states], ordering states according to their predictability. The top of the list will be the most classical. The predictability sieve selects states that entangle least with the environment."

E. Alahverdyan, R. Ballian and T.M. Nieuvenhuizen conclude [23]:
"We witness the emergence of standard probabilistic scalar-like correlations between [a system] and [its environment] in the final state."

The first theory of quantum mechanics which includes the creation of classical physical states, had been presented in 1986 by G. C. Ghirardi, A. Rimini and T. Weber ([24],[25]). "GRW-theory" is founded on the assumption that besides the standard evolution, physical systems are subject to spontaneous localisations occurring at random times and affecting these elementary constituents. For the example of one particle of mass m, localisations (the emergence of classicality) occur at randomly distributed times with a mean frequency $\lambda_m = \frac{m}{m_0} \cdot \lambda$, where m is the mass of the particle, m_0 is the nucleon mass and $\lambda = 10^{-16} \cdot \frac{1}{sec}$ is a parameter of physics.
The localisation fixes the position of the mass m to a region of the dimension $a = 10^{-7}m$.
The time evolution of the particle in the time interval $[0, t]$ is then described by a generalised master equation [18]:

$$| \Phi(t) >= e^{L_0(t-t_n)} L_{cn} e^{L_0(t_n-t_{n-1})} L_{cn-1} ... e^{L_0(t_2-t_1)} L_{c1} \mid \Phi(0) > \tag{5}$$

where L_0 describes the undisturbed time evolution given by the Schrödinger equation and the jump operators L_{ci} describe the effect of the corresponding elementary jump-process or the emergence of classicality. Merzbacher [18] comments this master equation:
"The fact remains that the experimental decay law, for which we have so much empirical support

in radioactive processes, is not a rigorous consequence of quantum mechanics but the result of somewhat delicate approximations."

In our epistemological view, this jump process finds a natural explication and its strong dependence on the mass m becomes also understandable. Mass corresponds in our picture of reality to structure and it is obvious that the more structures compose a system, the higher is the probability for a mutual stabilisation of the descriptions for the whole system and its emergence as a classical object.

The impossibility to predict emergence exactly has recently been demonstrated by Conway and Kochen's Free-Will-Theorem ([24]): "The particles response to an experiment is free."
This theorem states that the outcome of an experiment cannot completely be determined by the previous information accessible to whom performs the measurement. A result that can be obtained likewise from principle (E) of section 3.

All the principles, we have obtained from Husserl's phenomenological method are completely realised in Mohamed S. El Naschies E^{∞}-theory into an exact mathematical framework. To stress this correspondence we will repeat the principles which constitute, in our opinion, the fundamental ideas of E^{∞}.

E1: Space and time must be defined by a "flexible structure" that obtains their final form only through the events that occur in space-time. El Naschie clearly formulates [3],[2]:
"Different particle content spans different topological spaces."
"What we imagine to be physics could be equally understood as a consequence of the geometry and topology of space-time."

E2: Classical reality emerges from a lower background by a "zooming"-process ([26]). As this emergence cannot be controlled from the lower level, that lower level must appear in the view from the higher level as composed by fractals. In this way, E^{∞}-theory presents an answer to Merbacher's preoccupation that had been mentioned in our discussion of GRW-theory. Principle (E) of section 3 holds in E^{∞}-theory. El Nashie resumes [28]:
"One could attribute the "wave collapse" to the hypersensitivity of E^{∞}-space-time to the fainest perturbation in the topology and geometry of the micro-space-time."

E3: Classical logic and probability theory are insufficient for an explanation of all phenomena in physics. El Naschie used negative probabilities in his very convincing explanation of the two-slit gedanken experiment ([28][29]).

E4: Stability is the basic reason for the existence of all structures. El Naschie uses stability as a global and not only as a local concept, he writes [30]:
"The large determines the small and visa versa in an inverse way."

It is the great merit of Mohamed S. El Naschie to give all these fundamental principles in one theory a clear and well-defined mathematical meaning: E^{∞}-theory. Especially (E4) is a very strong tool which allows many new explications in elementary particle physics ([26][27]).

We think, that the correspondence between our illustration of physical principles obtained from Husserl's phenomenological method and E^{∞} provides a strong confirmation for E^{∞}. From two very different starting positions, finally the same conclusions could be obtained. We have started from an epistemological standpoint whereas E^{∞} is based on ontology (as it should be for a physical theory). Ontology searches for the meaning of being. In E^{∞}, "existence" is not an unanalysable a priori concept, but the result of a deep insight into the world: "Existence" is constituted by "the harmony" the existing entities maintain between each other.

Up to our knowledge, there exists no other theory, besides E^{∞}, that offers a comparatively open concept to understand "the meaning of existence".

6 Conclusions

In a recent article, the outstanding physicist David Ritz Finkelstein had stressed that thinking is a capability which can not only be learned from natural sciences. In Finkelstein's interpretation, Albrecht Dürer's famous picture "Melencolia" offers the understanding of the world of Dürers age. Finkelstein concludes [31]:
"Only prior knowledge enables us to convert what comes through the senses into new knowledge. Actually we act as much as we react when we study nature."

This statement is in accordance to Husserl's philosophy, because in phenomenology knowledge is always constituted by intentions and these are free.

The most important objective of science consists in the development of a framework for our understanding that does not restrict our thinking. Such a framework is provided by E^{∞}. El Naschie states [32]:
"E^{∞} gives a general philosophical framework to understand many results which although correct are not easily comprehensible."

Possibly the intention of western culture, to get fast and effective solutions, had simplified our thinking too much. The simplicity and superficiality of our age my be the reason why many results of modern physics seem so strange to us. Recognising the enormous variety of inter-cultural thinking, it is not astonishing that in this context, our results are absolutely not new. Roapa Hulikal Narayan writes in his article "The Theory of Matter in Indian Physics" ([33]):
The Nyaya Vaisheskita school of Indian philosophy presents a dualistic view where an objective universe exists, "which is taken to be atomic and the subjective universe of the experimenter or observer which is taken to be non-atomic".

To the early Indian philosophers, the existence of a basic outside world (the quantum world) seems to be necessary. That world exists independently of any active participation of human mind. On the other side, the emergence of the classical world was perceived as an adaptation of this knowledge to human beings.
"Vatsyayama, a later Indian philosopher called the property under which an object obtains proper definitis [or classicality]: "lakskana"([33]."

The most important lesson obtained from physics consists in the esteem for every culture. All human societies together constitute the truth of our world.

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