

PROSPECTS FOR CONSCIOUS BRAIN-LIKE COMPUTERS: BIOPHYSICAL ARGUMENTS

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ABSTRACT. The key problem of the future theory of consciousness is how to incorporate altered states of consciousness within a new paradigm, as purely biochemical mechanisms are not accelerated up to several orders of magnitude, in comparison with subjective time sense dilation in altered states of consciousness - in respect to the normal awake state. The electromagnetic (EM) component of ultralowfrequency (ULF) "brainwaves" provides an extraordinary biophysical basis for consciousness-like displays in both normal and altered states of consciousness: it enables perfect fitting with narrowed limits of conscious capacity in normal awake states, very extended limits in altered states of consciousness (due to the relativistic mechanism of dilated "subjective" time base), and most peculiar space-time transpersonal interactions in transitional states of consciousness during the interchange of normal and altered states of consciousness (due to the relativistic generation of wormholes in highly noninertial "subjective" reference frame, fully equivalent to extremely strong gravitational fields according to Einstein's Principle of equivalence); it also enables the dream-like mixing of the normally conscious and unconscious contents in altered states, due to the relativistic Doppler mapping of the EM component of the "objective" ULF brainwave power spectrum on the zero-degenerate-frequency "subjective" one. As the rather complex additional low-dielectric ($\epsilon_r \approx 1$) weakly ionized gaseous "optical" neural network is necessary in these processes, it seems that biological molecular hardware will essentially determine further development of brain-like computers with artificial consciousness, in the form of neural networks with embedded brainwaves-like ULF ionic electrical activity. In transitional states of consciousness such nonprogrammable brain-like computers could be able to solve even most subtle problems creatively, by multiple re-addressing the problem and taking the most frequent solution as the optimal one. As the whole situation resembles on the quantum theory of measurement, such creative brain-like computers with artificial consciousness might be named quantum computers.

Keywords: *Altered states of consciousness, transitional states of consciousness, theoretical model, biophysics, relativistic & quantum physics, brainwaves, neural networks, ionic structures, brain-like computers.*

INTRODUCTION

Now prevailing scientific paradigm considers information processing inside central nervous system occurring through hierarchically organized and interconnected neural networks. Alongside with development of experimental techniques enabling physiological investigation of interactions of hierarchically interconnected neighboring levels of biological neural networks, significant contribution in establishing the neural network paradigm was given by theoretical breakthroughs in this field during the past decade [1]. Neural networks, as a trial to emulate brain's functioning, have many good properties: parallel functioning, relatively quick realization of complicated tasks, distributed information, weak sensitivity on damages, as well as learning abilities, i.e. adaptation upon changes in environment and improvement based on experience.

During the learning process, apart from hierarchical brain's neural networks, significant role in global distribution and memorizing (over the whole cortex) of hierarchically processed information is played by brainwaves [2]. While something is learned, information is hierarchically processed in primary, secondary, and tertiary brain's areas, being afterwards spread by brainwaves over the whole cortex; however, when learning is achieved (so called habituation), the same visual stimulus can only be found in the visual system! Of particular interest in this process is also extended reticular-thalamic activating

system (ERTAS) [3], as a hierarchical system of neural networks which compare currently processed information with the one memorized in the cortex, giving priority and amplifying one piece of information to conscious level; the rest pieces of information remain nonamplified at unconscious levels. This is basically also the mechanism of "emotional coloring" of some information!

ALTERED STATES OF CONSCIOUSNESS: SPECIAL RELATIVITY UNAVOIDABLE?

Particularly significant role of brainwaves is involved in modeling the states of consciousness - and especially the altered states of consciousness, characterized by extraordinary acceleration in psychological information processing, which cannot be explained by purely biochemical intersynaptic processes in biological neural networks.

It should be pointed out that purely *biochemical* mechanisms of the ERTAS are not accelerated up to several orders of magnitude, as the subjective time sense is dilated in altered states of consciousness [4-6] (REM sleep, meditation, hypnosis, psychedelic drug influence, some psychopathological states, and near-death experiences) - in respect to the normal awake state.

The only mechanism that can account for the extremely dilated subjective time base in altered states of consciousness is the *physical* relativistic one, if only the "subjective" observer can be associated with an EM field of the ultralowfrequency (ULF) brain activity (ongoing (EEG) and evoked potentials (EPs), henceforth brainwaves) which can move through the brain with relativistic velocities, as it was extensively elaborated in our biophysical model of altered states of consciousness for the last ten years [7,8]. However, it is necessary that complete information (both conscious and unconscious) is permanently coded from neural network to brainwaves, presumably as brainwaves' spatiotemporal patterns of the brain ionic structure, resulting from the spatio-temporal changes and activations of the synaptic interconnections in the neural networks of the brain.

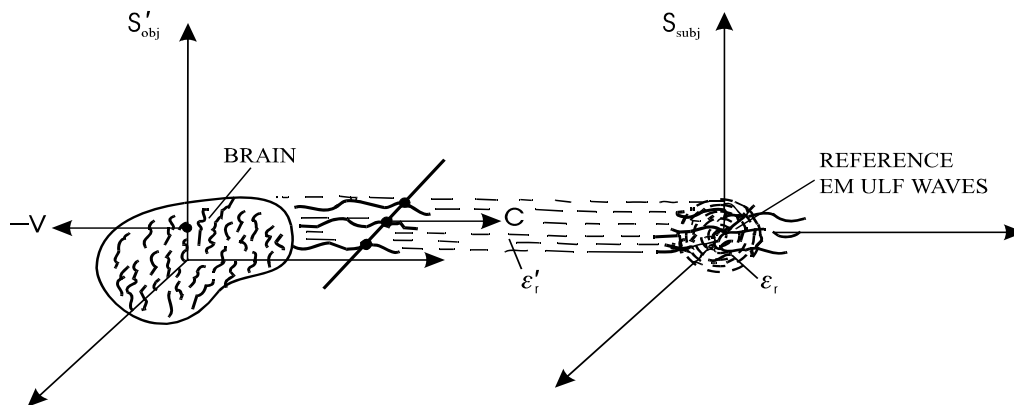


Figure 1. Figure accompanying the explanation for the necessity of the structured dielectric ($\epsilon_r \geq \epsilon'_r$) ionic medium, to ensure that the "subjective" observer (S_{subj}), related to EM field moving through the part of medium of greater ϵ_r , could register time-dilated information from faster EM waves moving through the neighboring part of medium of lower ϵ'_r [8]. More precisely, for inflowing information (in the form of EM field of ULF brainwave ionic currents, coded in spatiotemporal patterns from the brain neural networks) to be recognized by the structured ionic medium, that medium itself must have a form of some kind of "optical" neural network - thus the "subjective" observer S_{subj} being associated with the EM component of brainwaves in dielectrical "condensations" (of greater ϵ_r), behaving like "distributed centers of consciousness"!

To be more specific, the ionic medium supporting propagation of the brainwave ULF ionic currents must be unhomogeneous [8] to ensure that the "subjective" observer (associated with the EM component of reference ULF brainwaves), moving through the part of medium of greater ϵ_r , could register time-dilated information from faster EM component of brainwaves moving through the neighboring part of medium of lower ϵ'_r (cf. Fig. 1). Then, at every moment the "subjective" observer is associated with the EM component of brainwaves in the dielectrically "denser" medium, and the whole such system behaves like some "center of consciousness". The informational content of such "subjective" observer is

continuously replaced by a new incoming EM component of brainwaves. So, we have permanently some "stream of consciousness". More precisely, for inflowing information (in the form of ULF brainwave ionic currents, coded in spatiotemporal patterns from the brain neural networks) to be recognized by the structured ionic medium, that medium itself must have a form of some kind of "optical" neural network - thus the "subjective" observer being associated with the EM component of brainwaves in dielectrical "condensations" (of greater ϵ_r), behaving like "distributed centers of consciousness"!

It should be also pointed out that it might not be quite accidental that consciousness is related to the EM field of ULF brainwave ionic currents, as the intensity of irradiated ULF EM field is extremely low (intensity I of the field of frequency f , irradiated from a dipole source of linear dimensions d , has a dependence $I \sim f^4 d^2$ [9]), giving rise to consciousness localized around the body.

The model perfectly fits with the narrowed-down limits of conscious capacity in normal awake state (when brainwaves are predominantly located in the brain tissue with relative dielectric permittivity $\epsilon_r \gg 1$), and very extended limits in altered states of consciousness (characterized by low-dielectric $\epsilon_r \approx 1$ states, when the relative velocity between the "objective" laboratory reference frame and the "subjective" one is highly relativistic, $v = c_0/\sqrt{\epsilon_r} \approx c_0$, where c_0 is a velocity of EM waves in vacuum) - due to biophysical relativistic mechanism of *dilations of the subjective time base* [7,8] (cf. Fig. 2). ^a

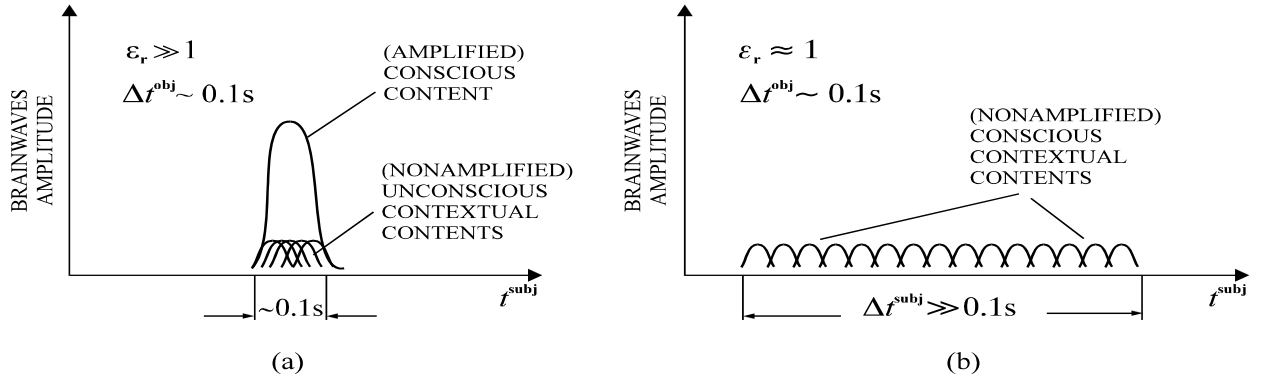


Figure 2. Schematic display of (a) overlapping process (during $\Delta t^{subj} \sim 0,1$ s) of amplified (by ERTAS) EM component of brainwaves with conscious content and non-amplified EM component of brainwaves with unconscious contextual contents, in normal awake state ($\epsilon_r \gg 1$), and (b) differentiated contextual contents, in altered states of consciousness ($\epsilon_r \approx 1$), with extremely dilated "subjective" time base ($\Delta t^{subj} \gg 0,1$ s) - due to the biophysical relativistic mechanism of the model.

^a By attaching the "objective" reference frame to the brain (i.e. laboratory) which moves relatively to the "subjective" reference frame with velocity $v = c_0/\sqrt{\epsilon_r}$ (where c_0 denotes the propagation velocity of the EM field in vacuum, and ϵ_r the ULF relative dielectric permittivity of the denser ionic structure where brainwaves propagate), the relativistic relation between the time intervals [10], from the viewpoint of the inertial "subjective" observer ($v = c_0/\sqrt{\epsilon_r} = const$), is

$$\Delta t^{subj} = \frac{\Delta t_0^{obj}}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\Delta t_0^{obj}}{\sqrt{1 - \frac{\epsilon_r'}{\epsilon_r}}} \frac{\epsilon_r}{\epsilon_r'} \approx 1 \gg \Delta t_0^{obj}$$

where $c = c_0/\sqrt{\epsilon_r'}$ denotes the propagation velocity of the incoming EM field inside the neighboring part of ionic structure with lower dielectric permittivity ($\epsilon_r' < \epsilon_r$, cf. Fig. 2). This could account for the striking dilations of the subjective time base (Δt^{subj}) in comparison with the objective time measured by the laboratory clock (Δt_0^{obj}), in altered states of consciousness, if $\epsilon_r/\epsilon_r' \approx 1$. This condition can be achieved only in a low-dielectric weakly ionized gaseous structured medium (with $\epsilon_r \geq \epsilon_r' \approx 1$), as the brain is a highly nonhomogeneous structure where ϵ_r could range from $\epsilon_r \geq 2$ (characteristic of biopolymers) across $\epsilon_r \approx 81$ (characteristic of free tissue water) to $\epsilon_r \sim 10^5$ (characteristic of cell membranes, with striking polarization of the volume ion density within the porous cell wall, strongly depending on metabolic cell processes) [11].

This relativistic mechanism also enables the *dream-like mixing* of the normally conscious and unconscious contents in altered states, due to the relativistic Doppler mapping of EM component of the "objective" ULF brainwaves power spectrum on the zero-degenerate frequency ^b "subjective" one [7,8] (cf. Fig. 3).^c So, in dreams we have "subjective" integration of normally conscious and unconscious contents, this being presumably their major role in the growth of human personality.

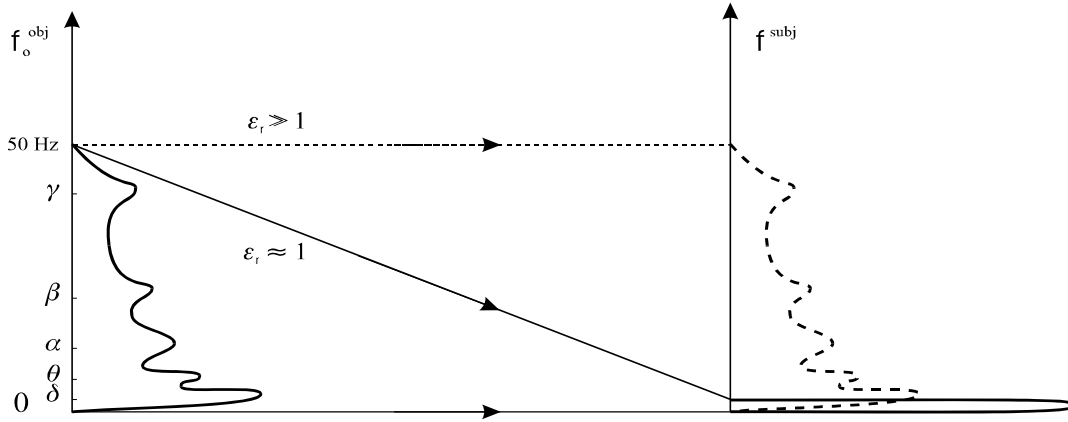


Figure 3. Display of Doppler mapping of EM component of the "objective" brainwave power spectrum on the "subjective" one, in psychologically altered states ($\epsilon_r \approx 1$, solid line), and normal awake states ($\epsilon_r \gg 1$, dashed line).

The biophysical nature of *low-dielectric* ($\epsilon_r \geq \epsilon'_r \approx 1$) structure has been analyzed in detail elsewhere [8]. It has been shown that this structure could be related to partly displaceable (from the body) unhomogeneous ionic acupuncture system which can conduct ULF ionic currents $\sim 10^{-7}$ A. The ionic concentration in the channels of displaced ionic structure has been estimated as $\sim 10^{15}$ cm⁻³, with a tendency of deterioration during a period of ~ 1 hour.

- ^b This does not diminish the rate of "subjective" information processing, as this process is not serial but parallel (both in spatiotemporal and frequency domains), being enhanced on "subjective" level by greatly enlarged temporal resolution due to extremely dilated "subjective" time base in altered states of consciousness (cf. Fig.2(b)).
- ^c The relativistic relation between the frequencies [12] measured in the two reference frames, moving away from one another ($\alpha = \pi$), is

$$f^{subj} = f_0^{obj} \frac{\sqrt{1 - \frac{v^2}{c^2}}}{1 - \frac{v}{c} \cos \alpha} \Big|_{\alpha = \pi} = f_0^{obj} \frac{\sqrt{1 - \frac{\epsilon'_r}{\epsilon_r}}}{1 + \sqrt{\frac{\epsilon'_r}{\epsilon_r}}} \ll f_0^{obj} \quad \frac{\epsilon_r}{\epsilon'_r} \approx 1$$

which describes the striking relativistic Doppler shift of the excited "objective" brainwave frequency (f_0^{obj}) down to the vanishing "subjectively" observed brainwave frequency ($f^{subj} \approx 0$ Hz) in low dielectric ($\epsilon_r \geq \epsilon'_r \approx 1$) altered states. This can account for the mixing of conscious and unconscious contents in the altered states of consciousness, as five main frequency bands of both the spontaneous (EEG) and evoked (EP) brainwave activities, $f_{0\gamma}^{obj}$ (30-50 Hz), $f_{0\beta}^{obj}$ (13-30 Hz), $f_{0\alpha}^{obj}$ (8-13 Hz), $f_{0\theta}^{obj}$ (3,5-8 Hz), and $f_{0\delta}^{obj}$ (0,5-3,5 Hz), the first three of them predominantly corresponding to normally conscious states [13] and the last two corresponding to normally unconscious states [14], for $\epsilon_r/\epsilon'_r \approx 1$ start merging from the viewpoint of the "subjective" reference frame: $f_{\gamma}^{subj} \approx f_{\beta}^{subj} \approx f_{\alpha}^{subj} \approx f_{\theta}^{subj} \approx f_{\delta}^{subj} \approx 0$ Hz, Fig.3. Although the "objective" brainwave power spectra in such states do not differ significantly from the spectrum of the alert state [15], the essential difference appears in the "subjective" brainwave power spectra; for the sake of comparison, in the alert state the brainwaves are predominantly located in the brain tissue (with $\epsilon_r \gg 1$), when a differentiated "subjective" spectrum exists: $f_i^{subj} = f_{0i}^{obj} \sqrt{1 - \epsilon'_r/\epsilon_r} / (1 + \sqrt{\epsilon'_r/\epsilon_r})$, $i = \gamma, \beta, \alpha, \theta, \delta$, cf. Fig. 3. This could be the biophysical mechanism of dreams, which particularly implies their psychological significance: in dreams one has continuous access and more efficient "subjective" integration of normally conscious and unconscious contents, giving rise to integration and growth of human personality (otherwise divided into conscious and unconscious associative "ego" states), which results in alleviation of emotional conflicts!

TRANSITIONAL STATES OF CONSCIOUSNESS: GENERAL RELATIVITY UNAVOIDABLE?

It should be noted that some peculiar *spatial* relativistic effects in altered states of consciousness (when $\epsilon_r \approx 1$) are predicted by the model [8]: the weakly ionized gaseous neural network, with embedded ULF brainwave currents, enables that even long "objective" distances can be "subjectively" optically recognized *contracted*; and, such displaced ionic "optical" neural network can perceive an environment *panoramicly*, as reported by reanimated patients.

Even more peculiar *spatio-temporal transpersonal interactions* are predicted in *transitional* (non-stationary) states of interchange of normal and altered states of consciousness (when brainwaves traverse from high-dielectric ($\epsilon_r \gg 1$) to low-dielectric ($\epsilon_r \approx 1$) state or *vice versa*, the relative velocity $v = c_0 / \sqrt{\epsilon_r}$ of "subjective" reference frame being subjected to abrupt change in short transitional period $\tau \sim 0,1$ s, with "subjective frame" acceleration $\sim c_0/\tau \sim 10^9$ m/s²). Deeper understanding of physical mechanisms of these processes obviously sinks into the General theory of relativity, applied to highly noninertial reference frames (like in enormously strong gravitational fields of "wormholes", where similar phenomena are expected [16]). From the point of view of General theory of relativity, physical processes in accelerated reference frame outside gravitational field and in that one inside gravitational field with equivalent (gravitational) acceleration - are identical (so-called *Principle of equivalence*, being one of the fundamentals of Einstein's theory of gravitation). Theoretical analyses show that in enormously strong gravitational fields so-called wormholes (or Einstein-Rosen space-time bridges) are created, whose entrance and exit could be in very distant space-time points. As in transitional states of consciousness the "subjective" reference frame, related to EM field of brainwaves, is subjected to quick change of velocity, with equivalent acceleration comparable with that one in enormously strong gravitational field of wormholes, according to the Principle of equivalence one could expect, in such brief states, the creation of Einstein-Rosen bridge and tunneling of "subjective observer", i.e. consciousness, in previously "mentally addressed" exit in space-time ^d - reminiscences on passing through some tunnel being really reported by many patients reanimated from clinical death [6]! It should be pointed out that apart from the EM field, the displaced part of ionic acupuncture system (in the form of ionic neural network, having the "optical" sensory function), must also be tunneled in such (acausal) interactions of consciousness with distant events in space-time! ^e

Finally, if the EM field of ULF ionic currents represents sophisticated internal display (related to consciousness) of neural network information processing, it seems that consciousness is not privilege of humans - but can be also a characteristic of higher animals. Even more, if microtubular cytoskeletal structures have neural network-like electrical activities on subcellular level [19], it seems that consciousness can be descended down to the cellular and even subcellular level. Naturally, the conscious content displayed in such EM internal displays depends on the complexity of corresponding neural network information processing at different levels, from subcellular to brain ones. Furthermore, as the EM field is only one out of four manifestations (electromagnetic, gravitational, weak and strong nuclear forces) of the unified physical field [20], it can be tentatively generalized that the unified field itself may be internal conscious display for various physical processes at different structural levels, from macroscopic cosmic to microscopic subnuclear ones. As a consequence, one could conjecture that Nature itself

^d To support this, one can cite the technique adopted by "extrasenses" when they want to exert some distant influence: they always intensely visualize the person or place, as mental targets! On the other hand, this could be deeply connected with the role of consciousness in quantum theory of measurement, where consciousness with its act of observation affects the final collapse of the initial wave function into one of possible probabilistic eigenstates - which implies that the collapse could be related with generation of local Einstein-Rosen bridge [16], as it is elaborated further on.

^e This could be a biophysical mechanism of the so-called astral projections of consciousness, those presumably being the basis of most psychic phenomena [17] (providing also explanation for transitional nature and difficult reproducibility of these phenomena); the mentioned "astral projections" are presumably also the basis of religious experiences [18], with mental addressing on spatio-temporally distant abundant ionic archetypic structures from religious traditions, being the target of prayer in transitional states of consciousness.

has consciousness at different structural levels, both animate and inanimate, as it is widely claimed in esoteric traditional knowledge^f [21].

Although such nonlocal pantheistic idea of consciousness is rather bizarre, it can naturally help in resolving the fundamental problem of the wave function reduction in the quantum theory of measurement [22], where in an act of measurement (including finally the very act of conscious observation of the act of measurement) the macroscopic measuring apparatus (including consciousness as a "subjective" observer) makes reduction of the initial wave function into one of the possible eigenfunctions of the system.

QUANTUM COLLAPSE: CONSCIOUSNESS UNAVOIDABLE?

The problem of the *wave function reduction* (quantum collapse) in an act of measurement is "orthodoxly" interpreted in quantum theory of measurement as the discontinues change induced by the observation of a quantity with eigenstates Ψ_1, Ψ_2, \dots , in which the initial wave function $\Psi = \sum_i a_i \Psi_i$ will be changed to the state Ψ_j with probability $|a_j|^2$. The collapse of the wave function and the assignment of statistical probabilities do not follow from the Schrödinger equation - they are consequences of an external *a priori* metaphysics, which is allowed to intervene at this point and suspend the Schrodinger equation, or rather replace the boundary conditions on its solution by those of the collapsed state function. The problem of quantum theory of measurement has not been consistently resolved to date, and has been the subject of many serious theoretical efforts, from the very beginning of Quantum mechanics [22].

On the other hand, Quantum mechanics is *nonlocal theory*, as even very distant parts of quantum-mechanical system (which cannot exchange light signals) can be physically correlated in the act of measurement (like in Einstein-Podolsky-Rosen paradox [22]). As an extreme consequence, this implies that consciousness as a "subjective" observer in such kind of experiment must have nonlocal properties. The property of *nonlocality of consciousness is automatically fulfilled* in our relativistic biophysical model, according to which consciousness is inherently and globally related to the very *electromagnetic field* of the brainwaves ionic current! Having in mind that EM field is only one of the four manifestations of the unified physical field - it might be that the very *unified field* is nonlocal internal *collective* conscious display for various physical processes at different structural levels, from microscopic to macroscopic ones.

This bizarre nonlocal pantheistic idea of consciousness can naturally help in resolving the fundamental difficulties of the wave function reduction. In one of the most recent approaches, Penrose proposes gravitationally induced wave function reduction [23]. Actually, gravitational field of the state of observing apparatus Φ , with all possible observable outputs Φ_i , must be also involved in the superposition of quantum eigenstates ($\Psi\Phi = \sum_i a_i \Psi_i \Phi_i$) - this implying different space-time geometries superimposed. However, when the geometries become sufficiently different (on the Planck-Wheeler scale $\sim 10^{-35}$ m), thus implying ill-defined standard superposition of the *matter* eigenfunctions in strictly *separate* spaces - Nature must choose between one of them and *actually* effects wave function reduction. Moreover, as microparticles are continuously subjected to fantastic accelerations ($\sim v^2/r \sim 10^{23}$ m/s² for electrons bounded in atoms, and $\sim 10^{29}$ m/s² for protons and neutrons bounded in nucleus,...), which can be met also in extremely strong gravitational fields - according to the Principle of equivalence one should expect [8] continuous opening and closing of local Einstein-Rosen bridges, addresses of their exits being related (probabilistically) to one of the possible eigenstates of corresponding microparticles. This process might yet be the mechanism for some sort of the wave function reduction, implying why so important the *mental addressing* is in transitional states of consciousness, described above (cf. footnote c)! It also reveals that Quantum mechanics and the General theory of relativity seem to be deeply interconnected on microparticle level, showing that microparticles are continuously vanishing and reemerging

^f In that context, all local consciousnesses might be interconnected (through previously described interactions in altered and, especially, in transitional states of consciousness) making the giant cosmic informational network with delocalized consciousness, implying the crucial significance of morals, both on the level of thoughts and feelings!

(subjected obviously to corresponding conservation laws) in measurement-like interactions, throwing a new light on wave-particle dualism and other quantummechanical phenomena.

In that framework, the role of consciousness in quantum theory of measurement turns out to be extremely important [8]! For instance, in gravitationally induced wave function reduction, the very mechanism for this process could be continuous opening and closing of local microparticles' Einstein-Rosen bridges, addresses of their exits being related (probabilistically) to one of the possible eigenstates Ψ_i of corresponding microparticles - and everything being related to corresponding probabilistic addressing Φ_i of "collective consciousness".

It should be noted that physical interaction of the displaced gaseous ionic "optical" neural network with *possible* "objective" system (described by *possible* wave function Ψ_i) or corresponding possible state of "collective consciousness" (Φ_i), during transitional states of consciousness - opens also a question on the nature of wave functions - which should provide a picture of quantum-level physical *reality* (not only serving as a calculational device, useful merely for calculating probabilities, or as an expression of the experimenter's "state of knowledge" concerning physical system)! ^g

INSTEAD CONCLUSION: PROSPECTS FOR BRAIN-LIKE COMPUTERS

Our biophysical analysis of the serial conscious psychological mode in normal and altered states of consciousness, implies that consciousness is subtle display in the form of electromagnetic component of ULF ionic brainwave currents, embedded in ionic structure capable of (even distant) spatio-temporal displacements from the body in transitional states of consciousness. As rather complex ionic structure is necessary in these processes, it seems that biological molecular hardware will essentially determine further development of brain-like computers with artificial consciousness, in the form of neural networks with embedded brainwaves-like ULF ionic electrical activity. Such neural networks could emulate most of altered states of consciousness, which might be technologically multiplied in respect to human ability to control such states, by far surpassing human brain.

Besides having artificial consciousness, in transitional states of consciousness such nonprogrammable brain-like computers could be able to solve creatively even most subtle problems. It would be only necessary to "mentally" re-address the problem multiply, to get the statistics of anticipatively obtained solutions: the most frequent one will be the optimal solution of the problem addressed. As the whole situation of probing the world of virtual possibilities ^h resembles on quantum theory of measurement, such creative brain-like computers with artificial consciousness might be named *quantum computers*.

^g Then by changing initial state of "collective consciousness" (Φ) one can influence probabilities of realization of corresponding states Φ_i , i.e. possible objective states Ψ_i . As the state of "collective consciousness" (Φ) is a composite state constituted of (noninteracting) states of all "individual consciousness" (φ_k), $\Phi \sim \prod_k \varphi_k$, it follows that the change of state φ_k of "individual consciousness" can affect the state Φ of "collective consciousness", and therefore the probabilities for realization of possible objective states Ψ_i . This is particularly true if the state Φ is very sensitive on small changes of initial conditions, which is the case for physical systems described by deterministic chaos [24]. Having in mind that the brain and corresponding state φ_k of "individual consciousness" is such kind of system, then the composite state Φ of "collective consciousness" is also described by deterministic chaos - and therefore very sensitive on small changes in initial conditions! Such a conclusion implies extraordinary practical significance of morals and contents of our "individual consciousness", as they directly determine the probability of realization of possible objective states Ψ_i , i.e. the future events, no matter how bizarre this conclusion looks like [8]!

^h What might be the physical nature of this world is still an open question, but one possibility is that it could be a world described by eigenstates Φ_i of "collective consciousness". This quantummechanical viewpoint is supported by the computer εξπειριμεντο ωιτη ρανδομ νυμβερ γενερατορσ, ιμπλινιγ τηατ ονλν νοναχτυαλιζεδ ποσσιβλε φυτυρεσ χαν βε αντιχιπατεδ (μορε αχχυρατελν φορ α πριορι γρεατερ προβαβιλιτιεσ οφ τηειρ ρεαλιζατιον) [25]. Ωηατ ισ αχτυ αλλν αντιχιπατεδ ιν τρανσιτιοναλ στατεσ οφ \forall ινδιβιδυαλ χονσχιουσνεσσ \forall μιγητ βε τηε επολπεδ στατε οφ \forall χ ολλεχτιπε χονσχιουσνεσσ \forall $\Phi(t)$ in some future moment t (to which "individual consciousness" has access, being the constitutional part of "collective consciousness", cf. footnotes *f* and *g*), which is quantummechanically described by deterministic unitary evolution governed by Schrödinger equation (or Dirac equation in relativistic case).

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REFERENCES

- [1] R.Hecht-Nielsen, *Neurocomputing* (Addison-Wesley, New York, NY, 1990).
- [2] E.R.John, Switchboard versus statistical theories of learning and memory, *Science* 177 (1972), pp. 850-864; E.R.John, T.Yang, A.B.Brill, R.Young, and K.Ono, Double-labeled metabolic maps of memory, *Science* 233 (1986), pp. 1167-1175; R.Eckhorn, R.Bauer, W.Jordan, M.Brosch, W.Kruse, M.Munk, and H.J.Reitboeck, Coherent oscillations: A mechanism of feature linking in the visual cortex?, *Biol. Cybern.* 60 (1988), pp. 121-130; C.M.Gray, P.Konig, A.K.Engel, and W.Singer, Oscillatory responses in visual cortex exhibit inter-columnar synchronization which reflects global stimulus properties, *Nature* 338 (1989), pp. 334-337; F.Crick and C.Koch, Towards a neurobiological theory of consciousness, *Seminars in the Neurosciences* 2 (1990), pp. 263-275; F.Crick, *The Astonishing Hypothesis. The Scientific Search for Soul* (Charles Scribner's Sons, New York, and Maxwell Macmillan International, 1994).
- [3] K.R.Poper and J.C.Eccles, *The Self and Its Brain* (Springer, Berlin, 1977), Chs. E2,8; B.J.Baars, *A Cognitive Theory of Consciousness* (Cambridge Univ. Press, Cambridge, MA, 1988).
- [4] In C.Tart, ed., *Altered States of Consciousness* (Academic, New York, 1972).
- [5] K.Jaspers, *Algemaine Psychopathologie* (Springer, Berlin, 1953).
- [6] R.A.Moody, jr., *Life after Life* (Bantam, New York, NY, 1975); M.Morse, *Closer to the Light: Learning from the Near-Death Experiences of Children* (Ivy Books, New York, 1990).
- [7] D.Raković, Biocomputers - the perspectives, *Proc. 15th Yug. Conf. Microelectr. (MIEL-87)*, pp. 143-146 (1987), in Serbian; D.Raković, Đ.Koruga, D.Djaković, Ž.Martinović, V.Desimirović, and Dj.Minić, Ultralowfrequency "optical" biocomputers: Biophysical arguments, in F.Hong, ed., *Molecular Electronics: Biosensors and Biocomputers* (Plenum, New York, NY, 1989), pp. 397-405; D.Raković, Đ.Koruga, Ž.Martinović, and G.Stanojević, Molecular electronics and neural networks: Significance of ionic structure, *Proc. Ann. Int. Conf. IEEE/EMBS* 11, pp. 1366-1367 (1989), Y.Kim and F.A.Spelman, eds., Part 4/6; D.Raković, Neural networks vs. brainwaves: Prospects for cognitive theory of consciousness, *Proc. Ann. Int. Conf. IEEE/EMBS* 12, pp. 1431-1432 (1990), P.C.Pedersen and B.Onaral, eds., Part 3/5; D.Raković, A cognitive theory of consciousness: Possible educational framework, *ibid.*, pp. 2373-2374, Part 5/5; D.Raković, Neural networks, brainwaves, and ionic structures: Acupuncture vs. altered states of consciousness, *Acup. & Electro-Therap. Res., Int. J.* 16 (1991), pp. 89-99; D.Raković, Đ.Koruga, Ž.Martinović, and G.Stanojević, On biophysical structure of brainlike biocomputers, in P.I.Lazarev, ed., *Molecular Electronics: Materials and Methods* (Kluwer, Dordrecht, The Netherlands, 1991), pp. 211-217; D.Raković, Neural networks versus brainwaves: A model for dream-like states of consciousness, *Proc. Ann. Int. Conf. IEEE/EMBS* 14, pp. 2651-2652 (1992), J.P.Morucci, R.Plonsey, J.L.Coatrieux, S.Laxminarayan, eds., Part 6; D.Raković, Neural networks versus brainwaves: Biophysical model for ELF interactions, *ibid.*, pp. 2750-2751 (1992); D.Raković, Neural networks, brainwaves, and ionic structures: Biophysical model for states of consciousness, *Int. Conf. Toward a Scientific Basis of Consciousness* (Tucson, April 12-17, 1994).
- [8] D.Raković, Brainwaves, neural networks, and ionic structures: Biophysical model for altered states of consciousness, in D.Raković and Đ.Koruga, eds., *Consciousness: Scientific Challenge of the 21st Century* (ECPD, Belgrade, 1995), pp. 291-316; D.Raković, *Fundamentals of Biophysics* (Grosknjiga, Belgrade, 1994,1995), Chs. 5,6, in Serbian; D.Raković, Hierarchical neural networks and brainwaves: Towards theory of consciousness, *Proc. ECPD Seminar*, pp. 189-198 (1996), Lj.Rakić, D.Raković, Đ.Koruga, and A.Marjanović, eds., in Serbian.
- [9] L.D.Landau and E.M.Lifschics, *Field Theory* (Nauka, Moscow, 1973), Ch. 9, in Russian.
- [10] *Ref. 9*, Ch. 1.

- [11] W.R.Adey, Tissue interactions with nonionizing electromagnetic fields, *Physiol. Rev.* 61 (1981), pp. 435-514, and references therein.
- [12] *Ref. 9*, Ch. 6.
- [13] E.Basar, *EEG Brain Dynamics* (Elsevier, Amsterdam, 1980), Ch. 2.
- [14] *Ref. 4*, Sect. 3; D.Foulkes, Theories of dream formation and recent studies of sleep consciousness, *Psychol. Bull.* 62 (1964), pp. 236-247.
- [15] *Ref. 4*, Sect. 8.
- [16] K.S.Thorne, *Black Holes and Time Warps: Einstein's Outrageous Legacy* (Picador, London, 1994), Ch. 14, and references therein.
- [17] R.G.Jahn, The persistent paradox of psychic phenomena: An engineering perspective, *Proc. IEEE* 70 (1982), pp. 136-170.
- [18] K.C.Markides, *Fire in the Heart. Healers, Sages and Mystics* (Paragon House, New York, 1990).
- [19] S.R.Hameroff, *Ultimate Computing. Biomolecular Consciousness and Nano-technology* (North-Holland, Amsterdam, 1987); Dj.Koruga, Molecular networks as a sub-neural factor of neural networks, *BioSystems* 23 (1990), pp. 297-303.
- [20] J.H.Schwarz, Superstrings, *Physics Today*, Nov.1987, pp. 33-40, and references therein.
- [21] K.Wilber, *The Atman Project* (Quest, Wheaton, IL, 1980); P.Vujićin, States of consciousness in esoteric practice, in D.Raković and Dj.Koruga, eds., *Consciousness: Scientific Challenge of the 21st Century* (ECPD, Belgrade, 1995); and references therein.
- [22] In J.A. Wheeler and W.H. Zurek, eds., *Quantum Theory and Measurement* (Princeton Univ., Princeton, 1983).
- [23] R.Penrose, Shadows of the Mind, *A Search for the Missing Science of Consciousness* (Oxford Univ., Oxford, 1994), Part II, and references therein.
- [24] A.Babloyantz, Chaotic dynamics in brain activity, in E.Basar, ed. *Dynamics of Sensory and Cognitive Processing by the Brain* (Springer, Berlin, 1988), pp. 196-202.
- [25] D.I.Radin, Effects of a priori probability on PSI perception: Does precognition predict actual or probable futures, *J. Parapsych.* 52 (1988), pp. 187-212.

