MACROSCOPIC QUANTUM EFFECTS IN BIOPHYSICS AND CONSCIOUSNESS

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Abstract. It is shown that investigations in the field of microwave resonance stimulation of the acupuncture system, as well as investigations of the interactions of consciousness with microscopic and macroscopic environment - imply the existence of local and nonlocal macroscopic quantum biophysical effects, with great potential implications in medicine, psychology, biology, physics, engineering, and philosophy/religion. The parallels between classical and quantum Hopfield-like neural networks were also emphasized, as well as biophysical quantum-relativistic model of altered and transitional states of consciousness, the roots of relative metatheory of consciousness in the quantum decoherence theory, and anthropic "coincidences" in classical and quantum cosmology.

Keywords: *biophysics; macroquantum local and nonlocal effects; holistic medicine and psychotherapy; acupuncture system & microwave resonance therapy (MRT); classical & quantum Hopfield-like neural networks; nonlinearity and nonlocality of the wave function collapse & macroquantum aspects of consciousness; altered and transitional states of consciousness & quantum-relativistic model; quantum decoherence theory & relative metatheory of consciousness; classical and quantum cosmology & anthropic "coincidences".*

INTRODUCTION

One century elapsed from the first discoveries of the quantum aspects of Nature, and *quantum laws of microworld* have got *enormous technological applications* in semiconductor microelectronics and measurements, optoelectronics and laser technique, computers and telecommunications, with a tendency of further expansion through miniaturization of semiconductor devices till nanometer dimensions. Discoveries of low-temperature and high-temperature semiconductors revealed that *quantum effects can be macroscopic as well*, with possibility of much wider application of quantum technologies, especially in electroenergetics and transport, and also in microelectronics and measurements of ultrahigh speed and accuracy.

Initially, *quantum mechanics* appeared as a theory of *microscopic physical systems* (elementary particles, atoms, molecules) and phenomena at small space-time scales; typically, quantum phenomena are manifested at dimensions smaller than 1 nm and time intervals shorter than 1 μs. However, from the very beginning of the quantum-mechanical founding the question of its *universality* was raised, i.e. the question of general validity of the quantum-physical laws for *macroscopic phenomena* as well, usually treated by the methods of classical physics. In the history of quantum physics, and especially quantum mechanics, this question has been temporarily put aside for very different reasons, being considered as a difficult scientific problem. The situation is additionally complicated by the existence of different schools of quantum mechanics, arguing about physical-epistemological status of the so called *collapse (reduction) of the wave function*. In this respect the situation is not much better today, and it can be said freely that the problem of universal validity of quantum mechanics is still open.

Starting from the 1980's, mainly in the papers of Leggett [1], a new period in investigation of quantum-mechanical phenomena on the macroscopic level began. Namely, a clarification of the notions and planning of experimental situations for observing some physical effects started. The central problem in this respect is a notion of macroscopic differentiation of the states of quantum system whose quantum-mechanical behavior is explored. More precisely, Leggett argues that the term *macroscopic quantum-mechanical effect* must be related to macroscopically different states, i.e. the system states (and observables) that carry macroscopic properties (and behaviors) of the system as a whole. These states (i.e. observables) must carry classical-physical behavior of the system as well, this posing a task for choosing physical conditions giving rise to observation of typical quantum effects related to these states[1]. Therefore a difference between macroscopic quantum phenomena: the ones usually explored by the methods of (quantum) statistical physics and not related to macroscopically differentiated states (being classified as macroscopic quantum phenomena of the first kind), and those ones regarding macroscopically different (differentiated) states (being classified as macroscopic quantum phenomena of the second kind, and being interesting to us). Numerous different macroscopic quantum phenomena of the second kind, some of them belonging to the fast developing field of the quantum computing and information, unequivocally sharpen the overall problem of universal validity of quantum mechanics.

In the context of macroquantum effects in biophysics, investigations at the end of 20th century in the field of microwave resonance *stimulation of acupuncture system*, as well as studies of *consciousness interactions* with microscopic and macroscopic environment - revealed the existence of novel local and nonlocal *macroscopic quantum biophysical effects*, with far reaching potential implications in medicine, psychology, biology, physics, engineering, philosophy and religion.

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[1] Paradigm of macroscopic, macroscopically differentiated states, are proper states of position (and impulse) of the center of mass of manyparticle system. On the contrary, so called relative coordinates (as observables) neither define macroscopically differentiated states nor carry classical behavior of the system, in any known physical theory or experimental situation.

LOCAL MACROSCOPIC QUANTUM BIOPHYSICAL EFFECTS:
MICROWAVE RESONANT STIMULATION OF THE ACUPUNCTURE SYSTEM

Microwave Resonance Therapy (MRT) is a contemporary technology of the *acupuncture stimulation*, which represents a synthesis of the ancient Chinese traditional knowledge in medicine (acupuncture) and recent breakthroughs in biophysics: affecting the appropriate acupuncture points by the generation of high frequency microwaves (52-78 GHz), remarkable clinical results in *prevention and therapy of stress*, as well as of many *psychosomatic disorders* were achieved [2]. MRT appears under different synonyms: short waves therapy, millimeter therapy, information wave therapy ... The method originates from the former Soviet Union, and first investigations in 1960's, resulted in construction of the first generation of MRT generators, were not related to their medical application but to military industry and satellite communications. Interest for influence of electromagnetic (EM) microwave (MW) radiation upon nonhuman biological objects appeared shortly afterwards (Zalubovskaya in Kharkow [3], Devyatkov et al in Moscow [4]), but necessity for application of MRT upon acupuncture points was discovered only in the early 1980's (Sit'ko et al in Kiev [5]) as appearance of sharply-resonant characteristic eigenfrequencies of human organism - which successfully stimulated development of the second generation of coherent and third generation of noise spectrum MW generators. Sit'ko and collaborators presented the MRT officially in 1989 at the international symposium in Kiev, where international multidisciplinary expert committee headed by Frohlich announced MRT as a perspective approach in the regulation of living systems and MRT clinical results highly efficient, and shortly afterwards the MRT was presented and introduced worldwide.

The *quantum-coherent characteristics* of MRT therapy should be especially pointed out: (1) highly resonant MW sensory response of the disordered organism sensitive to small changes in the frequency (0.01-0.1%) of the manually adapting coherent MRT devices; (2) biologically efficient nontermal MW radiation of the extremely low intensity (up to 10^{-9} W/cm^2) and energy (up to 10^{-4} eV); and (3) neglecting MW energy losses alongside acupuncture meridians (~ 1 m). On the basis of these empirical data, Sit'ko and collaborators has proposed that acupuncture system is a macroscopic quantum dynamic structure [5] which might simply be visualized [2,6] as differentiated at the locations of maxima of three-dimensional standing waves, formed as a result of the reflection of coherent MW Frohlich excitations [7] of molecular subunits in the cell membranes, proteins, microtubules etc. This is supported also by other investigations which have demonstrated that differentiation of gap junctions (GJ) channels (of higher density at acupuncture points [8]) - as evolutionary older type of intercell communication, which transmits metabolits and regulatory molecules between nonexcitable cells, and ionic electric signals (presumably by combined classical-ionic/quantum-solitonic mechanisms [9]) between excitable cells (of the cardiac muscle, smooth muscles, epithelial liver cells, neurons with electrical synapses, and acupuncture points and meridians) - might be slightly sensitive to voltage [10].

In that context the *explanation for efficiency* of the MRT, as noninvasive nonmedicamentous medical treatment, should be sought [2,6]: some disorders in the organism give rise to deformation in the standing wave structure of electrical field of the organism in MW region, which influences corresponding changes in spatial structure of the acupuncture system, and consequently its resonant frequencies, resulting in some disease. During the therapy, applying the MW sound at corresponding acupuncture points the excited acupuncture system of the patient is relaxing to the previous healthy condition, while reaching the normal resonant frequencies responses upon the wide spectrum MW source - and following to physiological mechanisms of the acupuncture regulation [11] the organism biochemically overcomes the disease.

The quantum-coherent characteristics of MRT therapy suggest that healthy condition might be considered as an absolute minimum (ground state) of Sit'ko nonlocal selfconsistent *macroscopic quantum potential of the organism*, while some disorders of an acupuncture system correspond to higher minima of the (spatio-temporally changeable) potential hypersurface in energy-configuration

space - this being possible explanation of higher MRT sensory responses of the more excited (more disordered) acupuncture system, and poor MRT sensory response of the healthy acupuncture system being already in the ground state [2,6]. Such a picture is very close to those of associative neural networks in their energy-configuration spaces [2,6], and pattern recognition as a convergence of the network towards corresponding bottom of the potential hypersurface, as a memory attractor of the neural network [12,13]. Thus, the process of psychosomatic disorder might be considered as writing and deepening of the corresponding memory attractor, while the process of MRT therapy might be considered as a subsequent removing of the memory attractor of corresponding psychosomatic disorder - implying that process of the MRT therapy could be most deeply visualized as *removal of the very information* on corresponding psychosomatic disease [2,6], cf. Fig. 1.
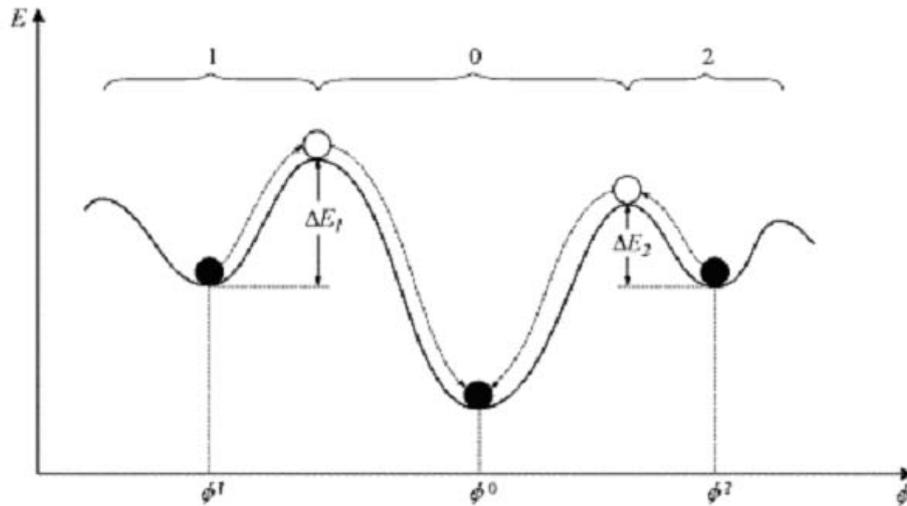

Fig. 1. Schematic presentation of the potential hypersurface of nonlocal selfconsistent macroscopic quantum potential in the acupuncture energy-state space (E, ϕ): 0 - basin of attraction of the ground (healthy) state ϕ^0; 1 and 2 - basins of attraction of the two excited (psychosomatically disordered) states ϕ^1 and ϕ^2 (hundreds of them being in general). It should be poined out that energy surface changes gradually during the MRT treatment, by decreasing the potential barriers ΔE_1 and ΔE_2 (and corresponding MRT sensory responses) of the potential wells 1 or 2, to be overcome in traversing to the 0 basin of attraction of the ground (healthy) state, when organism gradually recovers by further spontaneous approaching the healthy state ϕ^0 (with poor MRT sensory response, as already being in the ground-state). Such a picture is very close to the associative neural networks ones in their energy-configuration spaces, and to pattern recognition as convergence of the neural networks to the bottoms of the potential hypersurfaces, being the attractors of neural networks memory patterns ϕ^0, ϕ^1, ϕ^2.

Such a similarity between the two approaches is presumably not a coincidence, as (real) mathematical formalism of the model of Hopfield's associative neural network [12] is *analogous* [13] to (complex) mathematical formalism of Feynman's propagator version of the Schrodinger equation [14], cf. Appendix I. This also supports the *EM/ionic MW/ULF quantum-holographic function of the acupuncture system* (like complex oscillatory holographic Hopfield-like neural network [13]), and its essential relation to (complex-valued quantum relativistic) *consciousness*, as strongly suggested from modeling of altered and transitional states of consciousness [2,6,15], cf. Appendix II (it should be added that the displaced part of ionic acupuncture structure in these states would have a function of an "optical" MW sensor, which can extrasensory perceive an environment, as reported by patients reanimated from clinical death [16]). An additional support that acupuncture system is really related to consciousness is provided by novel *meridian (psychoenergetic) therapies* (with very fast removing of persistent phobias, alergies and other psychosomatic disorders [17]), whose simultaneous effects of *visualization* and *tapping/touching acupuncture points* might be interpreted as a *"smearing" of memory attractors* of the psychosomatic disorders [17]), through successive imposing new boundary conditions in the acupuncture energy-state space during visualizations of the psychosomatic problems [18].

So, it can be said that beside brain's hierarchical electrochemical neural network there exists acupuncture electromagnetic/ionic microwave ultralowfrequency-modulated quantum-holographic electrooptical neural network, with *brainwaves* being both the interface between them and ULF modulating factor of MW acupuncture network, implying also *biophysical basis of psychosomatic disorders* i.e. influence of psyche on the body; at the same time this presents explanation for the sensitivity of the organism on the *influences of extremely weak external* MW/ULF EM fields [19], through *MW/ULF EM induction* within EM/ionic circulatory acupuncture system, thus modulating acupuncture currents by external EM fields, *without any limitations by threshold potentials* which do not even exist within gap junction electrical synapses of the acupuncture system.

Such *brain/brainwaves/acupuncture system interface* is continuously *rewriting* information from brain hierarchical neural network into *acupuncture system*, they being there superposed keeping their *quantum coherence* of the parallel processed subliminal ULF lower-frequency unconscious information within acupuncture EM/ionic MW ULF-modulated quantum-holographic neural network [15]. The process of *collapse* of the wave function of macroscopic state of the acupuncture system, i.e. final *quantum decoherence within the brain*, might proceed through the same interface acupuncture system/brainwaves/brain. This is presumably realized through the brain's frontolimbic process [20] of the *selection and amplification* of the one out of many parallel processed subliminal ULF lower-frequency unconscious information (within the acupuncture system) toward ULF higher-frequency conscious thought in *normal states of consciousness* (within the brain), being subsequently *rewritten* into acupuncture system through the interface brain/brainwaves/acupuncture system, thus becoming amplified ULF higher-frequency *normal conscious content* [15].

NONLOCAL MACROSCOPIC QUANTUM BIOPHYSICAL EFFECTS: INTERACTIONS OF CONSCIOUSNESS WITH MICROSCOPIC AND MACROSCOPIC ENVIRONMENT

Consciousness is one of the oldest scientific problems, recognized already in ancient times, both in the civilizations of East and West. Although consciousness has been the central theme of philosophical essays for a long time from the very beginning of philosophical thought, or traditional esoteric practices of the East and West which have reached significant level in control of altered states of consciousness with significant philosophical and religious implications - the first scientific attempts to enlighten the phenomenon of consciousness appeared only in psychology of the second half of 19th century (through development of psychophysics and theories of personality), physics of the beginning of 20th century (through development of quantum mechanics and articulation of the problem of the so called wave function collapse, and the role of observer in this process), and computer sciences of the second part of 20th century (through development of artificial intelligence and the conception that the whole cognitive process can be reduced to a computer algorithm). However, due to scientific methodological difficulties the problem of consciousness has not gotten adequate treatment afterwards (corresponding multidisciplinary surveys on the problem of consciousness can be found in monographs of Baars [20], Poper and Eccles [21], Crick [22], Penrose [23], Tart [24], as well as in our proceedings [25]). Nevertheless, scientific investigation of consciousness underwent great renaissance in the last decade of 20th century, with a tendency to become *the most significant scientific problem* in a near future, being absolutely deserved owing to its *unparallel potential implications* in many fields (medicine, psychology, biology, physics, engineering, philosophy and religion), as recapitulated in the conclusion of the paper.

Holistic manifestations of consciousness, like altered and transitional states of consciousness [15], conscious/unconscious transitions, consciousness pervading body, and free will [26], as well as *nonlocallity of quantum mechanics* demonstrated by Einstein-Podolsky-Rosen effect [27] and Bell inequalities multiply confirmed experimentally last years [28], imply that *some manifestations*

of consciousness must have *deeper quantum origin* (in spite of recent Tegmark's theoretical investigations [29] which demonstrate that interactions with environment destroy in less than 10^{-13} s macroscopic quantum coherence within the brain, whose electrochemical neural networks might correspondingly be sufficient for modeling normal states of consciousness [20-22] - but not altered and transitional states of consciousness as well [24,25], whose nonlocal properties might be understood better through quantum-relativistic manifestations of the acupuncture EM/ionic microwave ultralowfrequency-modulated quantum-holographic neural networks [15], cf. Appendix II).

There are numerous macroquantum models of consciousness (some of them cited in ref. [29], whose aim is to investigate existence of the relevant brain/body degrees of freedom isolated enough to preserve their quantum coherence), and it is difficult to pretend on complete survey of these attempts. Therefore, in this paper we shall restrict ourselves on the approach and critique of the Copenhagen and von Neumann interpretations of quantum mechanics, and those attempts including ours to resolve *manifestly open quantummechanical problems in the context of consciousness*: (1) physical nature of the wave function *nonlinear collapse*; (2) physical nature of the instantaneous action on distance of the wave function *nonlocal collapse*; and (3) existence of the relevant *acupuncture macroscopic quantum degrees of freedom* within the body (related to altered and transitional states of consciousness) isolated enough to preserve their quantum coherence.

The first attempts to *treat consciousness strictly quantummechanically* originate from von Neumann [30], being supported by Wigner [31] and lately by Stapp [32]: in contrast to *Copenhagen interpretation* of Bohr, Dirac, and Heisenberg [33], which insists on *positivistic* limitations of quantum theory only on the observer knowledge about quantum system (thus becoming essentially subjective and epistemologic theory, as the only reality of this theory is 'our knowledge') - *von Neumann's* theory offers *ontologically* objective description of the reality and thus quantum framework for cosmological and biological evolution, including consciousness itself.

Besides, in the *problem of quantum measurement* i.e. collapse of the initial state of the quantum system in one of the possible probabilistic states of the system (when (linear) Schrodinger equation is *a priori* suspended and its boundary conditions are replaced by those corresponding to the collapsed state of the quantum system), in contrast to Copenhagen interpretation which treats it (*quantum inconsistently*) as an *ad hoc* process in the interaction of quantum system with classical measuring device - *von Neumann's* theory treats the measuring device quantum consistently by postponing the collapse of the initial quantum state until the final interaction with observer's consciousness in the chain quantum system/measuring device/observer, but also *not explaining* (nonlinear) *nature of the collapse*, with additional problem that ontological nonlocality of the collapse requests (relativistically inconsistent) *instantaneous action on distance* along space-like surfaces (which is the problem also implicitly transferred in the relativistic quantum field theory in spite of the relativistic invariance of the Tomonaga-Schwinger space-like surfaces [32])!

It is obvious that in von Neumann's ontological quantum theory, which consistently introduces phenomenon of consciousness, *two open problems* still exist: physical nature of the (nonlinear) collapse and instantaneous action on distance of the (nonlocal) collapse.

One possible solution of the problem of (nonlinear) collapse is proposed by Penrose [23] in *gravitationally induced reduction* of the wave function, in which the gravitational field of measuring device included in the superposition of corresponding possible probabilistic states of the device implies the superposition of different space-time geometries, and when the geometries become sufficiently different (on the Planck-Wheeler scale $\sim 10^{-35}$ m) this implies the break of standard quantum superposition of the state quantum system/measuring device (ill-defined in strictly separate space-time geometries) and Nature *must choose* between one of them and actually affects *objective reduction* of the wave function. (While regarding nonalgorithmic quantum-gravitational aspects of consciousness [23], Penrose tried to search for sufficiently isolated relevant macroscopic quantum degrees of freedom in microtubular citoskeletal structures of neurons (but not of acupuncture system!), which was undergone to severe critiques in Tegmark's paper [29].)

According to Raković's *biophysical quantum-relativistic model of consciousness* [15] (cf. Appendix II), the similar *objective reduction* of the wave function might have *quantum-gravitational origin* in space-time *microscopic wormhole tunnels of highly noninertial microparticle interactions* in quantum measurement-like situations (fully equivalent, according to Einstein's *principle of equivalence*, to strong gravitational fields - in which opening of wormholes is predicted [34]). The question how it is possible that these highly noninertial microparticle processes with inevitable relativistic generation of microparticles' wormholes were not taken into account within quantum mechanics which is yet extremely accurate theory(?) - might be answered as they were(!), but implicitly within the *ad hoc* von Neumann's projection postulate [30] to account for quantum mechanical "wave packet collapse" in quantum measurement situations (implying also that *von Neumann's ad hoc projection postulate is based on quantum gravitational phenomena*, being on deeper physical level than nonrelativistic quantum mechanical ones!). On the other hand, *nonlocality of collective consciousness* [15], as a giant space-time associative neural network with distributed individual consciousnesses (related to bodily acupuncture EM/ionic microwave ultralowfrequently-modulated quantum-holographic neural networks [6], mutually interacting quantum-gravitationally in transitional states of individual consciousnesses [15]), might explain (apparently) *instantaneous action on distance* in (nonlinear) quantum-gravitationally induced and (*nonlocally*) *channeled collapse by collective consciousness* (this being also in accordance with nonlocal Princetone's PEAR experiments of consciousness/machine interactions [35], nonlocal Ditron's experiments of consciousness/nonliving & living systems' interactions [36], nonlocal Novosibirsk's experiments of consciousness/living & nonliving systems' interactions [37], as well as with nonlocal clinical Duke's experiments on prayer-accelerated post-surgical patients' recovery [38])!

That quantum mechanically consistent approach to consciousness could really imply nonlocal properties of consciousness, might be supported by our considerations from *two additional directions* [39]: decoherence theory and cosmology.

Theory of decoherence seeks for physically consistent transition from quantum probabilistic indeterminism to classical reality, in the framework of quantum theory of measurement [40-42], by treating a quantum system as *open* (but with assumption of universality of the linear Schrodinger equation, the problem of "wave packet collapse" remains unresolved within this approach too [43]). Dugić recently demonstrated the existence of necessary conditions for decoherence process [44], giving rise in *macroscopic context* to wider physical picture which naturally encounters consciousness (cf. Appendix III): namely, *defining of the open quantum system* (S) *and its environment* (E) *which macroscopically includes consciousness as well*, is the *simultaneous process* - so that different macroscopic parts of the Universe as the open quantum system (S) are defined simultaneously with its macroscopic environment (E) which includes complementary consciousness (i.e. different macroscopic parts of the observed Universe define different complementary observing consciousness). In this way, within the context of universality of quantum mechanics *consciousness is only relative concept, nonlocally defined with all distant parts of the existing observed Universe* (although the reverse also holds true!).

This *relative metatheory of consciousness* is a part of *psycho-physical parallelism* which emphasizes holistic aspect of the whole Universe and naturally includes consciousness as its part [45-47]. In their lucid and instructive analysis of the collapse problem in quantum mechanics, Barrow and Tipler [47] offer, apart from unattractive solipsism and Everett's "no collapse" theory (with bizarre branching of the system and environment into many copies with different states, continuing their independent existences [48]), another three alternatives: either any being with consciousness can collapse the wave packet by observations, or a "community" of such beings can collectively collapse it, or there is some sort of "ultimate Observer" who is responsible for the collapse - the last two alternatives being natural candidates for incorporation within our relative metatheory of consciousness, thus supporting *nonlocallity of (collective) consciousness*. Such a viewpoint that macroscopic parts of the Universe play central role in physical understanding of consciousness may not be so surprising, especially if one takes seriously numerous *anthropic*

"coincidences" in both classical and quantum cosmology [47,49], with fine-tuning of the model physical parameters in the cosmological initial conditions close to the Big Bang singularity in order that life and consciousness be possible, as well as Ćirković's arguments on *relationship of quantum gravitation and transitional states of consciousness through their fundamental non-unitarity* (cf. Appendix IV).

CONCLUSION

It is shown that investigations in the field of microwave resonance *stimulation of the acupuncture system*, as well as the research of *consciousness interaction* with microscopic and macroscopic environment - imply the existence of *local and nonlocal macroscopic quantum biophysical effects,* with *great potential implications* in many fields:

(1) *medicine* (brain/consciousness relationship; brainwaves and brain functioning; acupuncture system and cognitive aspects of altered states of consciousness; relationship of nervous system and acupuncture system, and morphogenesis and psychosomatic disorders; local quantum holistic aspects of psychosomatics and wider application of the corresponding microwave resonance therapy on the level of acupuncture system; nonlocal quantum holistic aspects of psychosomatics and wider application of the corresponding transpersonal psychotherapy on the level of individual and collective consciousness);

(2) *psychology* (mechanism and role of dreaming and meditation, as altered states of consciousness, in the integration of personality; mechanism of ascending of unconscious conflict to conscious level, and interaction of conscious and unconscious in different psychotherapeutic approaches; control of creativity and transpersonal phenomena in transitional states of consciousness, and psychotherapeutic implications for transpersonal clinical psychology);

(3) *biology* (nonlocal interactions and adaptive mechanisms on the level of species; fundamental understanding of the significance of morality within human population);

(4) *physics* (fundamental role of individual and collective consciousness in quantum theory of measurement; revealing of deep relationship of consciousness, space-time and structure of matter, in transitional states of individual and collective consciousness; role of transitional states of individual and collective consciousness in controling exits of quantum-gravitational space-time tunnels);

(5) *engineering* (exploitation of technology of quantum-gravitational tunnels and technology of transitional states of consciousness, for radical surpassing of space-time barriers in transport and communication; computers with artificial consciousness and creativity, on deeper quantum-gravitational principles);

(6) *philosophy/religion* (ontological nature of individual and collective consciousness; removal of the matter/spirit duality; post-mortem consciousness continuity; nonlocal transfer of individual loads on descendants in emotionally loaded transitional states of consciousness; origin of free will; fundamental significance of nonlocal holistic space-time reprogramming of collective consciousness in prayer for fellow-men, enemies, and the dead; renaissance of the behavior based on hesychastic spiritual principles of charity).

APPENDIX I: ON PARALLELS BETWEEN CLASSICAL AND QUANTUM HOPFIELD-LIKE NEURAL NETWORKS

Hopfield's *classical neural networks* [12] has been extensively studied, simulated and used in *cognitive neurosciences* too [50]. However, it has also been shown recently that Hopfield's classical neural network model is mathematically analogous to Feynman's propagator version of the

quantum theory [14]. Hence, in this appendix the formal *informational parallelism* between classical and quantum Hopfield-like neural networks will be overviewed.

In the model of *Hopfield's classical neural network*, emergent collective computation is regulated by minimization of the Hamiltonian energy function [12]

$$H = -\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}J_{ij}q_i q_j = -\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\sum_{k=1}^{P}q_i^k q_j^k q_i q_j \tag{I.1}$$

where q_i is the actual collective activity of the *ith* neuron (out of N existing neurons in the network), while q_i^k is the contribution of the activity of the neuron i when taking part in encoding the *kth* memory pattern (out of P existing memory patterns in the neural network). The process of gradient-descent of this energy function is a result of a web of interactions between the *system of neurons* described by vector q (with elements q_i) and the system of *synaptic connections*, described by the *memory matrix J* (with elements J_{ij}).

Thus, in the model of Hopfield classical neural network, Hebbian dynamic equation for *neuronal activities*

$$q_i(t_2 = t_1 + \delta t) = \sum_{j=1}^{N}J_{ij}q_j(t_1) \quad \text{or} \quad q_{out}(t_2) = J\,q_{in}(t_1) \tag{I.2}$$

and dynamic equation for *synaptic connections* (weights)

$$J_{ij} = \sum_{k=1}^{P}q_i^k q_j^k \quad \text{or} \quad J = \sum_{k=1}^{P} q^k q^{kT} \tag{I.3}$$

exhibit a joint *classical parallel-distributed information processing system*. This is one of the simplest algorithms useful for theoretical brain modeling [50].

Equation (I.1) is *global* (variational) description, while system of equations (I.2-3) is *local* (interactional) description of the learning of input-data vectors q^k, in Hopfield's classical neural network. The corresponding neuronal activities can be inserted in the system of neurons q iteratively, or can be put in the very beginning simultaneously into the Hebb memory matrix J which contains all synaptic weights J_{ij}.

Equations (I.2-3) can be rewritten in *continuous form* incorporating spatio-temporal description of neuronal and synaptic activities:

$$q_{out}(r_2, t_2) = \iint J(r_2, t_2, r_1, t_1)\,q_{in}(r_1, t_1)\,dr_1 dt_1 \tag{I.4}$$

$$J(r_2, t_2, r_1, t_1) = \sum_{k=1}^{P} q^k(r_2, t_2)\,q^{kT}(r_1, t_1) \quad \text{ili} \quad J(r_2, r_1) = \sum_{k=1}^{P} q^k(r_2)\,q^{kT}(r_1)$$

(I.5)

The *memory recall* in Hopfield's classical neural network is done by input-output transformation $q_{out} = Jq_{in}$, or in developed form

$$q_{out}(r_2, t_2 = t_1 + \delta t) = \int J(r_2, r_1)\,q_{in}(r_1, t_1)\,dr_1 = \int \left[\sum_{k=1}^{P} q^k(r_2)\,q^{kT}(r_1)\right] q_{in}(r_1, t_1)\,dr_1 \tag{I.6}$$

From equation (I.6) it is obvious that if the input vector q_{in} is most similar to some of the previously memorized vectors, say q^l (and simultaneously almost orthogonal to all other memory vectors q^k, k

$\neq 1$), then the output vector $\boldsymbol{q_{out}}$ converges to the memory pattern-qua-attractor $\boldsymbol{q^I}$, i.e. Hopfield's classical neural network *associatively recognizes* the vector $\boldsymbol{q^I}$.

Haken has shown that introduction of biologically more plausible *neuronal oscillatory activities* gives richer dynamics of the neural network [51], with Hopfield's classical neural net real-valued variables replaced by the *complex-valued* ones (similarly to quantum variables, although in contrast to thus conveniently modified classical formalism, the complex-valued quantum formalism is essential). A step further is done with *quantum generalization* of Hopfield's neural network: Sutherland's *holographic neural network* [52] and, equivalent to it, Peruš's model of *Hopfield-like quantum neural network* [13]. In this appendix we shall review *Peruš's model*, based on the direct mathematical correspondence between classical neural (left) and quantum variables (right) and corresponding Hopfield-like classical and quantum equations, respectively:

$$q \Leftrightarrow \phi, \quad q^k \Leftrightarrow \phi^k, \quad J \Leftrightarrow G$$

$$(I.4) \Leftrightarrow (I.7), \quad (I.5) \Leftrightarrow (I.8), \quad (I.6) \Leftrightarrow (I.9)$$

The equations in pairs are *mathematically equivalent,* implying similar *collective dynamics of the neural and quantum systems*, in spite of different nature of the set of neurons ($\boldsymbol{q}$) and their memory synaptic connections ($\boldsymbol{J}$) in the neural network, on the one hand, and wave functions (ϕ) and their propagator connections (G) in the quantum system, on the other hand.

So, in Peruš's model of the *Hopfield-like quantum neural network* [12], dynamic equation for the *wave function of the quantum state*

$$\phi_{out}(\boldsymbol{r_2}, t_2) = \iint G(\boldsymbol{r_2}, t_2, \boldsymbol{r_1}, t_1) \ \phi_{in}(\boldsymbol{r_1}, t_1) \ d\boldsymbol{r_1} dt_1 \quad \text{or} \quad \phi_{out}(t_2) = G \ \phi_{in}(t_1) \qquad (I.7)$$

and dynamic equation for the *propagator of the quantum system*

$$G(\boldsymbol{r_2}, t_2, \boldsymbol{r_1}, t_1) = \sum_{k=1}^{P} \phi^k(\boldsymbol{r_2}, t_2) \ \phi^k(\boldsymbol{r_1}, t_1)^* \quad \text{or} \quad G(\boldsymbol{r_2}, \boldsymbol{r_1}) = \sum_{k=1}^{P} \phi^k(\boldsymbol{r_2}) \ \phi^k(\boldsymbol{r_1})^* \qquad (I.8)$$

exhibit a joint *quantum parallel-distributed information processing system*, where ϕ^k are *eigen wave functions* of the quantum system. So ϕ^k represents the *memory state*, and the propagator G constitutes the *memory* of thus informationally interpreted *quantum system*! (Actually, so defined propagator G is related to the usually used Green function propagator $\overline{G}$, by equation $G = -i\overline{G}$ [14].)

The *memory recall* in Hopfield-like quantum neural network is done by input-output transformation $\phi_{out} = G \ \phi_{in}$, or in developed form

$$\phi_{out}(\boldsymbol{r_2}, t_2 = t_1 + \delta t) = \int G(\boldsymbol{r_2}, \boldsymbol{r_1}) \ \phi_{in}(\boldsymbol{r_1}, t_1) \ d\boldsymbol{r_1} = \int [\sum_{k=1}^{P} \phi^k(\boldsymbol{r_2}) \ \phi^k(\boldsymbol{r_1})^*] \ \phi_{in}(\boldsymbol{r_1}, t_1) \ d\boldsymbol{r_1} \quad (I.9)$$

i.e. in the other form (where one can recognize the *quantum superposition principle*, i.e. the development of the wave function ϕ_{out} over the wave functions ϕ^k)

$$\phi_{out}(\boldsymbol{r}, t) = \sum_{k=1}^{P} c^k(t) \ \phi^k(\boldsymbol{r}) = \sum_{k=1}^{P} \int [\phi^k(\boldsymbol{r})^* \ \phi_{in}(\boldsymbol{r}, t) \ d\boldsymbol{r}] \ \phi^k(\boldsymbol{r}) \qquad (I.9')$$

From equations (I.9) and (I.9') it is obvious that if the input wave function ϕ_{in} is most similar to some of the previously memorized wave function, say ϕ^1 (and simultaneously almost orthogonal to all other memory eigen wave functions ϕ^k, $k \neq 1$), then the output wave function ϕ_{out} converges to the memory pattern-qua-attractor ϕ^1, i.e. Hopfield-like quantum neural network *associatively recognizes* the eigen wave function ϕ^1.

Or translated into orthodox language of the quantum physics [14], in the above example the propagator G represents the *projector* onto the wave subspace/state ϕ^1, i.e. makes *reduction* (collapse) of the wave function ϕ_{in} of the quantum system into the eigen state ϕ^1. Naturally, the collapse of the wave function of the *quantum processor* (not only of the hereby considered associative quantum memory) is also the final phase of the quantum computers as a network of quantum neurons (qubits) [53] - as well as the *quantum decoherence within the brain* [29], presumably through the brain frontolimbic [20,21] process of the *selection and amplification* of the one out of many (parallel processed subliminal ULF lowerfrequency) unconscious pieces of information toward (ULF higherfrequancy) conscious thought in *normal states of consciousness* [54].

Hopfield-like quantum neural networks are better then the classical ones because of the quantum phase differences which improve classical Hebbian amplitude coding [50]. Namely, by insertion of the eigen wave functions ϕ^k in the form of modulated plane waves or wavelets [13],

$$\phi^k(\boldsymbol{r}, t) = A_k(\boldsymbol{r}, t)\, e^{\frac{i}{\hbar} S_k(r,t)} \tag{I.10}$$

the propagator of the quantum system (I.8) becomes

$$G(\boldsymbol{r_2}, t_2, \boldsymbol{r_1}, t_1) = \sum_{k=1}^{P} A_k(\boldsymbol{r_2}, t_2)\, A_k(\boldsymbol{r_1}, t_1)\, e^{\frac{i}{\hbar}(S_k(r_2,t_2) - S_k(r_1,t_1))} \tag{I.11}$$

which describes the two-fold memory encoding: through the amplitude correlations, similarly to Hebbian rule in classical associative neural networks [50],

$$\sum_{k=1}^{P} A_k(\boldsymbol{r_2}, t_2)\, A_k(\boldsymbol{r_1}, t_1)$$

and through the phase differences, $\delta S_k = S_k(\boldsymbol{r_2}, t_2) - S_k(\boldsymbol{r_1}, t_1)$, similarly to holography [52].

The correspondence of the informational-physical laws of neural and quantum physics, presented in this appendix, seems to represent only one of illustrations of the *deep interrelations of the laws of Nature* on different levels. It has also been shown recently [55] that physical laws which describe simple clocks, simple computers, black holes, space-time foam, and holographic principle - are interrelated!

APPENDIX II: ON BIOPHYSICAL QUANTUM-RELATIVISTIC MODEL OF ALTERED AND TRANSITIONAL STATES OF CONSCIOUSNESS

According to Raković's *biophysical quantum-relativistic model of altered states of consciousness* [15], dreaming and similar hallucinate states are characteristics of the *low-dielectric altered states of consciousness*, with *relativistic mixing* of normally conscious and unconscious contents and *extremely dilated* subjective time base. Namely, according to this biophysical model, it is postulated that subjective reference system of consciousness is related to EM field of the ionic

currents in nonhomogeneous parts of the bodily acupuncture ionic structures, and from the biophysical analysis of the models it follows that it must be displaced out of body in altered states of consciousness! On the other hand, additional macroscopic arguments imply that *consciousness is related to EM field* of the bodily acupuncture EM/ionic microwave ultralowfrequency-modulated quantum-holographic neural network [15], while *analogy* of the mathematical formalisms [13] of the models of *Hopfield's* associative neural network [12] and *Feynman's* propagator version of Schrodinger equation [14] implies that *consciousness* might be a *property of the physical field itself* - implying that giant nonlocal quantum neural network with distributed individual consciousness processing units behaves as a collective consciousness of Nature itself, as widely claimed by esoteric/religious traditions [45,46]. This model might also provide additional route to the *quantum-gravitational objective wave-packet reduction*, and the role of consciousness in this process [15].

Namely, this might be deeply connected with the role of *collective consciousness* (as a composite quantum state Φ of all individual consciousness ϕ^k ($\Phi \sim \prod_k \phi^k$) in quantum theory of measurement, where collective consciousness with its *self-assembling* $\Phi \rightarrow \Phi_i$ (equivalent to convergence of quantum Feynman's propagator to the state Φ_i) contributes in *instantaneous quantum channeling* $\Psi \rightarrow \Psi_i$ (reduction of the initial wave function Ψ into one of (possible) probabilistic eigenstates Ψ_i) in quantum measurement-like situations. The very physical mechanism of the *objective reduction* in (nonlinear) collapse of the wave packet might have *quantum-gravitational origin* (similar to Penrose's gravitation induced collapse [23]), in the space-time *microscopic wormhole tunnels of highly noninertial microparticle's interactions* in quantum measurement-like situations (fully equivalent to extremely strong gravitational fields according to Einstein's *principle of equivalence*, when relativistic generation of wormholes is predicted [34]).

It should be also pointed out that the above *collective consciousness' self-assembling* $\Phi \rightarrow \Phi_i$ in the quantum theory of measurement (on numerously prepared investigated quantum system Ψ) should be interpreted as purely *probabilistic* in Penrose's gravitation-induced objective reduction of the wave packet (with relative frequency of their appearance given by quantum-mechanical probability $|a_i|^2$ of realization of corresponding microparticls' eigenstates Ψ_i, where $\Phi\Psi = \sum_i a_i \Phi_i \Psi_i$, i = 1,2,3, ...), depending not on the previous history of the repeatedly prepared quantum system. However, this might not be the case for *biological individual consciousness' self-assembling*, being *history-dependent deterministic* one (resulting in history-ponderous *more probable convergence* of the macroscopic consciousness-related-acupuncture electromagnetic/ionic microwave ultralowfrequency-modulated oscillatory holographic Hopfield-like associative neural network to the *deeper particular attractor* in the potential hypersurface [13], or equivalently to more probable convergence of quantum *Feynman's propagator* to the state ϕ^k, fixedly determined by the more dominant state of individual consciousness), implying that *strong preferences* in individual futures might exist, governed by individual mental loads, as widely claimed in Eastern tradition [45], also presumably supported by contemporary mathematical discovery of the hidden Old Testament's "Bible code" [56]; the same may apply to collective futures too, governed by interpersonal mental loads [15]. It should be also noted that these preferences in individual and collective futures might be *anticipated in transitional states of consciousness* [15] which might be the basis of intuition, precognition and deep creative insights [57]. What is really anticipated in transitional states of consciousness of individual consciousness might be the *evolved state of cosmic collective consciousness* Φ(t) (to which our individual consciousness ϕ^k has access, being the constituting part of cosmic collective consciousness), which is quantum-mechanically described by deterministic unitary evolution governed by Schrodinger equation.

However, it also seems that (non-Schrodinger governed) *nonlocal individual/collective consciousness reassembling* ($\Phi \rightarrow \Phi_i$) is possible, with direct influence on the collapse of the

observed system ($\Psi \rightarrow \Psi_i$), which is supported by Princeton *PEAR human/machine experiments* [35]. In these experiments (even distant) human operators have been able *solely by volition to influence the statistical behaviour of sophisticated machines* with (otherwise) strictly random outputs, in a statistically repeatable effects (of the order of a few parts in ten thousand) - but individually not reproducible at any moment, which is a standard request in contemporary scientific experiments! All this can be accounted by intentional transitional transpersonal biological (non-Schrodinger governed) *quantum-gravitational tunneling* of the operator's individual consciousness with *mental addressing* on the machine's content of collective consciousness in the operator's transitional states of consciousness (short and therefore not easily reproducible [57] highly noninertial processes of the out-of-body space-time quantum-gravitational mentally-channeled tunneling of operator's part of the EM/ionic acupuncture system [15]), thus *channeling intentionally the operator/machine composite state of collective consciousness* ($\Phi \rightarrow \Phi_i$), and automatically influencing the machine output ($\Psi \rightarrow \Psi_i$) in the non-Schrodinger quantum-gravitationally governed collapse-like process ($\Phi \, \Psi \rightarrow \Phi_i \, \Psi_i$). As a consequence one could really conjecture that *consciousness might be essential property of Nature* at different structural levels, macroscopic and microscopic, animate and inanimate, being presumably related to the *unified field itself* [45,46].

That such nonlocal (non-Schrodinger governed) individual/collective consciousness reassembling ($\Phi \rightarrow \Phi_i$) is really possible, can be additionally supported by 1998' *Duke feasibility study* conducted by the Duke University and Durham Veterans Affairs medical centers, in which angioplasty patients with acute coronary syndromes who were simultaneously *prayed for* by seven different religious sects around the world did 50 percent to 100 percent better during their hospital stay than patients who were not prayed for by these groups [38]! This is in accordance with long-lasting empirical evidences of various Eastern and Western esoteric/religious traditions [45,58]. It should be added, on this traditional line of evidences, that according to the consciousness-related-acupuncture electromagnetic/ionic microwave ultralowfrequency-modulated oscillatory holographic Hopfield-like associative neural network [15], *esoteric/religious notions* such as [45,58] *psychic body* (*manomaya, lingasarira, manovijnana, ka, psyche, astral body, subtle body, soul*, ...) and *spiritual body* (*vijnanamaya, suksmasarira, manas, ba, thymos, noetic body, mental body, mind*, ...) are biophysically inevitably associated with a *partly displaceable* (from the body, in altered and transitional states of consciousness) *ionic acupuncture system*, and an *EM component* of ionic currents embedded within it, respectively; also, the *ionic condensations* in the structured acupuncture system, with an *EM component of ionic currents* embedded within it, behave like *distributed centers of consciousness* (*yogic chakras*); finally, the *ionic nature of the etheric vitality* (*qi, prana, pneuma, bioenergy*, ...) and *etheric body* (related to *nondifferentiated ions*, essentially important for many biochemical processes within the body), might be noticed.

Finally, it should be pointed out that theoretical biophysical modeling of cognitive processes [54,59] might have *significant psychotherapeutic implications*: (1) *dreaming and meditation* (as a prolonged altered state of consciousness [45]) contribute to *integration of conscious and unconscious contents* around healthy associative memory ego-state, which results in growth of personality and *alleviation of emotional conflicts*; (2) *autogenic training* (as the most contemporary method of medical relaxation [2,54,60]) helps contextual messages to be associatively memorized at the subconscious level, from where they contribute to *softening of undesired psychosomatic reactions* on everyday stressful situations; however, for persons with strong psychological conflicts the main priority is *reprogramming of their psychological conflicts* and our modeling implies that this is possible in one of two possible ways: (3) *deep psychotherapeutic practices* (psychoanalytic, group, humanistic, gestalt, existential, body, transpersonal, expressive, hypno, integrative, experiential, ... orientation [61,62]) oriented to *recognition of the origin of unconscious conflict and its ascending to conscious level*, thus diminishing corresponding unconscious conflicting associative memory state, which enables further *integration of personality* around healthy associative memory ego-state [54]; (4) *transpersonal Christian/religious technique* (especially of hesychastic prayer [58,62]) bears probably essential transpersonal aspect of psychological conflict

and necessity of its *simultaneous transpersonal reprogramming* in all persons involved, contributing to its radical and final reprogramming at the level of *spatio-temporal associative memory network of collective consciousness*, which seems to be only possible through the *prayer for others in transitional states of consciousness of the praying person* [15,59].

APPENDIX III: ON THE ROOTS OF RELATIVE METATHEORY OF CONSCIOUSNESS IN THE QUANTUM DECOHERENCE THEORY

The process (effect) of *decoherence* can be qualitatively defined as a physical process "induced" by environment E upon the quantum system S, which leads to effective, approximately classical-physical behavior of the quantum system. For manyparticle systems, the effect is enormously quick (say of the order $\tau << 10^{-23}$ s), and hence it is not surprising that this effect is observed only recently, in a very demanding experimental conditions.

The system S is open quantum system to which unitary (reversible Schredinger) temporal evolution cannot be applied. However, for composite system S + E the universal validity of quantum mechanics is supposed, i.e. that it evolves in time according to Schredinger equation, with Hamiltonian $\hat{H} = \hat{H}_S + \hat{H}_E + \hat{H}_{int}$ which exists in the unitary operator of temporal evolution of the composite system: $\hat{U}(t) = \exp\left(-2\pi i \hat{H} t / h\right) \cong \exp\left(-2\pi i \hat{H}_{int} t / h\right) = \hat{U}_{int}(t)$ (as the interaction Hamiltonian ($\hat{H}_{int}$) is usually much greater than the "self-Hamiltonian" of the mutually noninteracting system ($\hat{H}_S$) and environment ($\hat{H}_E$)). Therefore, the problem of the decoherence theory is to calculate the "density matrix" of the system S, defined as

$$\hat{\rho}_S = tr_E \left(\hat{U}_{int}(t) \left| \Psi(t=0) \right\rangle_{SE\;SE} \left\langle \Psi(t=0) \right| \hat{U}*_{int} \right) \tag{III.1}$$

where "tr_E" denotes integration over degrees of freedom of the environment, while $\left| \Psi(t=0) \right\rangle_{SE}$ represents the initial state of the composite system S + E – alongside with finding ortonormalized basis $\left\{ \left| i \right\rangle_S \right\}$ in the Hilbert state space of the system S, where at least approximate diagonal form of the density matrix (III.1) is obtained: $\rho_{Sii'} \equiv {}_S\left\langle i' \right| \hat{\rho}_S \left| i \right\rangle_S \approx 0, i \neq i'$.

In a part of the literature the effect of decoherence is proclaimed as a very *basis of boarder-line* between the two quantum mechanical systems - the (open) system and its environment - in such a way that if there is no decoherence, then there is no boarder-line between the two systems mentioned above. Recent discovery of the existance of necessary conditions for decoherence [44] implies that quantum mechanics offers much more than one can (classically) comprehend and interpret. However, in the context of the above interpretation (according to which if there is no decoherence then there is no boarder-line between physical systems) the existence of necessary conditions poses the question: what about, mathematically possible, no-decoherence situations, when there is no possibility to establish boarder-line between the (open) quantum system and its (quantum) environment? At first sight, there is nothing to add here. However, it is not so; even more, a new "horizon" in investigation of the deeper fundamentals of the process of decoherence is opened, leading basically to some sort of metaphysical theory of consciousness. Some of the results will be shortly presented bellow.

Let the two (quantum) systems, S_1 and E_1, are given with their "degrees of freedom", alongside with their interaction which prevents the process of decoherence [44]. Then the following reasoning appears possible and physically justified: let us introduce new coordinates, i.e. define two new systems (new system and its environment), S_2 and E_2, but in such a way that degrees of freedom of these systems represent (analytical) functions of degrees of freedom of the both "old"

ones, S_1 and E_1, while the same interaction (i.e. the same interaction Hamiltonian), expressed in terms of new degrees of freedom, does not prevent decoherence. Then, the decoherence which is forbidden in the "old" composite system S_1 and E_1, now enables establishment of the boarder-line in the "new" composite system ("appeared" by redefining degrees of freedom in the same whole, $S_1 + E_1 = S_2 + E_2$)! I.e. the condition for decoherence *simultaneously defines* both the open system (S_2) and its environment (E_2). The "old" system and its environment, according to initial presumption, remain indistinguishable.

These transformations can be formally presented in the following way. Let the open system S_1 is given with its degrees of freedom and (its canonically conjugated) generalized momenta, (x_i, p_i), and analogously for its environment E_1, (X_j, P_j). Let the new (open) system and its environment, S_2 and E_2, are given with their variables, (ξ_m, π_m) and (Ξ_n, Π_n), respectively. Then the considered transformations have the form:

$$\xi_m = \xi_m(x_i, p_i; X_j, P_j)$$

$$\pi_m = \pi_m(x_i, p_i; X_j, P_j)$$
(III.2)

for every variable (degree of freedom and generalized momentum) of the "new" system S_2 (and (analogously) of its environment E_2). The Eq.(III.2) points out the following: the considered transformations (for instance, linear) interconnect degrees of freedom and generalized momenta of both ("old") system S_1 and ("old") environment E_1. So, the coordinates of the "new" system S_2 (and, *simultaneously*, of its environment E_2) are functions of the variables of both "old" systems, S_1 and E_1. In the quantum mechanical formalism, these transformations bear one very important consequence. Namely, in order that measurement of observables of the "old" systems might be possible, the measurement of observables of the "new" systems must be possible - simultaneously. But, this is not possible due to non-commuting degrees of freedom and momenta (of the "new" systems), and hence the transformation (III.2) is qualitatively different from the analogous classical transformations: if the interaction Hamiltonian is such that, *in respect to degrees of freedom of the "new" systems*, allows decoherence, then the decoherence concerns "new" systems, while (due to no-decoherence in respect to "old" systems) the "old" systems remain undistinguishable. Or more precisely: degrees of freedom of the "old" systems (S_1, E_1) are not defined by the condition of decoherence, while because of the uncertainty relations they cannot be measured even indirectly by virtue of measurement of observables of the "new" systems (S_2, E_2). This is the essence of the term "undistinguishable" for the "old" systems.

The generalization of this reasoning on the whole macroscopic systems of the physical Universe leads to an interesting conclusion. Namely, in the isolated macroscopic part of the Universe (MPU) the local transitions of the type $S_1 + E_1 \rightarrow S_2 + E_2$ are forbidden, i.e. *once established boarder-line (criterion for decoherence) cannot be changed locally, neither spontaneously nor by any external action*. While eventual *global transition*, regarding MPU as a whole, is unobservable. The related physical argument is following: the physical basis of consciousness is, by presumption, manyparticle system which is subsystem of MPU. Hence the imagined global transition of the above type simultaneously concerns this physical system too, and therefore the basis for observation of the considered global transition disappears. In other words: the above mentioned transformations of the degrees of freedom redefine the (open) quantum systems, their environments, but also physical basis of consciousness, giving rise that, effectively, *consciousness becomes a relative notion* - defined by degrees of freedom of other systems (and their environments). Therefore, the considered global transition defines MPU as a whole, including definition of (physical basis) of consciousness. As different definitions of MPU are mutually exclusive (at least in the context of existing paradigms), it is possible to talk about *relative metaphysical theory of consciousness*, which bears some sort of (but not in the sense of von Neumann's theory) *psycho-physical parallelism*.

APPENDIX IV: ENTROPY AND NONUNITARITY IN THE PHYSICS OF BLACK HOLES AND CONSCIOUSNESS

There are at least two aspects of the contemporary physics of black holes and its application in cosmology which imply holistic nature of the universe, and have significance for any anthropic way of thinking. The first one is related to the fact that black holes, considered as classical objects with some quantum properties, have enormous number of degrees of freedom manifested through entropy of gravitating matter. This is represented by Bekenstein-Hawking formula [63,64]:

$$S_{BH} = \frac{kc^3}{G\hbar}\frac{A}{4},$$ (IV.1)

where A is the surface of the black hole's event horizon, and the rest are fundamental physical constants (k is the Boltcmann constant, c is the velocity of light in vacuum, G is the Newton gravitational constant, and $\hbar$ is the Planck constant divided by π). It is obvious that the entropy of matter inside the event horizon is proportional to the surface of the horizon, while the physical problem of the (singular or nonsingular) state of the matter is not important from this point of view. In the simplest case of the spherically-symmetric nonrotating and electrically neutral black hole, the horizon is the sphere of the surface $A = 4\pi R^2$, where R is the Schwartzshild (gravitation) radius given by $R = 2Gm/c^2$ (where m is the mass of the black hole). In combination with (IV.1) this gives

$$S_{BH} = \frac{2\pi Gk}{\hbar c}m^2.$$ (IV.2)

Now it is possible to calculate gravitational entropy of the matter inside our cosmological (particle) horizon, if it would collapse in a some way into giant black hole. This would be the state of *maximal* entropy, as the state of the matter within black hole, as shown by Bekenstein, is the most probable one from the viewpoint of the gravitational interaction. Any other state, like the one observed today with the matter mainly concentrated in galaxies, stars, planets, etc. with a small number of black holes, is *a priori* less probable. It should be noted, on the other hand, in the context of contemporary cosmological models, that situation when all the matter was within its gravitational radius actually took part in the past: all the matter inside our horizon was in the initial singularity of the Big Bang about 14 billion years ago.

By applying the Boltzmann formula $S = k\,lnW$, it is possible to estimate the statistical weight (W) of the state characterized by the entropy (S) of the present universe (much less than maximal entropy from the Eq.(IV.2) estimated by Penrose (1989) as $\sim 10^{123}$, in the units of the Boltzmann constant k [23]). It is already qualitatively obvious that the presence of the logarithm in the Boltzmann equation implies that the present state is extremely less probable; its probability (W^1) is of the order $exp(-10^{123})$!!! Such a small number cannot be found in any other place in natural sciences. Hence this is most spectacular example of the "fine tuning", i.e. anthropic coincidences in cosmology. The former originates from the fact, realized by astrophysicists long ago, that very low gravitational entropy (sinonimous for relatively high uniformity of the early universe) is necessary for creation of the galaxies, which is the condition for existence of biological systems and intelligent observers. This conclusion was explicitly formulated by Collins and Hawking [65] even before Bekenstein's papers and sudden increase of interest for the problem of the gravitational entropy.

The second aspect of the physics of black holes, of the great importance for problems of consciousness and intelligent observers, is the possibility of essential violation of determinism in semiclassical process of the evaporation of black holes (Hawking's process). The hypothesis that

transitional states of consciousness include inherently indeterministic evolution ("free will") can be potentially explained physically as a residuum of deeper physical processes that include nonunitarity. Such processes were seriously suggested by now only in the context of quantum gravitation, the Hawking process precisely. This argument deserves more detailed consideration, as it is less probable that this is merely coincidence. Rather, it presents an indirect support for the hypothesis of significant quantum gravitational role in the functioning of consciousness.

Hawking (1982) was the first to point on the possibility of nonunitary evolution of a physical system, as one of possible answers to the problem of the loss of information in the black holes [66]. Namely, let us consider pure quantum state $|\psi\rangle$ which corresponds to the distribution of matter of the mass m which collapses under the influence of self-gravitation. The density matrix of such state is given by $\rho = |\psi\rangle \langle\psi|$, with vanishing entropy $S = - tr \, \rho \ln \rho$. If m is large enough, the matter will create the black hole inevitably. Afterwards, the black hole will evaporate slowly through the Hawking process, by emitting the black body radiation (which does not carry any nontrivial information). The semiclassical procedure used by Hawking in derivation of formula for the temperature of black hole will not be applicable when the mass of the evaporating black hole approaches to Planck mass, but what will happen with the information about the initial state still enclosed within the black hole? This is a puzzle of the loss of information within black holes (cf. for instance [67]).

The possibility proposed firstly by Hawking is that the black hole simply evaporates completely, so that information is lost irreversibly. This might be described as a fundamental *unpredictability* of black holes (and analogously of all other systems dominated by quantum gravitation). Although this idea remains as the simplest solution of the puzzle not contradicting any natural low, it raised a lot of discussions and controversies, as it necessarily implies *fundamental non-unitarity* of evolution of the complete system *universe + black hole*. Alternative solutions include possibility that information is still evaporated through the higher order corrections or that the Hawking evaporation is terminated when the mass of black hole becomes of the order of Planck's mass, leaving bellow the stable remnants encoding complete information on the initial state. However, these alternative solutions of the puzzle bear their deep problems, so the original Hawking's idea is still considered as the most acceptable possibility. It should be pointed out that this (alongside with the collapse of the wave function) is by now the only phenomenon in the physical world where fundamental indeterminism can be manifested. Whether this is really manifested can be only confirmed by the future observable (on detection of the evaporating black holes) and theoretical (on development of the correct theory of the quantum gravitation, exact on the Planck scale) works. In the framework of the idea - originating from Penrose - on the role of the future quantum theory of gravitation in explaining problem of consciousness, the possible causal relation of the indeterminism in consciousness and indeterminism in black holes might be an indirect confirmation of the idea that physical correlates of the mental states could be found only within some theory surpassing the contemporary physical theories.

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