An Approach on Information from Topological View

Gabriel Crumpei[1], Alina Gavriluţ[2], Maricel Agop[3], Irina Crumpei[4]

[1]Psychiatry, Psychotherapy and Counselling Center Iaşi, Romania
(E-mail: crumpei.gabriel@yahoo.com)
[2]Faculty of Mathematics, Al.I. Cuza University from Iaşi, Romania
(E-mail: gavrilut@uaic.ro)
[3]Gheorghe Asachi Technical University of Iaşi, Department of Physics, Romania
(E-mail: m.agop@yahoo.com)
[4]Psychology and Education Sciences Department, "Al.I. Cuza" University from Iaşi, Romania
(E-mail: irina.crumpei@psih.uaic.ro)

Abstract. To define information is not easy task due to the diverse forms in which it can be expressed and identified. The main forms that occur (data, information and knowledge) do not represent a mere structure with increasing complexity which implies the integration of information in knowledge and that of data within information. For data to represent information a processing system is necessary. For information to construct knowledge, the human psychic is necessary. On the other hand, Shannon's theory which is the basis of informational phenomena implies the approach of information from quantitative view and less from a qualitative one.

We shall demonstrate that this qualitative aspect is generated by the topology of the geometrical space which, in its turn, organizes the informational dynamics and explains the unity of reality from the informational point of view due to scale invariant feature of topology. We shall argue that from the qualitative point of view, information is made up of energy patterns situated at different topological configurations, while according to the quantitative approach, besides entropic elements, information is implied in fractal dynamics, the topology of geometrical space interfering in dimensional change. Such hypothesis will be supported by implying topology in all scales and reality levels, using the string theory and quantum physics, a new perspective of wave-corpuscle duality, as well as considering the molecular, biochemical, biological and mental levels, i.e. those places where information is permanently retrieved within topological dynamics.

We conclude regarding the hypothesis according to which topology as a mathematical discipline applied on information at different scales can offer a coherent perspective and an answer to the question "What is reality?"
Keywords: Information; Topology; Complex system theory; Fractals; Chaos.

1. Introduction

In our paper, we want to treat the information correlated to the substance and the energy, by applying the theory of complex systems, of complex analysis and of topology. We aim to highlight the fact that information can be found in the complex space of the wave phase spectral field. As a result, this complex space can be found anywhere and at every level of the reality. In our view, it is infinitely dimensional, as it can contain all the information in the Universe. From a mathematical viewpoint, the real space is included in and intertwined with the complex space generated by the electromagnetic waves. At quantum level, this intertwining can be achieved by the collapsing of the wave formula into the complex space of the wave phase and it can be transmitted into the complex space of the spin rotation, by transferring the whole information. This phenomenon is specific to reality at the level of the whole knowable universe, as everywhere there are electromagnetic waves and also at every level of the reality, including the human brain.

Our hypothesis is that the complex space is a physical space, which includes the real space which it generates and maintains through permanent dynamics. Thus, the complex space describes in fact a physical reality which integrates Newtonian reality, quantum mechanics and cosmology etc.

2. Information. Definitions and concept-making

In an etimological sense, the information is what gives shape to the spirit. It comes from the Latin verb *informare*, which means "to give shape" or "to form an idea on something". The perception on the information is as heterogenous as possible, the concept of information being a subject for reflection and analysis in: information theory, communication theory, knowledge theory, logics, semantics, philosophy, theology etc. Mainly, data forms information and information constitutes knowledge. Actually, the phenomena is not reduced only to an inclusion of a field into another. The information needs data and

operation and memory systems, whereas knowledge supposes an accumulation of information, but also of superior psychological systems, such as generalization, abstractization, synthesis, correlation and significance. This diversity under which information is presented determines both the defining difficulty and a unitary understanding of its significance at different levels of reality.

With quantum mechanics, the necessity emerged to define information at quantum level. In the theories which appeared in the second half of the twentieth century (the theory of chaos, the theory of fractals and of non-linear dynamics), all united into what is called the theory of complex systems, the necessity to define information appears more imperatively, especially because this theory is applied irrespective of the scale, to all levels of reality. The science of complexity, which attempts at modelling the structure of matter at different scales or reality levels, needs a new approach of information as a defining notion along with energy and substance. This is the reason why defining information becomes even more complicated from the perspective of the new paradigms. Traditionally speaking, there are two meanings of the information notion. One with the aristotelic acception, which designates the formation and structuring of a specific form, of an organization within an initially non-homogenous matter, the other signifying the transmission of a message. Information can also be seen as a proper fact, as a relation fact, as a fact of action transmission. That is why we are talking about an objective information transmission which is related to the structure of the Universe, be it macroscopic or microscopic, but also of a subjective meaning, which involves human communication, not only between human beings, but also between them and the various information technology devices and technologies.

The theory of information is connected to Shannon and Weaver [21], who defined, in the 50s and 60s, information as an entity which is neither true nor false, neither significant nor insignificant, neither credible nor doubtful, neither accepted nor rejected. As a result, it is not worth studying anything else than a quantitative component of information, but not also the semantic part, which allows for the association of information with the second theory of thermodynamics, with entropy, the information or the quantity of information being in inverse ratio with it.

Weaver connected Shannon's mathematical theory with the second thermodynamic law and asserted that entropy is the one which determines the information generation ratio. The formula of information is identical to the one of entropy elaborated by Boltzmann, but considered with a minus sign:

$$\mathbf{H} = -\sum_{k=1}^{i} \mathbf{p_k log p_k}$$

where p represents the probability of an element or event k within the system.

Information is, thus, entropy. It is important to notice that Onicescu [17] also formulated the hypothesis regarding the fact that the degree of organizing a system can be " measured" with the help of informational energy, thus defined:

$$\mathbf{E} = -\sum_{j=1}^{n} \mathbf{p_j^2(A)}$$

where p represents the probability of appearance of the event A.

This quantitative approach of information is applied in the field of telecommunication and of information technology. Under this approach it is important to establish the quantity of information and its true or false character in transmitting information, to which probability notions can be connected in order to find, with the receptors, the source-transmitted information. Even within this technological approach, two aspects of information are highlighted: information as a product, which reflects a static overview, and the approach as a process, which highlights the genesis and the scope of information. In fact, the two aspects represent the information as potentiality and the information expressed and involved in the dynamics of the becoming and structuring of matter.

Upon attempting to structure the multiple informational approaches, Introna [15] distinguishes two archetypes: the informational and the communicational one. The first was patented with the explosive development of informational technology and is connected to the making (development) of "productive"

informational systems. The second has its origins in the communicational frame of Shannon and Weaver [21], being less important in the field of informational system field, but it is more widely accepted in the theories of communication. Similarly, Stonier [18] is of opinion that the fundamental aspect of information is connected to the fact that this is not a mental construction, but a fundamental property of the Universe. Any general theory of information must start with the study of the physical properties of information, as it is manifested in the Universe. This action must be taken before attempting to understand the variants and the more complex forms of human information. The next step must involve the examination of the evolution of informational systems beyond the physical systems, first in the area of biology, then in the human, cultural area.

The scientific approach of the information theory starts from the classical opinion that mathematics is the general language of nature. The structure of the Universe is written in the mathematical language, and its letters are geometrical forms, symbols and mathematical relations. Tegmark [19] maintains that at the basis of reality there are mathematical structures and the relationships between them and that elementary particles are mathematical structures which can be perfectly described only by mathematical properties. Thus, these mathematical structures and the relationships between them define what we call today information, whereas science does not do anything else but decypher the information contained in the structure of the matter, by physical-mathematical modelling. According to this paradigm, information is to be found in nature, outside of, beyond and independently of the observer. As a consequence, information must have existed before the appearance of human conscience.

To put it different, the information is the fundamental component of reality, such as matter and energy, as the nature is filled with information. On a larger scale, information exists before, or, in other words, knowledge is ”more fundamental” than its observer and interpreter. Thus, the reunited concepts of matter (substance and energy) and information can explain the emergence, the forming, structure and dynamics of mind and knowledge, but also of the whole structure of the Universe. Information has an objective natural existence; people absorb it in their minds and the computer memory modifies and multiplies it through thought and bring it to the ”middle” of society via the language.

At the opposite end of this materialistic-objective approach of information is the belief according to which information is something one person communicates to another, whereas the meaning of information can be understood only if we take into account the presence of alive beings endowed with reason, placed into a socio-cultural context and analyzed from a historical perspective.

A fundamental trait of information is connected to its subjectivity. Whatever can be information for a person can mean nothing to other people. Whatever is considered as information for a person can be data for another person. On the other hand, starting from the same set of data, different individuals, through different processing, can infer different information. If the data has a physical, tangible existence, the information exists only with the receptor, thus it is intangible. Information is the product of human or artificial intelligence and what constitutes information for one person can represent mere data for another person.No matter how difficult the definition and significance of information is, a possible modality of understanding what information represents in its essence is to be able to define the connection between energy, substance and information.

3. The place of information in the wave-corpuscle duality

The paradoxes highlighted by quantum mechanics in the first half of the 20^{th} century include, apart from the uncertainty relations of Heisenberg [14], a strange involvement of the observer in developing quantum phenomena. These facts suggest that the splitting into subjective and objective information is artificial and that they should be regarded as aspects of the same phenomenon. In order to uphold this idea, we must take into consideration another paradox of quantum mechanics, which is just as exciting and linked to the entaglement phenomenon, which, as a result of repeated experiments, highlighted a reality which is hard to infer, that is that all the particles which interacted at a certain point remain connected.

All these paradoxes that quantum mechanics imposed, along with the wave-corpuscle duality, determined a new approach in physics, mathematics and in the scientific approach in general. If during the 20^{th} century it was studied from the elementary particles' point of view, of the wave component from the spectral viewpoint and materially under the form of substance and energy, the information was not treated at its true value, according to the role it has in quantum mechanics. The information technology era, as well as the theory of complex systems, with the chaotic aspects in which information has a potential character, but which explains the dynamic evolution patterns of the system which is highlighted in the phase space, have all imposed the comeback on the role of information at quantum level.

The complex systems theory imposes re-analyzing the wave-corpuscle duality from the perspective of fractal geometry and of non-linear dynamics, which also need the involvement of information as a third element in the wave-corpuscle duality.

In Scale Relativity Theory, the dynamics of any physical system is described through dimensions which can be expressed through fractal functions, that is functions which are dependent both on coordinates and on time, but also on resolution scales. Moreover, any quantity can be written as sum between a differentiable part, i.e., dependent only on coordinates and time, but also on a fractal part, i.e. dependent on both coordinates and time, but also on resolution scales. In such a context, the differentiable part is proved to be compatible only with the predictable states of the physical system, while the fractal part is proved to be compatible only with the unpredictable states of the same physical system.

The analysis of wave-corpuscle duality in de Broglie's theory involves the simultaneous existence of two types of movements: a deterministic movement, which is predictable and associated to a continuous movement of hydrodynamic type along a continuous line, which is specific to the corpuscle character, and a zig-zag random and unpredictable movement, which is specific to the wave character. De Broglie's model introduces the two types of movements only as hypotheses, but the real problem, how much it is wave, how much corpuscle, as well as the wave-corpuscle structural compatibility (the structure of the wave should be compatible with the corpuscle structure) has not been solved yet.

A new approach modality of the problematics involved in the wave-corpuscle duality resides, in our view, in supposing that the movement of a particle takes place along continuous and non-differentiable curves. This means passing from a classical approach of movement within an euclidean space to a non-conventional, non-standard approach, with the assumption that movement takes place within a fractal space-time.

Thus, de Broglie's difficult problem can be solved, meaning that this could not justify the uniform movement of the particle within the wave field (incompatibility with the straight-line, uniform movement of the wave-corpuscle duality). The postulate through which motions are introduced on continuous and nondifferentiable curves solves this problem of the straight and uniform movement, meaning that on the new fractal manifold the movement is free (on geodesics). By accepting such a postulate, on the basis of the model of Scale Relativity Theory, it results that the geodesics of a fractal space-time supports a double representation, a stochastic, unpredictable one, described by Schrödinger type equations and specific to the wave character, and at the same time a deterministic, predictable representation, through the fractal hydrodynamic model, which is specific to the corpuscular character.

In Schrödinger's representation, only the modulus of the square wave function has physical significance, while in the second case we talk about average movements of some fluid particles which are submitted to a datum force, a force which is induced by the unpredictable part (non-differentiability of the motion curves). Non-predictibility, described through the non-differentiability of motion curves can be related to a Shannon-type fractal informational entropy, which, based on a maximization principle, leads to an egalitarian uncertainty principle. Within this uncertainty principle, the interaction constants are specified on the basis of an Onicescu-type informational energy. Now, we mention the fact that only the constant value of the Onicescu informational energy settles the interaction constants within the uncertainty relations.

Through the maximization principle, the integrally invariant functions are simultaneously probability density and movements on constant energy curves. Practically speaking, through the principle of informational maximization, the unpredictable, wave character given by the probability density is linked to the corpuscle character given by the energy.

The unpredictable part must be directly correlated to non-differentiability and is manifested through the existence of a potential, also called fractal potential. The principle of maximization of the informational energy gives a concrete form to the potential and the latter, introduced in the fractal potential, gives complete form to the force field. As a result, the informational energy not only stores and transmits the information through interaction, but also connects it directly to the deterministic part through interaction. So, practically speaking, the owner of all "mysteries" is the fractal potential, which imposes the intelligent, fractal medium and the informational energy which gives the force.

As above-specified, on the basis of the non-predictable component, one can define a fractal entropy in Shannon's sense and, starting from here, a fractal informational energy in the sense of Onicescu. By using a maximization principle of fractal entropy in Shannon's sense, one can demonstrate that, if fractal informational energy in Onicescu' sense is constant, then the ratio between the corpuscle energy and the frequency of the associated wave is a constant at any resolution scale. As a result, the wave-corpuscle duality is achieved through movements on curves of informational energy constant in Onicescu's approach (for details, see [1-7, 11-13]).

4. Information as an expression of topological transformations. Different levels of reality

Topology studies the deformations of the space through continuous transformation, practically-speaking the properties of sets which remain unchanged at some transformations. Movement is a fundamental aspect of the real world and any elaborate study of dynamics leads to topology, as long as there is a dimensional space. Nevertheless, applications of the topological ideas appear in various fields, such as the theory of chaos, the quantum theory of fields, molecular biology, where the description and analysis of twists and deformations of the DNA molecule needs topological concepts. More specifically, the so-called topology of the knots allows for understanding the way in which the two spiral chains which make the double elicoidal structure of the DNA molecule can be unfolded when the genetic plan controls the development of the living being.

Starting from quantum microcosm towards our Newtonian reality, we meet the information under the same topological forms at every scale. Atoms form molecules and macromolecules, whose spatial configuration suffers topological modifications which grant them some properties. Organic macromolecules in protein and enzyme form ''ship'' the information to cellular receptors, under the form of topological structures. Any modified radical determines a reconfiguration of spatial structures, which generates a certain property necessary in the chain of metabolical transformations which in this way are topologically equivalent, as they are obtained through topological transformations.

Any biochemical structure represents a graph, every cellular structure represents a network which forms knots and whose dynamics can be described by the network topology, which explicitly mentions the vicinities of every point. All this information comes from the structure of the DNA. The latter, apart from the succession of nitrate bases which form the genes, has a topologically-complex structure, in agglomerations which form the chromosomes, but which also influence the coding functions. The same information transmission mechanisms from DNA to RNA messenger and RNA ribosome and the constituting of protein and neurotransmitters we can also find within the structuring and functioning of the nervous system. We meet networks, knots, graphs, thus topological transformations also in this instance. All these represent only one part of the reality, because atoms, molecules, macromolecules, etc., are bodily aspects of the wave-corpuscle duality. All these structures have also a wave part, they are practically doubled by a spectral reality, of electromagnetic field.

The term topology is used also for establishing the projecting manner of a network. In order to highlight the physical (real) and logical (virtual) inter-connections between the knots, one can distinguish two corresponding types of topologies: a physical and a logical one, respectively. The physical topology of the network refers to the configuration of the transmission environments, of computers and peripheral devices, whereas the logical topology represents the method used to transfer information from one computer to another. The theory of domains developped within lattices represents a modality of modelling the topological concepts in a computational form, which allows for the processing of information.

Now, coming back to the wave-corpuscle problem, an analysis of the particle behaviour can be made from the perspective of fractal space-time, with the unpredictable and non-linear evolution, allowing that, on the basis of the informational theory of Shannon, we connect it to entropy and further, through a maximizing process, to the informational energy in the acception of Onicescu. There still remains an essential question: where can we search for and find the information in this quantum dynamics. It must be present both in the wave structure and in the particle properties. This connection cannot be made otherwise than in the phasic component of the wave, which is to be found in the spinning of the particle and which allows for the transfer of information from the spectral reality to the corpuscular reality, as it is demonstrated by the transform and the reverse of the Fourier transform. The phase is given by the magnetic component of the electromagnetic field and it represents the unpredictable, potential part, described by the complex function of Schrödinger's wave formula, as these characteristics can be explained both through the fractal theory and through the topological transformations supported by the phase from the electromagnetic wave, respectively by the spin from the particle description.

The spinning movement is mathematically modelled using the complex analysis. This model is dynamic, as it undergoes transformations at the level of topological dimensions through the successive passage from the topological dimension 0 (of the point) to the topological dimension 1 (of the line) etc. Thus, a complex, infinitely-dimensional space is made, which explains the difficulty of highlighting the informational component. The successive passage through Euclidean, fractal and topological dimensions determines a quantitative, but also qualitative dynamics of energy. The moment in which this qualitative diversity is expressed is given by the moment of topological transformations at every dimension. This diversity which is practically unlimited renders quality, apart from quantity, to energy in its dynamics. From the perspective of complex systems we can find, in the statements above, the main characteristics specific to complex systems: non-linear dynamics, fractal geometry, with a latent informational energy which is

potential, along with a dynamics of a practically infinite diversity, obtained by topological transformations in the phase complex space.

If we accept that topological transformations are invariant as compared to the scale and that these topological transformations represent energy patterns, configurations through which information is expressed, it should happen that, irrespective of the level of reality and of scale, the information has as an underlayer these topological transformations. The consequence of this is the ubiquity of information, just as the substance and energy, both at the level of microcosm and at macrocosm level.

Obviously, there exists structural information which, along with energy and substance, structures the matter at different scales and aggregation states. It is a structural information, which is achieved through topological transformations in fractal dynamics and even in euclidean dynamics. The topological space represents the place where information gains diversity, whereas energy gains a qualitative character. Qualitative variations of energy appear here, which constitute the informational energy or the psychological energy at mental level. Jung, in his research [16] over the unconscious and archetypes considers psychological energy to be a form of energy described through qualitative, not through quantitative ones, as physical energy was described. We will detail these considerations further below.

5. Dynamics of the real space – complex space in the structure of reality and psychism

Complex functions mathematically describe physical phenomena which assume the rotation movement around the own centre, including the movement of the magnetic vector of the electromagnetic wave, as well as from the fluid dynamics, and they sustain such hypotheses, theories and phenomena that the modern technology presupposes. This phenomenon is present first of all in the electromagnetic waves and thus it can be found in many situations which are theoretically and technologically described. The electric field corresponds to the real part, whereas the magnetic field corresponds to the imaginary component. The magnetic vector has a spinning movement, which is described by complex functions. At a 90-degree rotation (multiplication by i), an inversion of the components of the complex number takes place, a movement which in physics implies a Wick rotation. By multiplication with i , the amplitude and the phase are mutually modulated and their correlation is achieved by information.

The unpredictable, a-causal, unstructured, potential part of the complex systems structure can be found in the structure of the spectral field, associated to the corpuscle from the structured, causal, Newtonian, predictable part. This spectral component contains, through the imaginary component of the wave formula that describes the phase (the dynamics of the magnetic vector) the access to complex spaces, where the whole information can be found, structured in the topological geometry of energy configurations. The infinitely-dimensional possibility of these complex spaces, just as the infinite diversity of topological transformation within these spaces, along with their scale invariance allows for the estimation that in this infinitely-dimensional complex space we can have access to the whole information of the Universe. Thus, in a unitary approach, one can find the theory of complex systems, which comes from a physical perspective of the fluid physics, fractal theory, chaos theory and topology, with the complex analysis and the complex functions which use complex numbers with their imaginary component and which describe, in physics, the imaginary, unpredictable, potential, non-differentiable part, which can be found in the theory of complex systems.

As in mathematics information can be stored or processed by algebrical equations or by trigonometrical functions, in physical reality also information can be either algebrically or geometrically structured. The Fourier series and the Fourier transform achieve this through the interface between a spatial-temporal reality and a spectral one. Because the spectral reality is a-temporal, a-spatial, the Fourier transform and the reverse of the Fourier transform make this switch between the algebrical and the geometrical description. The mathematical model for the complex spaces includes the existence of topological transformations within an infinitely-dimensional space. As a result, the reality of the wave formula as being a-temporal, a-spatial, represents an interface between the newtonian reality and the complex ''reality'' of the complex spaces (Hilbert space).

The discontinuity of reality described by Planck as an energy quanta, by Gabor as information quanta, the non-differentiability specific to fractal dynamics, as well as the property of complex systems with deterministic chaos, all are due to a continuous interference between the physical and the complex reality through the spectral field. Depending on the local field conditions, of forces and scale structure, with the action of attractors, information from the complex space is absorbed (qualitative energy patterns, diversified through topological transformations), in order to structure the quantum or comsic Euclidean space.

The dynamics between the complex and the physical space is an expression of the mathematical description of reality through algebrical or trigonometric equations. The potentiality can be encompassed, codified in trigonometric equations and it expresses the information in an a-spatial, a-temporal reality which is specific to the wave and which is algebrically transformed in geometric form when a spatio-temporal reality appears, as it happens when the wave collapses into a corspuscle. In both cases, topological transformations are possible (in an a-spatial, a-temporal situation trigonometrically expressed, but also in a spatial-temporal one, expressed algebrically or geometrically).

Another argument of the physical character of the complex space is the wave function and wave function equation description which impose the existence of the Hilbert space. This abstract space allows for the description of the wave function and of the Schrödinger wave function equation. This space imposes the inclusion of both the real part of the wave and of its imaginary, complex one. As a result, the Hilbert space has properties of the complex space (the infinitely-dimensional character), the description by complex functions (complex analysis), but also the real part which includes the amplitude of the wave and its potential capacity of becoming real in the collapse of the wave formula. Another element which belongs to the real part is the space-time continuum character which we can find in the Minkowski space, but which we also find concentrated in the Hilbert space in the characterizing expression of the wave as being ,''a-spatial", ''a-temporal". In our view, the Hilbert space is an interface between the real space and the complex space and a proof that the complex space is a physical space connected through a permanent dynamics with the real space, as long as we accept the wave as real, with its wave function and wave equation.

The dynamics between the complex and the real space (the neuronal network), by way of the spectral field (wave field represented by the totality of the waves associated to the corpuscles in the neuronal network) is the basis of the psychological system functioning. This paradigm can generate new hypotheses which should explain the mysteries of the psychological life, just as the old ''mind-brain" duality. This new topic structure of psychism, associated with the theory of complexity and simplicity, applied to fractal geometry, through which reality is structured, allows the brain to have access also to the knowledge of the fractal as a whole, when the mathematical model is reduced as a number of informational bytes, to put it different as a symbol, but also, through the analysis and synthesis capacity, to be able to conceptualize the fractal at any point or at any scale, with the cost of an enormous informational content.

From a physical viewpoint, at any scale, there is a differentiable hydrodynamic description mathematically modelled by hydrodynamic equations, but also a stochastic, potential description, expressed by the equation of the wave formula. If we accept that the Hilbert space presents both the properties of the Minkowski space and the ones of the Euclidean space, just as of the infinitely-dimensional complex space, then it results that the Hilbert space represents the interface between the real space with all its descriptions and the complex space with all its potentiality.

Thus, the whole psychological life can be considered to take place in this Hilbert space which allows also for a Minkowskian perspective, a spatial-temporal continuum, under the form of the fractal space-time, where the information trigonometrically stored is a-spatial and a-temporal, thus creating the conditions of a stable memory, but also a spatial-temporal tri-dimensional perspective which represents sections in time and space of this continuum. This material component of the neuronal network allows for the processing of information, but for the superior psychological processes, the processing is achieved in the complex space, so that the synthesis, generalization, abstractization, conceptualization, all assume a multidimensional perspective, which can be made only in the infinitely dimensional complex space. More precisely, the dimensional dynamics from the 0 dimension to infinitely dimensional which in our reality is realized only up to three dimensions, can be realized multidimensionally in the psychological reality in the complex space (through the fractal potential).

6. An approach from the perspective of the complex systems theory for the processing, storage and transmission of information at brain level

As we already know, a complex system cannot be analyzed on principle through the part fragmenting, as it is made up of elements which make sense only within the privacy of the system. It has an unpredictable evolution (than, mostly, within a short time frame called temporal horizon), can suffer sudden transformations, no matter how big, without obvious external causes and it manifests different aspects according to the analysis scale. It is on principle different from a complicated system because the difficulty of prediction is not to be found in the inability of the observer to analyze all the variables which would influence its dynamics, but in the sensitivity of the system to initial conditions (slightly different initial conditions which lead to extremely different evolution possibilities), to which one can add the effect of an

auto-organization process (process determined by the very interactions between the component sub-systems and whose effect is the spontaneous emergence – principled unpredictable – of some order relations).

A complex system can be modeled and studied within a topologically-equivalent space, called the phase space, in which specific notions are defined: attractors and repulsors, attraction basin, trajectories, limit cycles, etc. In this context, one can talk about a functional modeling, which is much more abstract and ''unbound'' from the constraints imposed by a concrete ''anatomy'' and ''physiology''. While classical modeling starts by approximating what ''can be seen'', functional modeling involves the identification of an equivalent dynamic system, whose behavior can be analyzed through specific methods with an extremely high degree of generalization.

In the systems composed by a great number of elements, the properties of the systems cannot be found in the total amount of the complex systems properties. The emergence property is what creates a link between the multitude of the components and the properties of the complex systems.

All these theories are trying to describe, as close to the reality as possible, the privacy of the functioning of systems with a great number of elements, which interacts with other systems (dissipative systems) and which in fact are widely-met in the physical reality. These systems have a series of properties, among which the emergence is one with special implications, but also the dynamic structure they presuppose, generally characterized by a structured, causal, Newtonian, predictable component and an unpredictable, a-causal, unstructured, potential one. Physical experiments (the ones in the plasma tubes but also in the fluid dynamics, etc.) have highlighted these components just as the dynamics between them, which presuppose an auto-structuring tendency by means of the attractors within a certain space called the phase speace. However, there remains an important question connected to the source of information which allows for the auto-structuring and thus the dynamics between the potential component and the predictable one. In the plasma tubes experiments, the phenomena can be more easily observed because upon modification of the system constraints (modification of electrical tension to the two ends of the tube) we can obtain different particle organisation patterns which presuppose the interference of some informational structures. The current explanations for the source of this information is that it comes from the privacy of the system. However, in the structure of the system (if we stay with the more simple model of the plasma tube) there are only particles and their attached wave component. Considering that the information contained by the particle comes from the coherent wave, the question which arises is where the information comes from, at wave level. In everyday life, today, in the information technology era, the information is trasmitted via waves, by their analogical transformation into waves which modulate a carrying wave. Modulation can be the modulation of the amplitude (little employed because it is too easily affected by noise, but anyway the amplitude is in inverse ratio to frequency), the generally-employed modality is that of angle modulation, which presupposes a modulation of either the frequency or of the phase, which is finally transmitted to the modulation of the magnetic vector angle. The phase is recognized as being an imaginary, complex component of the wave formula. The movement of the magnetic wave described by complex equations generate a complex plan, which connects the wave to the complex space and allows for the storage of information in the topological modifications from this infinitely-dimensional space. To put it different, the information in the complex systems is to be found in the complex space, which gives the characteristics of potentiality, non-differentiability, a-causality from the description of complex systems.Coming back to the plasma tubes, the privacy of the system from which information comes is represented by the coherent wave phase with every particle (the wave corresponding to every particle from the wave-particle duality) which represents the connection to the complex space, where the whole physical reality is to be found at the potential mode, under the form of information. This is the consequence of permanent dynamics between the complex and the real space, by means of information. Depending on the system constraints from the complex space through the wave phase, the information which reaches the particle generating the auto-structuring patterns is undertaken.

In the structure of complex systems there is a potential part with a chaotic aspect and a structured, causal, newtonian part, as well as different intermediary phases. From there it results that a certain uncertainty exists in all the structure of reality. Moreover, we find the uncertainty principle (Heisenberg [14]) in Gabor's theory of communication (the information quanta). At brain level, the non-linear, potential, apparently chaotic part corresponds to the unconscious, whereas the structured, causal part corresponds to the conscious; the intermediary parts, as well as the structures which process both the information from reality and from the unconscious, all are represented by what Freud called SuperEgo.

The chaotic part is structured via attractors, depending on the constraints of the system (for example, the way in which some physiological needs generate, during the dream, a certain structure). During the wakefulness there is a dynamics with the chaotic, potentially unconscious part in the background and which allows accessing the information, the memories, the logical links (for example, a discourse).

We must therefore accept that, also in the living world, including the brain functioning, there exists a spectral, wave component and the transmission of senses is achieved spectrally, by vibrations [9, 10].

Thus, a reality which coexists with us is the a-spatial a-temporal one, described by the wave formula and which is involved in the visual perception phenomenon, in which the undertaking of the spatial-temporal information is made by light through modulation of its frequency, a phenomenon which is described by the Fourier transform, while the stimulation of the retina involves the collapse of the wave formula and the emergence of corpuscles which stimulate the retina cells by inversing the Fourier transform. As a result, all we look at and see, in order to be seen, goes through an a-temporal and a-spatial phase, in the interval necessary for the light to reach from the object to us. This interval can be million of light years for cosmic objects or minutely small fractions of a second when we look at our friends, our home or our garden.

Information is codified energy which is expressed as pattern, structure templates, innitiated by attractors which are active in the phase space, between the chaotic part and the structured one. The information lies stored in the spectral space and it expresses the patterns in the structure of atoms, molecules, macro-molecules and cells. It has a potential existence which is expressed by substance and energy under certain conditions (of local coherence).

A virtual, Newtonian reality as projection of physical reality is completed by the unstructured, a-causal, apparently chaotic component: the imagination, the dream, the failed acts, the subliminal mechanisms, the unconscious etc., which can be associated with the causal, potential, unstructured and non-differentiable component of complex systems, the source of inspiration, of creation and of access to non-Euclidean realities to holospace. These potentialities can become conscious through patterns (see the archetypes and the collective unconscious of Jung) and they can be found in logical, algorithmic, organized and systematic form in everything that is creation (from making a speech, conversation, improvisation, to creating new musical pieces, new artistic work, new scientific work). The chaotic, unpredictable part does not only contain the Newtonian reality to which we have access, but more, maybe even the structure of the whole Universe, at informational potential level. The brain has access to the implicit part (the implicit reality of Bohm [9]), if we associate this part to what the classics called unconscious. From here derives the capacity for mathematical reasoning, for physics, for reasoning reality in n dimensional spaces, a-temporal realities, a-spatial realities.

The development of the neuronal network is made according to fractal criteria, just as all the other apparatuses and systems of the human body. As a result, the spectral field formed by the waves corresponding to corpuscles form the neuronal network are coherent, allowing for the processing of information both in the neuronal network and in the spectral space (the Hilbert space), where both the a-spatial a-temporal components exist, as they allow memory to develop, but also the complex component which offers the possibility of a multi-dimensional processing which can explain the superior psychological processes (conceptualization, semantics, abstracting and generalization etc.). At any scale we can find the two types of realities: a differentiable one and a non-differentiable one, highlighted by the Madelung hydrodynamic model Madelung and respectively by the stochastic model.

Analyzers manage on principle the transformation of wave information in the corpuscle, thus generating the tri-dimensional and the spatial and temporal vision upon reality, but the processing at brain level is also spectrally made (de Valois [20]). Because the whole of the analyzers achieve the information transfer from a wave form to a body form, the processing of information is achieved both within a material, corpuscle network, the neural network, but also in a spectral network, of the coherent field associated to the neuron network. Through the waves of the spectral field the dynamic link to the complex space is made, process which allows for the occurrence of the superior psychological processes, specific to the human being, which need multidimensional development in order to be formed, development which is only allowed by the complex space. The psychological reality represents the permanent dynamics between the neuronal (material) network, the associated spectral field (the fractal potential) and the complex space (infinitely-dimensional).

The processing of information for the information provided by analyzers is made in a differentiable, causal, algorithmical form at the level of the neuronal network (Barabassy [8]), whereas beyond the analyzers it is made within a complementary network found in the complex space, which is mediated by the fractal potential from the spectral potential of neurons. As a result, the qualitative leap represented by the appearance of culture would not have generated only the appearance of mirror neurons which are present also in some animals, but the development of genetic patterns which allowed for a better connectivity between the two networks. It is not a matter of chance that the appearance of articulate speech is associated to this qualitative leap in human development. The centre of speech appears to represent a system of processing information which allows for connecting to the infinite and complex-dimensional space and thus to the possibility of emergence of superior psychological processes. The study of the mimic-gesture language of the deaf individuals highlighted the fact that, in learning this language, there is a first phase of learning of a mimic-gesture behaviour which is processed in the right hemisphere, which is specialized in spatial representations and becomes truely language only when it is undertaken by the speech centre from the left hemisphere. Then the mimic-gesture is processed at the level of notions and concepts

and superior processes can be achieved, such as abstractization, synthesis and generalization. The result is that the centre of speech can be such a module which allows for the connection of the neuronal network with the one corresponding in the complex system and thus the leap towards Homo sapiens can be explained.

Concluding remarks

The complex systems dynamics and especially that of the complex and of the real space (from the inner part of the systems) may lead to new hypotheses and theories about the structure of psyche and about its functioning.

The whole collection of the analyzers manages the transfer of information from its wave form into corpuscular form. This allows for the information processing to be accomplished both in a corpuscular, material network, the neuronal network, but also in a spectral network, of the coherent field associated to the neuronal network. Through the waves of the spectral field the dynamical link to the complex space is realized, situation which allows for the occurrence of the superior psychic processes, which are specific to the human being, and which need multidimensional development in order to be formed, a situation which is only allowed by the complex space. The mental reality represents thus the permanent dynamics between the neuronal (material) network, the associated spectral field (the fractal potential) and the infinite dimensional complex space.

The aim of this paper is to apply the theory of complex systems in order to sustain the hypothesis of the complex space as a physical space. We want to treat the information correlated to the substance and the energy, by applying the theory of complex systems, of complex analysis and of topology. We aim to highlight the fact that information can be found in the complex space of the wave phase spectral field. As a result, this complex space can be found anywhere and at every level of the reality. In our view, it is infinite dimensional, as it can contain all the information in the Universe. From a mathematical viewpoint, the real space is included in and intertwined with the complex space generated by the electromagnetic waves. At quantum level, this intertwining can be achieved by the collapsing of the wave formula into the complex space of the wave phase and it can be transmitted into the complex space of the spin rotation, by transferring the whole information. This phenomenon is specific to reality at the level of the whole knowable universe, as everywhere there are electromagnetic waves and also at every level of the reality, including the human brain.

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