QUANTUM NEUROLOGY: A KEY WITHIN PHYSICS TOWARD THE KNOWLEDGE OF THE CONSCIOUSNESS?

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ABSTRACT: The contents of this paper are centred on the dialogue between the experimental and positive Sciences and Theology. This dialogue should be based on the principle that both parts have to assume the existence of undemonstrated axioms that are necessary for obtaining their respective valid conclusions. Besides, all interlocutors have to accept the submission of their arguments to the scrutiny of the general scientific method. The relationship between Neurology and Theology is centred on the dichotomy established in the dilemma summarized in whether the conscious acts of the human being are exclusively generated via physical states or are due to an essence within its anthropology that originates the will to do them. Although I do believe in the second branch of this dichotomy, the research of the correlations between physical states of the brain and the consciousness actions are the main goal of my analysis. The fundamentals of Classical Neurology lie in the assumption that the neuronal system is a complex electronic lattice in such a way that the procedures and developments carried out in it should be similar to those performed in a classical computer. After an analysis of the difficulties of this model in the interpretation of the ontological consciousness properties, I give the basis of the brain study from a Quantum Physics point of view presenting both the known proposal of the Hameroff-Penrose and new proposals based on coherent collective states. The possibility of the survival of quantum coherence of these many-body states to temperatures higher than that of the human body is the main objection posed by the classical neurologists to the availability of Quantum Neurology. The description of two different ways of attaining these many-body coherent states allows us to understand the reasons for this possible survival, this being the main contribution of this work.

KEY WORDS: emergentism in the human soul, brain and self, classical *versus* quantum neurology, microtubules and tubulins, coherence and collective coherent states, excitonic model of microtubules. Biexcitonic model.

Neurología cuántica: ¿una clave física para el conocimiento de la consciencia?

RESUMEN: La temática de este trabajo está centrada en el diálogo entre la Teología y las Ciencias positivas y experimentales. Las bases de este diálogo hay que encontrarlas en el hecho de que todos interlocutores deben aceptar que se puede llegar a conclusiones con sus respectivos modelos si y sólo si se aceptan unos principios axiomáticos e indemostrables que dan soporte a dichos modelos. Además todos interlocutores deben utilizar en sus argumentos el método científico general. La relación entre Teología y Neurología se centra en la dicotomía de si los actos conscientes se deben a determinados estados del cerebro o existe una entidad inmaterial que genera la voluntad de realizarlos. Aunque creo más en la segunda parte de esta dicotomía, mi aportación al diálogo estaría en la búsqueda de correlaciones entre los actos de conciencia y determinados estados del sistema neuronal. Los fundamentos de la Neurología clásica radican en que el cerebro es como una red eléctrica compleja que debe analizarse como si se tratara de un ordenador electrónico clásico. Una vez expuestas las objeciones a este modelo clásico de cerebro, propongo las bases del su estudio dentro de la Física Cuántica, explicando la conocida propuesta de Hameroff y Penrose y nuevas propuestas posibles basadas en estados coherentes colectivos. La principal objeción de los neurólogos clásicos a la Neurología Cuántica es la imposibilidad de la supervivencia de la coherencia a temperaturas del cuerpo humano. La descripción de dos modelos de obtención de estados coherentes permite entender por qué es posible esta supervivencia, siendo éste el mayor logro de mi trabajo.

PALABRAS CLAVE: emergentismo y alma humana, cerebro y ego, neurología clásica *versus* cuántica-microtúbulos y tubulines, coherencia y estados coherentes colectivos, modelo excitónico de los microtúbulos, modelo biexcitónico.

1. Preface

The dialogue concerning the relationship between Theology and Experimental Sciences in issues such as Cosmogony, Cosmology, Universe models and possible multivers is clear. Ideas that immediately rise in this dialogue are the creationism versus the matter immanence; thomist requirement of the Supreme Being versus the reason why the matter-energy dualism and their laws of evolution are not sufficient; the essential need of the existence (or not) of an Agent who gradually implements the play rules within this dualism in front of the possibility that the energy itself is the true creator according to a seminal monism, i.e. energy and matter being two sides of the same coin in such a way that the spatial energy accumulation is the essence of matter. All these questions converge in this stimulating dialectic and the possible answers can illuminate all parts of the dialogue which can serve to their mutual development analyzing both the common points and the divergences. However, the fact of taking into account the Neurology and Neurobiology in this face to face between Sciences and Theology seems too widespread and complex since no religious text deals with issues related to the neuronal system, brain, mind and/or human soul.

A deeper analysis in this theme allows the obtaining of clues and reasons for establishing the possible controversy founded in the following question: what are the states of brain matter which define the self and the will of this self from a philosophical and theological perspective?

A golden rule of this dialogue for the sake of its efficacy is that both parts of this confrontation should be considered in strictly equal starting conditions. Moreover, both parts should recognize the existence of unproven and axiomatic principles which are necessary for the development of their respective inference rules in order to obtain valid conclusions. In addition, all interlocutors have to accept that there exists no prevalence of any principle over others and all have to submit their assertions to the scrutiny of the general scientific method.

2. Philosophical background

We will begin with the inspiration arising from the mottos and goals of the general project of the institutionalized Science-Theology dialogue. What are the key points and roots of our common origin? What are the main essential elements of personhood, self, soul and mind of the human being? Can a physical conception of the human person be valid as a self without soul? All these principles are in the frontispiece of the international Metanexus projects. We have to accept in order to initiate this dialogue the weak anthropic principle, although one might be sceptical and present resilience to assume it as a true principle. In addition, it is convenient also to assume the strong anthropic one, the so-called meganthropic principle, although, obviously this may be yet received with much more coldness. These two dialogue bases imply that the whole design containing the conditions

for the raising of the human race already existed in the constituting primordial elements in the universe zero time, this being defined as the emergency of human existence. The requirement of this design is necessary in the basis of the anthropic principle and necessary and sufficient in the case of meganthropic one. The direct interpretation of the emergency as a philosophical category would condition a certain self-transcendency of matter that would generate new ontological entities due to inextricable complexity laws. In virtue of those laws and the continuous evolution of the pristine matter components, the existence of man becomes conceived, by non theist philosophies, without requiring either any direct intervention or creationism of a Prime Creator. These philosophical positions give an autonomy and self-immanence to the energy-matter dualism plus the primordial laws which could be capability of evolution. The belief of creative action of this Prime Creator is reserved for the appearance and existence of the primordial elements and the fundamental four interactions, i.e. the starting point of development of the Universe. On the other hand, a complementary interpretation of the emergentism (emergentness) should be the acceptance of the anthropic principles as responsible for the formation of the necessary structural coupling among the constitutive elements of the starting cosmic «soup». This implies the erection of successive intermediate structures and conglomerates so that step by step and by the evolution principle, the final result is the present human race. In a virtual straight line that followed the development of the reality according to the complexity laws emerge, the physical hot cosmic soup would be considered the most simple starting point. Physically, this evolution would be triggered by cooling and expanding the primordial soup, which is formed by gluons, photons and quarks, these being the initial elemental particles. The gradual cooling plus the activation of the four fundamental elemental particle interactions (gravitational, electromagnetic, electroweak and strong nuclear) generated the successive interparticle couplings. In first place was the hadrogenesis with the formation of the protons and neutrons which are constructed with three quarks. This allows the atogenesis (or generation of the atoms) by the combination of hadrons and the most stable leptons, the familiar electrons, which for cooling and evolution arrived up to the molecule formation. Then, the complexity chemical laws activated their mechanisms for achieving by means of the matter consolidation processes, the appearance of the macromolecules that are formed by atoms and this sets the bases for the following important and critical step with the genesis of the replicating structures, the cells. The association of cells constitutes the organs and at the final of a large generative chain, the mammalians appear. Then a new critical transition occurs by following the evolution process of these mammalian animals: the human race arises and the irrational Zoology science is then extended and raised to the rational animal Psychology.

The most accepted ideas within of non theist development of the universe are those arising from the so-called Darwinian evolution. These ideas advocate that this universe evolution development is produced without the meddling of a Supreme Designer, and are more or less accepted as philosophical starting

hypotheses for using in the challenge of opinions even from a theist cosmogony point of view. Maybe, this acceptance should be considered as a rational effort and a sign of willingness from the theist cosmogony believers in order to facilitate the dialectic with other materialist perspectives. As a consequence, we should accept as truth that the starting primordial interactions plus the chain of befallen complexity laws produce the whole evolution. This is equivalent to accept that from the initial single physical reality of the cosmic hot soup and as a consequence of the random evolution, the human race appears in the world without interfering of any supreme Architect as a consequence of a simple and random evolution. The possible darkness of this acceptance reasoning is clarified with, and justified by, the implementation of the anthropic principles within the philosophical categories, which define the concept of emergence within the matter evolutionism. In any case, the theist philosophical position of the universe creationism plus the acceptance of an autonomous performance of the matter evolution without intromission of God would seem to imply that the primordial physics laws should not be modified in this evolution progress, since any change in these laws only could be attributed either to God or to the matter immanence itself. This self-transcendence of the matter could be unacceptable for the theist positions because a certain competition between God and matter evolution would seem to be established.

Before this evolutionary straight line a question immediately arose: is there the possibility of either a correspondence nexus or a causality rule between the simplest stage of the physical reality with the final anthropic consequence, the conscious human being? It seems that the more probable answer to this question is no, because the interplay of the huge amount of intermediate complexity laws hinders a direct relation between the first and last phases of reality evolution. However, there is an opinion stream in accepting that it is possible to find correlations between the Physics phenomenology in the brain with their psychological manifestation. In a certain sense, this would seem an attempt to achieve the structure and performance of the human soul, i.e. what are the quantum states that define the human soul actions? These states do appear when the soul acts, but their appearance is conditioned by these acts and, in contrast, the inverse proposition does not seem correct.

We have not deliberately taken into account as a philosophical starting position, the existence of the Prime Creator intervention in the evolution of matter within the cosmology, since we assume the autonomy and self-sufficiency of the dualism energy-matter in its cooling process across the time. Therefore, it seems to require that one should abandon the idea of any supernatural element existence, at least as that philosophical supposition and hypothesis, which transcends to the dualism energy-matter in the description of conscious knowledge, sentiments and emotions. Maybe, we should attempt to explain the rational functions by means of a clear correlation between well defined states when these sentiments, emotions and knowledge arise and are developed in the human being. A principle that would give support and induce legitimacy as a valid assertion of these correlations should

be the acceptance of the monism, which claims by an only ontological substance constitutive for the human race.

3. Brain. Mind. Soul. Self

The belief in the existence of the human soul can be justified from an exclusively rational point of view. It is conceived as an individual human property with a strong sense of social communion and whose provenance and nature are divine. This human property subsists on the observation, judgement and influence of God over the human beings. Therefore these «God actions» give the true essence of the soul to men and women, anthropologically complementing them by means of a finite participation of the Divine image and nature. However, it is difficult to justify, if one accepts the monism principle, the idea of a human soul as an immaterial new substance, independent on the human physical body and hypostatically included in its human nature. For this reason, it is difficult to accept that this non material soul feature is independent of the continuous Divine action, especially if one is coherent and consistent with the another idea, above mentioned, that the energy-matter evolution is attained without any interfering of the Prime Creator. It is also complicate to believe in, and justify, a spirituality arising from the energy-matter evolution in virtue of the emergentism principle and whose explanation has to have coherence without considering a theist human anthropology. It would imply that the matter evolution should generate new ontological substances yielding a certain immanence and self-transcendence of this matter. We can illustrate this complex and debatable point by means of a metaphor, which can be limited in presenting analogies with the real case but can serve for explaining this real case in a better way. If one inspects any universal painting from a rigorous Chemical-Physics study, we can analyze and observe all atomic and molecular components of both the canvas and the oils used in its confection, and this can be carried in a similar way by a possible observation of the microscopic and nanoscopic components of our brain. However, this study even being totally complete does not give the whole information of the work of art. The spectators of this work observe another thing which is independent of its atomic and molecular components, they appreciate its beauty which generates in them sentiments and emotions that are not included in the Physical Chemical analysis. This observation is the cause of the true new feature of its nature: in a metaphoric sense, its «soul». Consequently, we can argue, by using the art analogy, that a complete analysis of the physical brain phenomenology does not ensure us the global knowledge of the human nature and its spirituality. It is the existence of the Prime Observant Creator Who confers to the human ontology a new dimension, the dimension of the human soul. This divine influence produces in the generic man the will and the stimulation to look for perfection by means of the self-improvement. This is a radical idea that can be epitomized by saying that if God does not exist, the human soul either, thus, the mind, consciousness and deep self are submerged and contained in the brain.

The belief of many people is that the human soul is linked to God's existence and therefore the impulse that induces self-improvement for man may not lie in his brain. Nevertheless, the Theology-Science dialogue ought to imply that the theist supporters of the universe existence should accept that the conscious acts can be also analyzed from a non theist cosmologic development point of view. As a consequence, descriptions of the consciousness actions should be given and analyzed independently of the existence (or inexistence) of the soul. It is possible that given the unconscious knowledge and assimilation of the infinitum in the popular imaginary, a certain personal relationship of the non believer with the supposedly infinitum universe can exist. This complex feeling is named «ultimateness». This situation can confer a pantheist spiritual sense that should not be confused with the human soul spirituality, which is a highlight of the immanent, omnipotent and omniscient being that we named God. However, this mutual relationship, universe-man, can be satisfactory for the non believer and well cultivated mind.

Important lines of thought have arisen around the relation between the brain and the mind, soul and deep self within Philosophy and Psychology. A shining example, though too conjectural, is the so-called supervenience between brain and mind. A summary of this concept, re-introduced by Nancey Murphy, professor of Philosophy in Pasadena University, California, the mental actions supervene to the brain dynamic if and only if for all action in the first, at least, there is another in the second. Several grades of supervenience are recognized according to algebraic category, univocal or biunivocal, of this correspondence. Actually, it is accepted as a possibility that a given mental action can be determined by the dynamic of several neuronal states. This brilliant and not refutable concept is vague and imprecise since the useful point would be the determination of which several neuronal states are predetermined by a given mind action. This fact, empirically shown, could allow either to ratify or to rectify the terms of the supervenience that as a philosophical concept can be important, but its value, in my opinion, is limited from a scientific point of view. Another concept relating the ontological self to the brain is the mereologic reductiveness. The meaning of this concept deals with the possibility of reducing the properties of the whole of the self by means of the analysis of the properties of its parts: brain, mind, soul, etc. This rare concept presents certain similarities with the grammatical figure of the Spanish «sinécdoque» that our students know or should know without requiring high level studies of phenomenological research and Psychology. It is interesting to emphasize that when a fact result to be unexplainable, there is a tendency to look for either a concept or principle whose contents attempt to hide the incapacity for understanding, describing and analyzing issues from an evolutionary and scientific point of view. These imposed concepts and principles allow us to hide our vacuum of arguments arising from a lack of explanatory clearness.

This extensive and, in my opinion, necessary preamble is confectioned in order to incardinate the contents of Quantum Neurology within the general context of the dialectic between Theology and the experimental Sciences. This introduction

can be epitomized saying that there are difficulties in obtaining the knowledge of the consciousness intrinsic sense of the rational beings by means of exclusively physical methodologies, but the great interest of the issue is worthy of the intent. However, the global nature of man does not end with the understanding of this physical study, because the will and the search for self-perfectionism are outside this analysis since it depends on the existence of the human soul and this, in turn, depends on the existence of God. On the other hand, the most complicated tasks in the physical interpretation of the conscious events are in understanding how the knowledge arising from, and developed by, human intuition can be determined with states of brain. This complexity and difficulty is due to these states arising from mental actions can not be algorithmically developed. Nevertheless, they have to be described by means of a mathematical treatment which is a logic expression of a physical model and therefore, contradictorily, they should proceed from an algorithm. However, even considering these complications, there exists the intuition that we can establish unequivocal correlations between these mental actions with determined brain states whose understanding allows us to scientifically concrete and evaluate the philosophical concept of supervenience. And this can be undertaken without requiring assistance to psychological and philosophical arguments different from those arising from the temporal evolution of physical brain states corresponding to the different mental actions. The construction, explanation and analysis of these correlations are the main keys and cornerstone of Quantum Neurology.

4. Classical *versus* Quantum Neurology

The state of art of Quantum Neurology is too primitive and its development is yet initial. Recently, several works have been published about the determined quantum states concerning processes of exterior signal communication [Scholoffeen et al. (2005) and Engel et al. (2007)]. In these works, the authors pretend to give experimental proof of properties that are too simple about signal communication in systems that present analogies with the neuronal transmission. These experiments are too early and they foretell a long theoretical and experimental course whose culmination is the achievement of results that serve for tests of theories about the physical models of consciousness and shed new light on all these issues. Nevertheless, the scanty knowledge of the physical perspective of consciousness should be stimulating for the physicists and it should not be a reason for desisting from further study.

In physics there are two scenarios for developing the different theories which analyze the material systems. In some cases both theories arrive at apparent contradictions and sometimes these contradictions are not apparent but totally essential. These theories are the so called Classical Physics and Quantum Physics.

Classical Physics sets its fundamentals in the determinism of its main laws, which allow the calculation of physical magnitudes in function of the space-

temporal evolution of the system components that are macroscopic bodies and/or corpuscles. This evolution becomes fixed by equations in such a way that known the initial conditions, one can know precisely and evaluate without uncertainty where and how each component of the system will progress in the space-time dimension. Quantum Physics operates with a different philosophy. The basic point of this theory lies in the system states defined each by its corresponding wavefunction. These wavefunctions are calculated by deterministic equations, either the Schrödinger equation in the non relativistic case or the Dirac equation in the relativistic one. The physics reality becomes defined by means of a complete set of physics variables whose values are probabilistically obtained. These variables have not, in general, a given value; when one of these variables is measured in the system, it can only attain a value corresponding to an eigenvalue that corresponds to an eigenstate belonging to the spectra of the cited variable. In addition, any state that is not eigenstate is strongly disturbed and modified when any measurement is made, and it is transformed into a different state. Consequently, the really important value of the infinite non-eigenstates of system is the average probabilistic value, which proportions certain knowledge of the reality independent of the experimental measurements.

Since the inception of the Physics Neurology, Classical Physics was used for understanding some neuronal processes, and more recently Quantum Physics is initiating its long process of implementation in this discipline. The main aim for including the QP in this study of Neurology is the possible assimilation of a microscopic measurement with the conscious knowledge of this system. At the present time, both physical theories contribute in developing the Physics Neurology; the association of both theories yields often complementary conclusions from their reasonings, and in other cases, this association is converted into competition since their propositions are contradictory solutions and discrepant aphorisms.

Nowadays, a strong controversy is raised between both contending parts of the Physics in proving what is the most appropriate physical theory for explaining both the conscious acts and the external signal transmissions in terms of neuronal states The development of Neurology from the Classical Physics lies in the idea that the nervous systems, in general, and brains, in particular, are similar to classical computers that manipulate information with input data and draw results as an electronic chip. The information transmission is carried up by means of either chemical transmitters, such as the glutamate of acetylcholine, serotonine, noraldrenaline, etc., or electrical transmitters whose functions are established between presynaptic and postsynaptics membranes. The electrical transmission of signals becomes a study of electric networks named neuronal lattices, which is performed within the electronic analysis of intelligent webs. As a consequence, the classical model of Neurology is physicalist and reductionist, since the mental actions could be deterministically defined by the electric signal transmission inside an electric lattice, complex but simply an electric circuit. This classical model presents philosophical difficulties due to the structural complexity of the

brain whose actions can not often be described via mathematical algorithms, therefore, it is doubtful that its performance can be modelled with the deterministic laws of the Classical Physics. In addition, there are several reasons within the internal coherence of Classical Physics that hinder the acceptance of this theory, at least exclusively, as a suitable scenario for explaining the brain performance. One of these reasons which may not be the most important objection but is the easiest argument to understand, is that the electromagnetic communication in the neuronal lattices should be produced without existing interneuronal electric contacts among synapses, implying an EM transmission with infinite impedances, this giving rise to an Alzheimer disease brain. This objection is clearly and easily annulled within the Quantum Mechanics, since the key for solving this difficulty lies in the fact that the intersynapses communication is carried up by tunnel effects among contiguous synapses. This criticism of Classical Theory and the possibility that the EM propagation is due to either the tunnel or Josephson effects, which we will summarize later, are sufficiently robust arguments to attempt the analysis of the excitation transmission in the brain performance within these quantum models. In any case, even considering the assumption, hard to accept, that the deterministic classic theory is more appropriate for explaining the brain phenomenology, the quantum effects can not be forgotten, since they should be taken into account in the charge behaviours of the proteins that compose the neuron cytoskeletons.

5. Components of the system. Summary

The brain is a physics system constituted of a hundred Spanish trillion (10^26) elemental particles named electrons whose dynamic is fundamentally governed by electromagnetic interaction. These electrons belong to approximately ten trillion atoms (10^25) which are grouped in a hundred thousand million (10^11) neuronal cells. Each of these cells has around ten thousand synapses which are the connections of the neurons where the adjoining cells get the nervous streams. In addition, inside each neuron, the above cited cytoskeleton works as a structure whose function is similar to that of a spine kind. This cytoskeleton is constituted of filaments and microfilaments that provide the adequate environment for the microtubules which are the true elements for the electrical activity inside the neurons i.e. these microtubules are the transmitters of the nervous signals. Therefore, these microtubules are the main responsible elements of the transmission, storage and implementation of the brain actions. On the other hand, it is necessary to take into account that the mental actions imply the existence of physical states that can involve up to a hundred neuron cells connected by synaptic connections.

Each microtubule is a hollow cylinder whose diameter of the bases has twenty five nanometres and its length is around two hundred nanometres (each nanometre is millionth of millimetre). Inside this cylinder, water, lipids and

proteins travel across its hole supplying an appropriate dielectric behaviour that favours the corresponding function in the global physical state. The microtubules of each neuron cell are composed of around ten millions tubulins that are light proteins, polypeptides even simple amino acids. The geometrical location of the tubulins within the lateral surface of the microtubules is hexagonal and its dimension is between four and eight nanometres. There are two kinds of tubulins according to the sign of its total charge: the positive charge tubulins, henceforth, we will name them alpha-tubulins and those whose charge is negative beta. The gravity centres of two adjacent tubulins are split around four nanometres. These constituent elements of the microtubules and the neuron cells that are the main responsible of the generation of the physical states can associate forming pairs that are called dimmers. Each tubulin has a spatial nanometric dimension and is the most single quantum state that presents the features of a qubit (quantum bit of a quantum computer). Consequently, the associated tubulins forming dimmers are biqubits that, in turn, are two particle system quantum states.

6. Quantum Mechanics of tubulins

Each tubulin is a molecule, as cited above, generally a protein. Each dimmer or tubulin pair constitutes a dipole with a well defined module of its dipolar moment. The dipolar moment is a vector whose module is the product of the positive charge with the distance between two contiguous tubulins. The dipole moment vector of each tubulin pair fluctuates space-temporally in all possible directions. The quantum physical interpretation of each tubulin is a two dimensional Hilbert space whose basis contains two states corresponding to the |1> and |0> classical bit states of the standard Computer Science. However, the number of states for each tubulin can be infinite from a quantum physics point of view, since the state of each tubulin can be defined by a superposition of alpha and beta states, in such a way that a quantum state is defined by |x>=A|alpha>+B|beta>, where A, B are complex numbers where the sum of the squares of their modules is the unity. The meaning of these numbers within Quantum Mechanics is related to the probability amplitude of that the |x>-state in a given time can collapse in either the state |alpha> (the value |A|^2) or |beta> (the value |B|^2). When this collapse is due to the environment interaction with the corresponding |x>-state it is named einselection (see Zurek 2003). This terminology refers to a genuine quantum theory action whose meaning is the selection of a given eigenstate of a physical variable (magnitude). Each eigenstate of a given physical magnitude has an associated eigenvalue which becomes determined via a secular equation H|n>=a|n>, where H is the hermitic operator defining the magnitude, |n> is the eigenstate and the a-parameter is the corresponding eigenvalue. As a consequence, there are infinite possible states for each tubulin and each given state is defined by its two complex numbers A and B. An paradigmatic metaphor that allows the clarification of the different

philosophies within the Classical and Quantum Physics of the tubulins is the well-known Schrödinger's cat example. This example serves for distinguishing between the standard bits and the quantum qubits. In a normal global state of a neuron or neuron set, each tubulin is in a different one-body state, i.e. each tubulin contain different A and B values and thus, the neuron is in an incoherent random state which does not contain and not store any computable information. The external excitations (stimulations) produce nervous streams that are transmitted towards brain, which starts a process that becomes represented by a quantum state in the tubulins. In principle, the individual states are different in each tubulin and the global many-tubulin state is then incoherent. The brain acts as an observer of the global state and this observation is equivalent to a measurement process in it. This process leads to the collapse of each tubulin wavefunction which implies the selection of a eigenstate of each tubulin corresponding to the eigenvalue which is the result of this measurement. When this selected state is simultaneously equal in the tubulins of a neuron, the global state of this cell coherently oscillates. The obtained coherence allows the information storing of the external excitations, since a correlation between the nervous streams produced by the external signal and the coherent global state is established. The internal coherent global state can be transmitted to the network of connected neurons by means of a Josephson-like effect similar to that occurring in superconductor-insulating-superconductor devices. There is multiple nature and structure for the dynamic reasons that are able to undo the quantum superposition of the individual tubulin states and that impel the election of a given eigenstate, either alpha or beta. As a continuation, we will give some of these reasons that are extended in the section of proposals in this paper.

In September of 2007 at the Madrid Sophia-Iberia congress, several concepts from a philosophical point of view were placed in discussion with a clear symbolic and metaphoric sense in order to understand the behaviour of matter from a non experimental point of view. The most striking ideas were those concerning the existence of two kinds of matter, bosonic and fermionic, whose different structure and properties have certain similarities with those of the same physical denomination. The fermionic matter was defined, in this occasion, as the matter composed of individual and separable elements so that the properties of the whole should be considered as the sum of those of their components. In contrast, the bosonic matter was described as a global and inseparable bulk whose properties are those of the whole in itself. Obviously, the physical definition is much more precise referring to the elementary particles. The fermionic particles such as electron, proton, neutron, electronic and muonic neutrinos, etc, are defined as those particles that occupy an individual state (one-body state) and, in addition, each of these states contains only one particle. On the other hand, the bosonic particles such as photon, phonon, gluon, graviton, exciton, magnon, etc., can share any arbitrary (even infinite) number of these particles in the same state. Furthermore, other two properties distinguish the fermionic from bosonic particles: i) the first are those that suffer interactions among themselves and the second are messengers and transmitters of these interactions, ii) the fermions

have a half integer spin and the bosons have an integer spin (the spin is the internal angular moment which is the total angular moment in the repose reference system). The property of different spin value for each kind of particle is equivalent to that of different state occupation according to the spin-statistic principle.

Another important phenomenology arises from the associations of even numbers of fermions whose resulting entities are bosons: each two half integer spin particles joined via an attractive interaction generate a new bosonic composite particle. An indefinite number of these new particles can occupy the same state and thus the global many body state of either one or several neuron cells is coherent in itself. Two examples of global coherent states are, on one hand, the case of superconductors based on electron pairs, the so-called Cooper pairs, and on the other hand, the cases of some Bose-Einstein condensate whose elemental pair components are excitons formed by electron-positron (hole) pairs. It seems that the mental and brain actions arise from the appearance of global coherent states that evolve in the neuronal lattices. We say «seems» since there is yet not a conclusive and apodictic theory that confirms and ratifies this point. The storing and reproduction properties of these global states are due to the easy intersynapses transmission of external signals via tunnel and Josephson effects. Moreover, these states become perfectly characterized with the internal parameters required in their construction. However, the issue that the global coherence implemented within the neuron lattice can be representative of assigned mental/brain actions present difficulties that do not invalidate the theory but three serious objections should be previously answered before a future and possible consolidation of this assertion.

i) The dynamics in the brain are almost exclusively provided by electrons in such a way that the inclusion of the Quantum Neurology within the Electronic Physics discipline is legitimated, and these particles are fermions. As a consequence, in order to build up the coherence with global states, the coupling of either electron-electron or electron-hole pairs is necessary. As it is well known, the interactions among electron are repulsive and those existing between electrons and positrons though are attractive, the excitation of an electron from the valence band to the conduction band is necessary. Therefore, in both cases there are difficulties, not impossibilities, for obtaining pairs. The remedy for attaining the coherent global state via pair couplings (either e-e or e-h) is in the interaction between the tubulin system and the environment. This interaction is mediated by the circulation of water, lipids and polipeptides inside the microtubule hole yielding a dielectric medium in which the coupling of two tubulins (or pair coupling) is then favoured. These dimmers have a bosonic spin character and then the coherent states can be transmitted among synapses of the neuronal lattice. The theoretical and experimental problem is to know how the dimmers can be formed, this question being a point that presents similarities from a physical point of view with the antiferromagetic dimmers construction via Rostoker-Kittel-Kasuya-Yosida (RKKY) exchange interaction. The antiferromagnetic lattices acquire the appropriate

conditions via the existence of a determined medium that is equivalent to the cellular environment in the neuronal systems. The tubulins are submerged in a medium containing proteins, lipids, water and peptides such as oxotina, serotonina, noradrenalina, oxicetina, riboflavina, endoforfina, etc., which are responsible for the microtubule bath that favours the evolution of tubulin dynamics. A large biochemical experience has improved the neurological studies in such a way that there is a huge amount of experimental data about which nourishment can aid to the development of the performance of the brain and mind actions.

ii) The second problem is more complicated and is related to the quantum coherence. This quantum property is extremely subtle and easy to break. The possibility of obtaining coherent states is relatively easy and normal in electronic many-body systems, but these usually have a very short half life and therefore, their processed implementation and recording even in the appropriate brain zone is not possible. A coherent state requires at least a thousandth of second to attain a mental representation and this time is extraordinarily large for the permanence of a coherent state. This is the reason for the requirement of catalytic activators of the memory which fulfils the task of lengthening the half life of the quantum coherent states in order to facilitate their recording. The analysis of the macromolecules, proteins, amino acids, etc., that are necessary for favouring the memorizing of mental and brain actions is an important point within the biochemical and biophysical Neurology.

iii) The third problem constitutes the most important objection of the so-called classical neurologists against Quantum Neurology. This is, maybe, the strongest criticism and the most substantial discrepancy in the development of Quantum Physics in the issue of coherence and the quantum coherent states within Neurology. This objection is founded on the fact that the coherence of neuron-neuron propagated states are constructed via internal interactions within the brain. Consequently, this property should be maintained only at very low temperatures: 125º C below zero would be the maximum temperature at which this coherence is possible, this being, at least, the opinion of the quantum neurology objectors. Temperature is the variable that implies the increase of the electronic white noise whose strength grows with this variable from –273º C, which is the absolute zero. In addition, the electronic noise at +36,5º C (average temperature of the brain) presents a widespread of frequencies implying the existence of interacting waves which generate an environment that interacting with the tubulin states completely break the coherent global state. At the present time, a hard debate between classical and quantum neurologists is based on whether the coherence is or not possible for temperatures around 309 K. Two researcher groups challenge the hegemony in this theme using these contradictory arguments. Tegmak's group maintains that the correlation between the consciousness actions and cerebral states can not be explained by quantum coherence and proposes robust, not apodictic but well structured, arguments against the fact that this quantum property can be held at these high temperatures. Therefore, this group refutes Quantum Neurology as a possible theory for explaining the mental actions and prefers to pay its attention to the neuronal classical lattices as solutions for

the physical scenario for Neurology. In contrast, the group led by Hameroff, who joined Penrose proposed the orchestrated objective reduction model (see Hameroff-Penrose 1996) for the consciousness physical definition, defends, with good arguments but not totally conclusive, that microfilaments and hydrophobic liquids produce an environment with a dielectric and plasma medium in the intertubulin space. The interaction between this environment and neuronal tubulins allows the maintenance of the coherent states up to higher temperatures than that of the human body. Concretely, these authors with their model justify that the dielectric medium modifies the dipole-dipole interaction among alpha-beta pairs in such a way that a quantum protectorate of the coherent state is created allowing the isolation of the tubulins implicated in this quantum system. In other words, the cerebral medium inundated by proteins and other macromolecules screens to the neurons of the thermal noise. The semantic term «quantum protectorate» was introduced by the 1998 Physics Nobel Prize, Laughlin in the Quantum fractional Hall effect (Laughlin 1999); according to this author, some coherent states can be built by means of the interaction with determined magnetic fields so that these states can be maintained up to high temperatures with procedures similar to the optic pumping of the laser state. Some new technical subjects such as the magnetoencephalography applied to the cerebral diagnostic uses the existence of certain magnetic behaviour of the brain, which implies that the neuronal magnetic behaviour might have the conditions for the appearance of a quantum protectorate that preserves the coherence up to high temperatures. In any case, the criticism of Tegmark's group is a robust idea that should induce reflexion to the quantum neurologists in order to dispel the existing doubts about the applicability of Quantum Mechanics to the physical knowledge of consciousness.

The aim of the following sections is to present both some known and other novel solutions to the existing problems concerning the applicability of the Quantum Theory to the cerebral processes exposed in the former section.

7. Known Proposals

Penrose and Hameroff in 1996 published the orchestrated objective reduction model, which is founded in the genuine philosophy of the Quantum Mechanics, using the superposition principle of those eigenstates which constitute a basis of the Hilbert space. We start heuristically explaining some of the necessary concepts of Quantum Mechanics required for understanding this model. In Quantum Mechanics, the first step is the determination of those physical variables whose measurements can lead us to the understanding of the reality in a better way. Each variable, also named physical observable, has assigned a hermitical linear operator using the correspondence principle with the Classical Physics. Each observable, A, has a set of eigenstates {|x1>, |x2>,.....|xn>} with its corresponding eigenvalues {a1,a2,.....an} which can be deduced via the above cited secular equation: A|xi>=ai|xi>, where the i-index runs over 1,2,.....n. In

order to determine the physical reality we require a complete set of variables, such as mentioned above, whose corresponding hermitical operators commute and then, all these observables share the same set of eigenstates. Furthermore, the commutation property of these sets of operators implies that the corresponding variables can be simultaneously measured. Obviously, although the eigenstates are the same for all complete sets of operators which commute, each variable has different eigenvalues for the same eigenstates. For instance, we suppose the complete set of variables A1, A2,…… An, and the corresponding eigenvalues for a given eigenstate |x>, are a1, a2, …..,an, then, we can identify the |x>-state with the corresponding eigenvalues (|x>=|a1,a2,….an>), in such a way that a given variable of the complete set Ai satisfies the following equation: Ai|a1,a2,….an>=ai|a1,a2,….an> . Then, if one measures the variables Ai in the system when it is in the |x>-state, it will obtain the value ai and will achieve a bit of reality. The eigenstate set constitutes a basis of the Hilbert space, and the dimension of this vector space can be either finite or infinite. Classically (i. e. from a Classical Physics point of view), only the states of the basis ought to exist, however, from a quantum mechanics point of view, there are infinite states which completely fulfil the Hilbert space. The mutation of the system from a superposed state toward an eigenstate is equivalent to the conversion of a quantum situation with total ignorance of the values of the observables to a clear and deterministic realistic knowledge of them. Those states different from the ones belonging to the basis are obtained by means of a linear superposition of the type: |y>=c1|x1>+c2|x2>+c3|x3>+….cn|xn>,where the numbers c1,c2,c3,…..,cn are complex. Then, the square of the module of each number, for instance ci, is interpreted as the probability that by measuring a given variable of the complete set, we obtain the corresponding eigenvalue, ai, of this given eigenstate |xi>. Moreover, the sum of all these |ci|'s is equal to the unity, since it is the sum of all probabilities corresponding to the possible classical states. When a given variable measurement is carried up, the non existence of a value for this variable in a superposed state implies the degree of ignorance that the observer, apparatus or brain, has about the reality. This can be justified because the only values that can be obtained in a measurement are the eigenvalues. In addition, if the |xi>-states are located in different regions and these are defined by punctual particle positions, the superposition implies that each particle has probabilities to simultaneously be in different space positions. This fact has not any sense within Classical and deterministic Physics. On the other hand, when the external signal produces in the brain one of the superposed states, it perceives a conceptual blurredness which is only dispelled when this superposition state is converted into an eigenstate. Then, the corresponding eigenvalue, in contrast, is clearly exempt of uncertainty and the correlation between the signal and the state is converted in knowledge that can be reproduced and stored. Consequently, the existence of a superposed state proportions no mental action and therefore, it does not yield any recorded knowledge.

The application of these ideas to the case of a Hilbert space whose basis is constituted of two tubulin eigenstates, alpha and beta, has already been explained

in a former section.The quantum superposition implies the definition of an infinite number of states of the type |x>= a|alpha>+b|beta>. All these states not belonging to the basis of Hilbert space are modified when a measurement of any observable is carried out in them. The cerebral mechanisms for which the brain selects a determined state for confectioning the mental knowledge is yet unknown and only conjectures can be established. The cornerstone idea of the Penrose-Hameroff model is the attribution of this eigenselection to the difference in the gravitational interaction of the mass corresponding to an eigenstate with respect to the superposed state. Then, the minimal energy principle due to the attractive sense of the gravitational energy difference induces the selection and therefore conscious knowledge. The collapse of the wavefunction of a superposed state by means of its objective reduction can be effective in a simultaneous way in a determined set of tubulins and then the recording of this state implies the conscious knowledge of the external signal which provoked the superposition. This can be explained because the conscious brain actions produce the wavefunction collapse, this point is clearly the key idea of the Penrose-Hameroff model.

8. Our proposals

8.1. *Excitonic model*

The Penrose-Hameroff model for the physical concept of the consciousness is brilliant and fascinating but intuitive and conjectural and, to my knowledge, is not justified by either any experimental reason or data obtained from any measurement. The gravitational incidence in this point may be a smart argument which can have theoretical intern charm and coherence but has the additional difficulty that it theoretically adjoins the intervention of two theories, General Relativity and Quantum mechanics which, at least at the present time, seem to be incompatible.

In the first place, we describe the excitonic model, which presents certain similarities with the photosynthetic conversion of the sun light for the green vegetable world [see Engel et al. (2007)]. The charge density inside the tubulins is such that a geometrical distribution of positive and negative unity charge appears in the microtubules. This implies the existence of an alpha-beta state lattice in the microtubules within each neuron cells. Each alpha-beta state pair presents a strong attractive binding energy which allows us to treat these pairs with a similar dynamics to hydrogen atoms. The positive-negative charge structure has a clear image within the condensed matter theory and this is that of the excitons, concretely, Wigner's excitons. These excitonic structures are constituted of two elemental quasiparticles, similar to an electron and a positron, whose half integer spin is equal to ½. Therefore, the resulting excitons are composite particles with integer spin (this can be either 1 or 0), and consequently, these composite particles are bosons in such a way that an undefined number of them

can occupy the same state. The occupation of states is governed by the minimal energy principle and therefore all will occupy the state with null linear moment. In other words, the total energy of the microtubule system formed by the alpha-beta dimmers is decreased by the attractive energy of the binding potential of the excitons (here excitons and dimmers are two equivalent words). The microtubule global state is, obviously, coherent because when these excitons start to be moved before either an electric or magnetic fields, all dimmers move with the same linear moment a kinetic energy. Hence, the resulting global many-body state is formed by bosons and therefore, it is a coherent Bose-Einsten condensate.

On one hand, an external signal produces an electric excitation which implies a wave of linear moment and kinetic energy changes within the coherent BE condensate. The resulting many-body state presents a new set of quantum numbers. Then this excitation remains labelled by the new and modified BEC state, a correlation existing between an external signal and the physical change of the resulting modified condensate. The tunnel effect is responsible for the intercommunication across the intersynaptic gaps. This effect is not the normal tunnel crossover of electrons between conductors through an insulating layer, but the transmission of a many-body coherent BEC state that pass by the dielectric medium existing among synapses of different neuron cells. This anomalous tunnel effect is more similar to the superconducting Josephson one than that arising from the metal-insulating-metal devices.

The existence of an electric field between the device electron exit element and that of electron input can favour both the strength of the normal tunnel and Josephson effects. However, the coherent BEC state is built up with excitons whose total charge per composite particle is null and therefore the electric field is not necessary (it is useless) for favouring the intersynapses crossover. This fact implies that the transmission of coherent state among synapses of different neurons is due to the Josephson-like effects rather than the normal tunnel because the strength of this later quantum effect is zero for null electric field charge acceleration, in contrast to the Josephson intensity that can be different from zero for a null electric field. Moreover the transmission of the coherent BE condensate oscillates between synapses even for continuous field, this being an additional experimental fact that gives support to the Josephson channel. The existence of this oscillating transmissions, perfectly characterized by means of fixed quantum numbers corresponding to a coherent BE condensate propitiated by a external signal is the fact that can allow the establishment of a correlation between a conscious mental action described by the BEC state and the corresponding cited signal that provoked it. This correlation serves for attributing the recorded BEC to the information arising from the external signal, this attribution being established in an unconscious and automatic way. An example that could shed light and illuminate this crucial point, which has analogies with the photosynthetic function of the green vegetable world is the optic image construction by the interaction between the electromagnetic radiation to visible frequencies and the ocular cells of the retina. The EM interaction produces an optic excitation in these sensible ocular cells similar to excitons which are transmitted by means of nervous streams toward the brain, generating in it a

coherent state whose association with the cited exterior EM field gives us the idea of the exterior optical image.

Obviously, a quantitative evaluation of these processes should be carried up for obtaining a true analysis from a physical point of view. In order to satisfy this objective, it is necessary to calculate the energy and linear moment of the ground many-body state formed before and after the presence of the exterior stimuli as well as the possible excitations of the total neuronal system. This requires a quantitative study which can only be analyzed from the quantum field theories, and whose technical details will be published in a specialized journal.

8.2. *Dipole-dipole interaction: biexcitonic and interacting boson model*

The tubulin dimmers, named tubulin pairs too, as mentioned in former sections, constitute dipoles which are Wigner's excitons from a Condensed Matter theory point of view. These dipoles, as it is well known, interact between themselves via dipole-dipole interaction, forming exciton pairs, i. e. the so-called biexcitons. These biexcitons are also bosons since they are constructed of two composite particles of integer spin, and therefore each biexciton is a new complex bosonic particle, equivalent to a hydrogen molecule. The interesting question is when the microtubule global state will prefer the existence of either single excitons or biexcitons. This preference will depend on whether the interaction electron-positron is more or less stronger than the Van der Walls-like interaction existing between two hydrogen atoms (equivalent here to a pair of excitons). The natural selection will depend on which one demands less energy between the two possibilities: the energy arising from the global state only formed by excitons or that from a many-body state built up by biexcitons. Another important and decisive point in the above cited selection model, apart from the minimal energy reason is: what global state model presents more straightforwardness in the intersynapses and interneuronal transmission of the resulting coherent many-body state? Obviously, nature will choose the condition for one of the two models of ground state according to the balance of influences in each case between the two phenomena: minimal energy and Josephson interneuronal transmission.

The dipole system developed in the microtubules based on the tubulin pairs presents similarities to a Hopfield lattice (see Behrman 2006) and whose dynamic is similar to certain antiferromagnetic classical lattices that can be solved via Ising's models. These models are particular cases within the Heisenberg exchange interaction issue. As it is well known, characteristic features of the brain, experimentally ratified in multiple and several experiences, are its plasticity and its capability of self-transformation before successive neuronal actions. These features will allow us to consider this plastic organ as a ferroelectric system with hysteretic behaviours similar to a dielectric with the permanent dipoles, also named electrete. The hysteresis cycle implies that the external agent stimuli would produce multivalued responses in the brain, this fact having a clear psychological meaning in the tiredness and boredom produced in the brain before repetition of the same stimulation. This effect presented in the brain is similar to that of an elastic string

when is successively forced and stretched inducing in it deformations. These deformations are never equal for each stretching process due to the recording that is produced in the material before the successive application of exterior forces. The idea of the elastic behaviours of the neuronal system as well as the existence of dielectric hysteresis cycles give support to the philosophical concept of the supervenience since several phases of the neuronal hysteretic process would be related to the same mental action. On the other hand, these elastic behaviours similar to the ferro-antiferromagnetic and ferroelectric materials can justify the biexcitonic model since these behaviours are consequence of the dipole-dipole interaction which is only considered in this model and it is excluded in the single excitonic one. Moreover, the dipole-dipole interaction can produce transitions from ferroelectric to paraelectric phases, the temperature being the responsible physical variable that induces the phase change. This change occurs at the transition temperature that can be sufficiently high for ensuring the permanence of the biexcitonic coherent state for temperatures higher than 309 K which is that of the brain.

However, it is necessary to be careful in choosing a model for analyzing a determined mental action and the choice will be conditioned by the experimental clues of the corresponding states generated in the neuronal system. What are the experiments that can shed light on this election? The answer to this question is an interesting task which depends fundamentally on the experimental data, and can serve to generate a syncretism between the Quantum Field Theory and genuine Neurology. In any case, according to the available experimental data, at the present time, it seems that the coherence states in their different possibilities and phases are a correct way to deepen the relationship between these two areas of knowledge.

9. Comments about the different models

A general comment deserves the possible consistence of each of these three models summarized in the former sections as well as the concurrence and concomitance between all them for acting altogether. The physical sense of the consciousness can require several directions of thought. In a first place, the Penrose-Hameroff model stress the idea of the eigenselection of a superposed quantum state for all one-body states in an orchestrated way as a simultaneousness action arising from the gravitational incidence over these starting point states. The experimental justification for this overwhelming idea does not seem easy to give because even from a theoretical point of view it is difficult to reconcile the general relativity, theory of the gravitational interaction, with the quantum field theory, theory of the coherent states. The excitonic model is inserted within the generation of the coherent states via pair coupling that in this case is due to the electron-hole attractive interaction. This model is compatible with the biexcitonic generation and the possible prevalence of any of the two models depends on the

imbalance of total energy yielded via the electron-hole potential versus the Van der Walls-like interaction among single excitons in a similar way as the hydrogen atoms are joined for constituting the hydrogen molecules. Even one can argue that these two models could coexist in either simultaneous or successive neuronal actions. The selection of any model will depend on which is the experimental data that have to be explained.

10. Epitome and last considerations

The fundamentals of this paper are, on one hand, the insertion of Neurology in the dialectic between the experimental sciences and Theology, and on the other hand, the analysis of mental actions from the perspective of Quantum Physics. The bases of thought in the assertions of this paper should be found in establishing correlations between the mental conscious actions of the human self and determined states generated in the complex neuronal system. But it is difficult to explain the will and the spirit of self-improvement implemented in the human consciousness. These human virtues are inspired and induced by the spiritual impulse of the human soul whose existence can only be justified by the transcendent existence of the Prime Creator and do not seem likely to be predetermined by any brain state, neither quantic nor classic. However, we look for correlations of the mental actions produced by the consciousness with phenomenology occurred in the brain. Another important point established in this work is the dynamics of the brain, which can not be explained by means of the deterministic laws of Classical Physics. Moreover, there are sufficient reasons and certain experimental data that give support to fact that the coherence of some many-body states within the tubulin system is the main cause and better representation of these mental actions. The analysis and discovery of the correlations between the different coherent states and mental functions as well as the representation in the brain of the exterior signals will allow a scientific valuation of the interesting philosophical concept of the supervenience. The teleological study of these correlations by means of general theories avoiding the «ad hoc» simple models is the objective in Quantum Neurology, this being my Physical research in progress. Probably, this task will be difficult to be completed in all its terms, since some mental actions arising from no algorithmically procedures can not be represented by known coherent states and their analysis can depend on other, at the present time, unknown brain phenomena. The challenge of the discovering of the methodology for these situations can inspire fascinating issues which make worthwhile the spending of efforts in their research. On the other hand, I want to express my personal opinion that our human anthropology is dependent on the existence of the Great Architect, but, in order to maintain the dialogue between Science and Theology, the belief in this principle does not preclude our philosophical acceptance of non theist principles and argumentations that explain the meaning of our own nature.

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