Schumann Resonance and Brain Waves: A Quantum Description

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ABSTRACT
In this paper for the first time we compared spectra of the brain and Schumann electromagnetic waves. We argue that both modes of electromagnetic radiation: brain waves and Schumann waves can be analyzed with the help of the Planck formula. From our calculation we deduced the temperature of the Schumann and brain waves T= 10^{-10} K.

Key Words: brain waves, Schumann waves, model calculation, Planck formula
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1. Introduction

Geospaceis the term that relates to the solar-terrestrial environment and the relevant space occupied by Earth and her fields. Schumann Resonances (SR), global electromagnetic resonances, excited by lightning, is one of the natural electromagnetic (EM) fields in our planetary environment. But resonances can be excited by any electromagnetic disturbance in the atmosphere. The fundamental SR mode roughly corresponds to a wave with a wavelength equal to the circumference of the Earth. Transverse resonance is predominantly a local phenomenon containing information on the local height and conductivity of the lower ionosphere and on nearby thunderstorm activity. Waves in the ultra-low frequency (ULF) range ULF range (i.e., below the first Schumann Resonance), will have wavelengths much larger than the circumference of the Earth. ULF waves, at approximately 1 mHz to 1 Hz, play a major role in propagating energy throughout the magnetospheric system. At the lowest end of this frequency band, the wavelength of ULF waves is comparable to the entire magnetosphere. In this frequency range, the global structure of the magnetosphere can lead to global cavity resonances and waveguide modes. The structure of these modes is determined by the gradients in the Alfvén and fast mode speeds in the magnetospheric system. SR is *not* the internally-generated resonant frequency of the planet Earth, which is 10 Hz as Tesla discovered. It is electromagnetic oscillations - the Earth's global electric circuit consisting of the frequencies that play through the ionospheric cavity (space between the ground and ionosphere) as waves in a plasma. The ionosphere is a highly-conductive region of cosmic plasma (Nikolaenko and Hayakwa, 2014).

The solar-terrestrial environment is modulated by solar cycles which affect the global climate and all organisms in the biosphere. Interference patterns are the transducers of

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energy, which at its most fundamental is described as information. Earth functions like a planet-sized electrical capacitor or condenser, storing electrical potential (Nikolaenko and Hayakwa, 2014).

The space between Earth and the ionosphere is a dissipative closed cavity between 50-375 miles that can sustain quasi-standing waves at wave lengths of planetary dimension. Electrical conductivity in the atmosphere is driven largely by cosmic rays that generate a torsion field. Conductivity increases exponentially with altitude because the lower atmosphere buffers collision frequency. The ionosphere begins about 50 miles out from the Earth's surface and extends out over 180 miles. It consists of charged particles. This highly dynamic region is constantly exposed to harsh ultraviolet radiation from the Sun. It breaks down molecules and atoms. Highly charged ions and free electrons therefore fill the ionospheric layers creating a "spectral power station". Lightning radiates broadband EM fields that spread laterally into the cavity. Global thunderstorms excite the Schumann resonances, which can be observed around 7.8, 14, 20, 26, 33, 39 and 45 Hz (Nikolaenko and Hayakwa, 2014).

The resonant spectrum is a superposition of global lightning discharge. For these resonant values to change, the planet would have to change diameter.

The detection of Schumann resonances in the ionosphere calls for revisions to the existing models of extremely low frequency wave propagation in the surface-ionosphere cavity. Such frequencies have wrapped earth's life since its inception. Normal daily variation ranges ± 0.5 Hz. Driven by lightning, this primary SR pulse calibrates us and enhances our physical and mental well-being (Nikolaenko and Hayakwa, 2014).

That natural resonance helps us achieve our optimal brainwave states, but this atmosphere to human linkage is disrupted by the electrosmog of today's technology.

2. Schumann Waves (SW)

That information is propagated as sequential series of digital signals along distinct paths whose lengths are much longer than their widths is a primary assumption of contemporary neuronal function. Dispersion rates are within the range of 1–100 m/s with space constants in the order of about 1 mm. The fastest of these transients exhibit saltatory movements between specialized conductive spaces along the axon barrels. The ratios and scaling of the spatial and temporal relationships of these mediators of the "language of the brain" share remarkable similarities to lightning. Because lightning's absolute spatial scale is so large compared to the observer's reference point, minute characteristics are discerned whose equivalence at the level of the axon are below contemporary resolution. Quantitative identities between these two classes of phenomena could encourage alternative interpretations of the electromagnetic (EM) components of action potentials and reveal recondite relationships concerning neuronal function.

The identity between exogenous and endogenous "electricity" is not really a new idea. The observation that atmospheric electricity, lightning, and the electrical fields within living systems, "nerve conduction," shared similar origins was considered as early as the 18th century by Galvani and Volta. Galvani showed contractions in frog muscles elicited from Leyden jars and electric machines was the same as those evoked during lightning when a long metallic wire was connected to the nerves and pointed to the sky. The similarity has been viewed historically as more of a congruence of quality than a potential blueprint for quantitative characteristics. In the present comparison these features are demonstrated. To facilitate understanding the calculations and reasoning for the similarities between action potentials and lightning will be articulated in greater detail than the usual narrative discussion in the neurosciences.

The concept of scale-invariance or recurrent ratios within measurements of the physical world assumes an intrinsic repeated structure within the varying increments of space (Δs) and time (Δt) as well as their relationship. For example the proportion of matter (protons and electrons) that occupies the space (volume) occupied by an atom is about 1 part per trillion. The ratios of the volume of the sun and planets within the space of the solar system and the stars within galactic space are the same order of magnitude.

One temporal example is the equivalent order of magnitude of the ratio of the electron orbital time of a hydrogen atom to its precession and the earth's rotation to its spin axis gyration. Comparable "scale-invariance" has been found within the human brain and for functional EM fields within the cerebrum and over very large spaces.

3. Classical description of the Schumann and brain waves

The brain is a massive source of extremely low frequency (ELF) signals that get transmitted throughout the body through the nervous system, which is sensitive to magnetic fields. Brainwaves and natural biorhythms can be entrained by strong external ELF signals, such as stationary waves at Schumann resonance. Entrainment, synchronization, and amplification leads toward coherent large-scale activity, rather than typical flurries of transient brainwaves. Thus, resonant standing waves emerge from the brain, which under the right conditions facilitates internal and external bioinformation transfer, via ELF electromagnetic waves (Nikolaenko and Hayakwa, 2014). These SR waves, exhibit non-local character and nearly-instant communication.

The EEG (electroencephalograph) measures brainwaves of different frequencies within the brain. Rhythmicity in the EEG is a key variable in the coordination of cortical activity. Electrodes are placed on specific sites on the scalp to detect and record the electrical impulses within the brain. Frequency is the number of times a wave repeats itself within a second. It can be compared to the frequencies on a radio. Amplitude represents the power of electrical impulses generated by the brain. Volume or intensity of brain wave activity is measured in microvolts.

Raw EEG frequency bands include Gamma (higher than 30Hz); Beta (14-30Hz); Alpha (7.5-13Hz); Theta (3.5-7.5Hz); and Delta (less than 4Hz). Their ranges overlap one another along the frequency spectrum by 0.5 Hz or more. These frequencies are linked to behaviors, subjective feeling states, physiological correlates, etc. Clinical improvement with EEG biofeedback is traceable to improved neuroregulation in the basic functions by appeal to their underlying rhythmic mechanisms.

Schumann's resonance forms a natural feedback loop with the human mind/body. Our brains and bodies developed in the biosphere, the EM environment conditioned by this cyclic pulse. Conversely, this pulse acts as a "driver" of our brains, and can also potentially carry information as well. Functional processes may be altered and new patterns of behavior facilitated through the brain's web of inhibitory and excitatory feedback networks.

Like sound waves, the brain has its own set of vibrations it uses to communicate with itself and the rest of the body; EEG equipment distinguishes these waves by measuring the speed with which neurons fire in cycles per second. At their boundaries these waves can overlap somewhat, merging seamlessly into one another, so different researchers may give slightly different readings for the range of cycles per second. Rate of cycling determines the type of activity, kindling wave after wave over the whole surface of the brain, by igniting more neurons.

There is a harmonic relationship between the earth and our mind/bodies. Earth's low frequency isoelectric field, the magnetic field of the earth, and the electrostatic field which emerges from our bodies are closely interwoven. Our internal rhythms interact with external rhythms, affecting our balance, REM patterns, health, and mental focus. SR waves probably help regulate our bodies' internal clocks, affecting sleep/dream patterns, arousal patterns, and hormonal secretion (Başar, 2011; Başar, 2005).

The rhythms and pulsations of the human brain mirror those of the resonant properties of the terrestrial cavity, which functions as a waveguide. This natural frequency pulsation is not a fixed number, but an average of global readings, much like EEG is an average of brainwave readings. SR actually fluctuates, like brainwaves, due to geographical location, lightning, solar flares, atmospheric ionization and daily cycles (Nunez, 1995).

The most important slow rhythm is the daily rhythm sensed directly as change of light. Rhythms connected with the daily rhythm are called circadian (an example is pineal gland melatonin secretion). Some experiments in the absence of natural light have shown that the basic human "clock" is actually slightly longer than one day, and closer to one lunar day (24h and 50 min). The lunar day has a similar period (24h and 50 min).

On a slower scale, a strong influence on the Earth is its geomagnetic field, which is influenced by the following periods: the Moon's rotation (29.5 days); the Earth's rotation (365.25 days); Sun spots (11 and 22 years); the nutation cycle (18.6 years); the rotation of the planets (88 days to 247.7 years); and all the way out to the galaxy's rotation cycle (250 million years).

Very important rhythms are in the order of 1-2 hours, like hormone secretion, and dominant nostril exchange. In the range of human EEG, we have the Sun's electromagnetic oscillation of 10 Hz, while the Earth-ionosphere SR system is resonant at frequencies in the theta, alpha, beta1 and beta2 bands.

Different species often have internal generators of environmental rhythms, which can be extremely precise, up to 10^{-4}. The frequency of these oscillators is then phase locked loop (PLL) synchronized with the natural rhythms. Environmental synchronization sources are often called "zeitgeber". The mechanism of optical synchronization can be shown. The presented rhythms should inspire a better understanding of the interaction of internal and external rhythms during specific states of consciousness.

This bioelectrical domain is geared to thalamocortical generation of rhythmic activity. In neurofeedback, what is being trained is the degree of rhythmicity of the thalamocortical regulatory circuitry. Rhythmicity manages the entire range of activation and arousal in the bio-electrical domain. One role advocated for rhythmic activity is that of time binding, the need for harnessing brain electrical activity which is spatially distributed while maintaining it as a single entity. Brainwaves indicate the arousal dimension, and arousal mediates a number of conditions. Changes in sympathetic and parasympathetic arousal "tunes" the nervous system (Polk, 1982).

Delta waves are the slowest but highest in amplitude. They are abundant in deep, dreamless sleep, non-REM sleep, trance, and unconsciousness. Theta waves mean 'slow" activity connected often with creativity, intuition, daydreaming or recalling emotions and sensations. Focus is internal in this state between waking and sleep. Under stress it may manifest as distraction, lack of focus. Alpha waves aid relaxation and overall mental coordination, calmness, alertness, inner awareness, mind/body integration and learning.

Beta is a 'fast' activity, present when we are alert or even anxious; problem-solving, judgment, decision making, processing information, mental activity, and focus. Gamma appears to relate to simultaneously processing information from different brain areas: memory, learning abilities, integrated thoughts, information-rich task processing. Gamma rhythms modulate perception and consciousness, which disappears with anesthesia. Synchronous activity at about 40 Hz appears involved in binding sensory inputs into the single, unitary objects we perceive (Polk, 1982).

The brain responds to inputs at a certain frequency or frequencies. The computer can create wave form patterns or certain frequencies that compare with the mind's neural signals in terms of mind patterns. If people can control their mind patterns, they can enter different states of being (mental relaxation, study, etc.). What happens when the mind is entrained with a sound or vibration that reflects the thought patterns? When the mind responds to certain frequencies and behaves as a resonator, is there a harmonic frequency that the mind vibrates to or can attune to? What does the study of harmonic resonance - sound or vibration have to do with the brain's frequency waves?

Soundwaves are examples of periodicity, of rhythm. Sound is measured in cycles per second (Hertz or Hz). Each cycle of a wave is in reality a single pulse of sound. The average range of hearing for the human ear is somewhere between 16 Hz and 20,000 Hz. We cannot hear extremely low frequencies (ELFs), but we can perceive them as rhythmic. Action potentials are the carriers of the discrete signals along the axon barrel. An average net potential difference for an action potential (-70 to +50 mV) is 1.2×10^{-1} V which would exert on each unit charge of 1.6×10^{-19} Coulomb (A·s) an energy of 1.9×10^{-20} J. If we assume $\sim 10^{10}$ neurons occupy human cerebral cortices with an average frequency of propagation of 1 Hz, the total energy per second involved with just the effects of all action potentials within brain space would be about 10^{-10} J/s. The volume (~1330 cc) of an average brain is 1.3×10^{-3} m^3. This results in an energy density of about 10^{-7} J/s·m^3. On the other hand the typical lightning stroke involves a flow of ~10 Coulomb (C) of electrons across a potential difference of

10^8 V resulting in 10^9 J. There are about 70–100 lightning flashes/s worldwide resulting in (assuming 100 flashes) the generation of 10^{11} J/s or 100 Gigawatts of power. For reference there is 4.3 × 10^{12} J per kiloton (kT) of standard explosives such that the energy generated every approximately 14 min by global electrical discharges is equivalent to about a 20 kT (Hiroshima-like) nuclear explosion.

Most of this energy from lightning discharges is within a narrow shell of about 2 km within the biosphere. The volume of this shell, assuming a radius of 6,378 km for the earth, would be about 1 × 10^{18} m^3. This means the energy density would be 10^{11} J/s·10^{18} m^3 or 10^{-7} J/s·m^3 (10^{-7} W/m^3). *This energy density is remarkably similar to that generated by action potentials within the brain*. When applied across the 3–5 mm thickness of the cerebral cortices, the value is equivalent to 10^{-10} W/m^2 which is within the range of power of photon emissions near the skull when subjects engage in specific imagination and which is strongly correlated with the power of electroencephalographic (EEG) activity.

4. Scaled densities

About 5 C is distributed within a lightning channel with an average current of 100 A. Although the width of a leader channel is about 1 m the current flows through a channel with a radius of about 1 cm. With this cross-sectional area the density is 10 × 10^1 A divided by 3.14 × 10^{-4} m^2 or 3.2 × 10^5 A/m^2. A reasonable radius for an axon is 1 μm. However the actual locations of the major movements of ions that affect the transmission of EM field-mediated information along the axon are within the membrane which is about 10 nm in width. The cross-sectional area of this small annulus around the axon would be 2 × 10^{-14} m^2. Given the average current of 10^{-9} A (from the approximately 10^3 ion channels each with 1 pA capacities around the ring or circumference of the axon), this would mean that the cross-sectional current "density" would be ~10^5 A/m^2.

Consequently even though the current is much larger in a lightning stroke because of its absolute size by a factor of 10^{10}, the "minuscule" axon potential current is comparable per cross-sectional area. The range in the widths of normal axons would affect the coefficients rather than the order of magnitude. It may also be relevant that the actual charge and current per lightning stroke also displays a comparable range in the coefficient of variation. Such a large relative magnitude of potential across neuronal membranes is not a new concept. For example, the 90 mV potential differences across a 10 nm membrane is equivalent to 9 × 10^7 V/m. Most lightning (90%) is between clouds. The leader moves in discrete jumps of 50 m at about 1.2 × 10^5 m/s to 1.5 × 10^5 m/s. This conspicuous conduction of lightening has a ratio of [1.2 × 10^5 m/s]/50 m or 2.4 × 10^3 Hz (about 2 kHz or 0.5 ms) which is remarkably similar to the absolute refractory period of the action potential. In comparison the action potential moves along the myelinated axon in discrete steps of 1 mm compared to the approximately 2 μm width of the nodes of Ranvier.

The wave shape characteristics of action potentials and lightning flashes are similar. All lightning pulses were the same polarity; most were single peak but about one-third were multiple-peaked. Although the mean width of the initial peak was 25 μs (SD: 13 μs), the ratio of the overshoot duration to the initial peak was 5.7 μs (SD: 2.1). This ratio is within the range of the typical relative refractory to absolute refractory period in the average axon. More recent measurements of artificially triggered lightening revealed comparable peak widths. Interestingly, the initial-stage discharge time was about 20 ms and the time between strokes ranged from 18 to 210 ms (mean 87 ms). This interval is within the range of the global rostral–caudal propagating, coherent waves over the cerebral cortices and the microstates that determine a percept and consciousness (Nikolaenko and Hayakawa, 2014).

Although the velocity of a leader exceeds the 10 m/s values exhibited by non-myelinated axons by a factor of 1.2–1.5 × 10^4, the scaled values for the mass mediating the movements of charges are similar. For example, the mass of Na^+, the major mediator of the action potential, is 30 Daltons or 48×10^{-27} kg while the mass of an electron is 9.8×10^{-31} kg. The difference is in the order of 10^4. The coefficients converge more closely when the range of hydration states (accompanying H_2O molecules) associated with the ions are included. As the leader approaches to about 10 m above the ground it creates an electric field sufficient to initiate discharges rising from the ground (streams). When contact is made between the upward and downward fields a heavy surge of current occurs within 1–5 ms. This surge produces the luminosity that progresses up the path produced by the step leader at $\sim 10^8$ m/s. About 40–50 ms after the return stroke, another region of luminosity, about 50 m long, moves from the cloud to the ground (dart leader). It does not fork or branch. There is an average of three to four strokes with a maximum around 20. The approximately 10 m interface or boundary where the exchange of energy between the atmosphere and ground occurs is about 3×10^{-3} the length of the pathway. For cortical axons with lengths between 1 and 5 mm, this would be equivalent to a length of between 3 and 15 μm which is within the range of the length of the terminal endings or boutons within which the digital information of the action potential is transformed to chemical equivalents.

The surge of current lasting for 1–5 ms is within the range of the time involved with release of the contents of the synaptic vesicles. The energy transfer mediated by the mass of molecules released from the vesicles into the synaptic space would be analogous to this relatively large increment of current. The occurrences of subsequent surges from the cloud to the ground after an interval of 40–50 ms or about 20 times after the first surge is comparable to the first and second surges of vesicular releases.

The billions of action potentials and their correlates per second within the cerebral cortices generate emergent phenomena inferred by EEG measurements that include microstates and transient coherence of activity over areas (tens of mm^2 to tens of cm^2) of the human brain's cortical surface. Between the earth's surface and the lower ionosphere there is a shell of optimum conduction within which the results of focal energies in one area are generated throughout the volume. Cloud-to-ground lightning discharges from global thunderstorm activity are the main excitation sources within the earth-ionospheric cavity. These omnipresent pulses propagate for megameters without appreciable attenuation and behave as a "cortical manifold" for distributing tissue-level energies throughout the biosphere. The fundamental frequency (1/s = Hz) is the velocity divided by the circumference. Assuming the speed of light of 3×10^8 m/s and the circumference of the earth as 40,000 km (4×10^7 m) the natural frequency is 7.8 Hz. Harmonics for this values, often described as the Schumann resonances can be obtained by taking the square root of $[(n(n + 1))/2]$ multiplied by the base frequency (7.8 Hz), where n is the progressive series of integers 1, 2, 3,..., etc. Those that have been measured have peaks around 8, 14, 20, and 26 Hz.

As described by Nunez (1995) in his classic chapter on "*Towards a physics of the neocortex*" comparable solutions exist for the human brain. The probability density function for myelinated cortico-cortical propagation peaks at about 6–9 m/s with the half-width of the distribution is estimated to be between 3 and 4.5 m/s. Published estimates of the neocortical surface areas range from 1,600 to 4,000 cm^2. The effective cortical radius after flat-mapping is between 11 and 18 cm. As a result the non-dispersive brain waves from mode $n = 1$ would be between 7 and 18 Hz. Subtle shifts in peak power in this frequency vary with head size, defined by the cube root of the product of three linear measures. As the size increased over a normal range of volunteers the peak frequency decreased from 10.6 to 9.8 Hz.

The EM signals associated with lightning are propagated through a medium. The simplest calculation of a time constant is the product of the resistance (in Ohms) and capacitance in Farads (F). For free space resistance is 3.70×10^2 Ohms $[(kg\cdot m^2)/(A^2\cdot s^3)]$ and capacitance is 8.8×10^{-12} F/m $[(A^2\cdot s^4)/(kg\cdot m^2)]$/m or 32.56×10^{-10} S/m. When multiplied by the circumference of the earth, the time constant is 130 ms or about 7.7 Hz; this is within the natural variation of the fundamental Schumann resonance.

Cerebral tissue is also a medium. The permeability (inductance/m) of cortical gray matter at 1 kHz is about 10^{-2} Henrys, while the permittivity of gray matter is 2×10^{-1} F/m. Application of the formula $f = 1/(2\pi(LC)^{-1/2})$, the equation for resonance frequency of a closed circuit, results in a value of about 7 Hz. The convergence of a fundamental cerebral resonance with the Schumann solutions indicates that higher order harmonics may exist within EM fields within cerebral space and be associated with specific functions. There are often strong correlations between fluctuations in power values measured by quantitative EEG across traditional frequency bands. That resonance could occur *between* fields within cerebral volumes and the Schumann phenomena may have significant implications for the biosciences.

The classical although arbitrary division of EEG activity into delta, theta, alpha, and beta activity with a myriad of complexes and transients have been considered both emergent and reflective of "distant" fields of neuronal activity. As shown by Koenig et al. (1981) all of the fundamental frequencies and patterns of EEG activity are measured within the Schumann (earth–ionospheric) cavity or as local electric field configurations during thunderstorms. In addition, biofrequency (1–100 Hz) pulses of about 0.5 ms whose carrier frequencies diminish from 100 kHz to about 10 kHz at distances more than 1000 km from the source display magnitudes in the nanoTesla (nT) to picoTesla (pT) range.

Within the range of 7 –40 Hz the electric field components associated with the EM fields generated through the ionospheric–earth cavity are about mV/m, while the magnetic field components are between 1 and 10 pT. For comparison the magnetic field intensities within galaxies are in the order of 10^{-10} T with upper limits of 10^{-13} T for extragalactic fields. In a manner similar to the changing, averaged power outputs of neuronal activity within the cerebral volume that can vary in response to fluctuations in subtle external energy, the Schumann values also display discrete alterations.

The long-term averages for the Schumann frequency, damping, and amplitude change as a function of solar proton events (SPE). They increase the Schumann resonance frequency from a reference value of ~7.8 Hz by between 0.04 and 0.14 Hz depending upon the intensity of the proton flux. The amplitude of the resonance increased by several 10% from a mean value of about 1.0 pT. Electric fields within the mV/m range and magnetic fields within the pT range also define the operating intensities overly spatially distributed cerebral functions. The strong correlations between variable power densities within the ionosphere–earth cavity and power changes within quantitative EEG measures as well as the quantum-like properties of interhemispheric interactions indicate that physical connectivity may be pervasive. Phase modulation has been considered the most optimal means to propagate the most information over distance. Phase shift can be obtained by time divided by the square root of v^2/c^2. Because the EM fields associated with lightening generated within the earth–ionospheric cavity are within the 10–100 kHz ("atmospherics" or "sferics") range, the $\Delta c/c$ (c, velocity of light) is 0.05 for this range. This means that the phase shift for every 1 s is 1/0.9897 s or 16 ms. This magnitude of phase shift is remarkably similar to phase comparisons associated with the presence of the continuous "40 Hz-oscillations" over the entire cerebral cortical mantle. An approximately 12 ms phase shift between the rostral and caudal pole of the brain has been reported (Pollk, 1982 search for the "missing" equivalents between lightning and action potentials could be revealing in a manner similar to the search for Mendeleyev's missing elements in the Periodic Table. There is no traditional equivalent of the "return stroke" at the synapse, although back propagation might be considered a conceptual candidate. However, back propagation influences the dendrites of the neuron from which the action potential has been propagated. Its variable effect depends upon the extent by which the neuron's action potential penetrates into its own distal dendrites.

When a stepped leader approaches within a few tens of meters above the ground, it is met by a positively charged return stroke towards the cloud. Within a synaptic scenario, this would be equivalent to a "return field" transiently generated from the post-synaptic region towards the presynaptic membrane just before the arrival of the action potential. If the quantitative scale-invariant relationships between lightning and action potentials can be generalized in this context, then impulse magnetic flux densities from the post-synaptic membrane must emerge and cross the synapse into the presynaptic membrane during the few milliseconds *before* the helical EM field (the action potential) reaches the synapse. In other words, a comparison with lightning would predict that sub-threshold, electrotonic-like shifts in voltage (approximately the Landauer principle limit: ln 2 kT, or about 10^{-21} J) should be apparent at the synapse in advance of the arrival of the major action potential. It is more likely we have not measured this equivalent rather than a frank deviation from Newton's third law: for every force there is an equal and opposite force. It is well known the repolarization of the (heart) atria after its depolarization (P) during electrocardiographic measurements is masked by the QRS component of the massive depolarization of the ventricles.

As indicated, the scale-invariant similarities between lightening and action potentials evoke the possibility of mutual interaction. In addition to comparable values for magnetic and electric fields, the power density for Schumann resonances within the 8–21 Hz range is in the order of 10^{-10} W/m²/Hz. This is the same order of magnitude as the power density of photon emissions from the human brain during imagination and the correlated changes in power measures from quantitative EEG. Laboratory experiments who exposed volunteers for about 1 ks to simulated lightening-related sferics by generating 10 kHz signatures (amplitude 50 nT, pulse repetition: 7–20 Hz; pulse duration 0.5 ms), demonstrated that protracted changes within the alpha band and experiences similar to those attributed to natural phenomena were reliably elicited. The similarities in quantitative characteristics between action potentials and lightening presented in this paper might be expected if the intrinsic organizations of matter and energy are reflected within different spatial and temporal levels of observation. Perhaps by careful quantification and observation of the larger phenomena, such as lightning, processes can be discerned that will point the direction of focus for what we have not yet measured.

5. Quantum description of Schumann and brain waves

In order to put forward the classical theory of the brain and Schumann waves we quantize the both fields. In the model (Marciak-Kozlowska and Kozlowski, 2013) we assumed (i) the brain is the thermal source in local equilibrium with temperature T.(ii) The spectrum of the brain waves is quantized according to formula

$$E = \hbar\omega \qquad (1)$$

where E is the photon energy in eV, $\hbar$=Planck constant, $\omega = 2\pi\nu, \nu$ -is the frequency in Hz. (iii). The energies of the photons are the maximum values of energies of waves. In this paper we extended the model for Schumann waves too for the emission of black body brain and Schumann waves we propose the well know formula for the black body radiation.

In thermodynamics we consider Planck type formula for probability dE for the emission of the particle (photons as well as particles with m≠0) with energy (E,E+dE)by the source with temperature T is equal to:

$$N(E)dE = AE^2 e^{(-E/kT)} dE \qquad (2)$$

where A= normalization constant, E=total energy of the particle, k = Boltzmann constant=1.3 x 10^{-23} J K^{-1}. K is for Kelvin degree. However in many applications in nuclear and elementary particles physics kT is recalculated in units of energy. To that aim we note that for 1K, kT is equal k1K = K x 1. 3 10^{-23} J x K^{-1}= 1.3 10^{-23} Joule or kT for 1K is equivalent to 1.3 10^{-23} Joule= 1.3 10^{-23} /(1.6 10^{-19}) eV = 0.8 10^{-4} eV. For comparison measured and calculated energy densities we applied the formula:

$$\frac{dP}{dE}\left[\frac{Watt}{m^2 eV}\right] = BE^2 e^{(-E/T)} \qquad (3)$$

where dP/dE denotes radiation surface energy density for waves with frequency E, $E+dE$ where, B is the normalization constant T is the temperature of the wave source in eV.

In Figures 1-3 we present the results for brain waves and in Figures 4-6 for Schumann waves. As can be easily seen the agreement of calculated and measured spectra is very good.

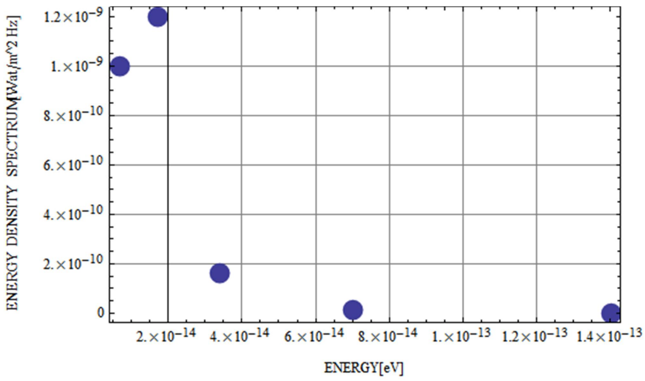

Figure 1. Energy density spectrum for brain waves, measured.

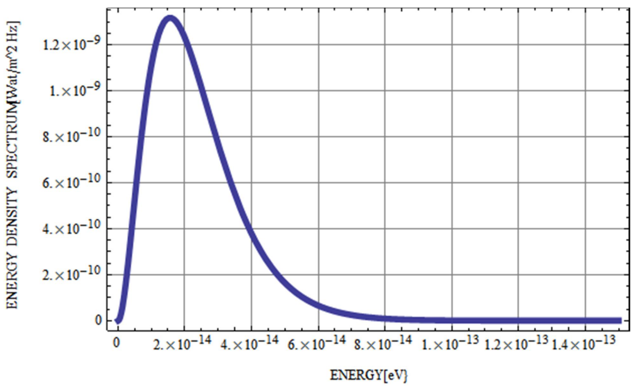

Figure 2. Energy density spectrum for brain waves, calculated.

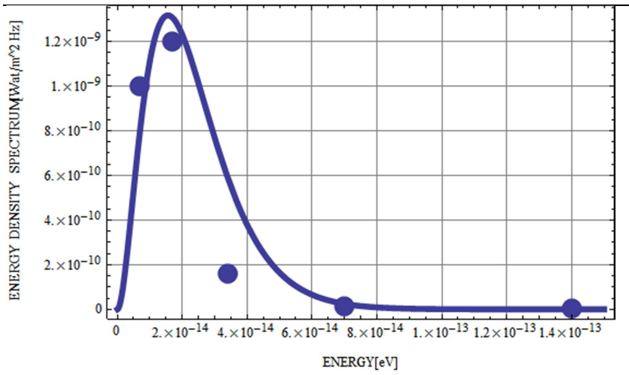

Figure 3. Comparison energy density spectrum of the brain waves calculated and measured. The line is the result of calculations.

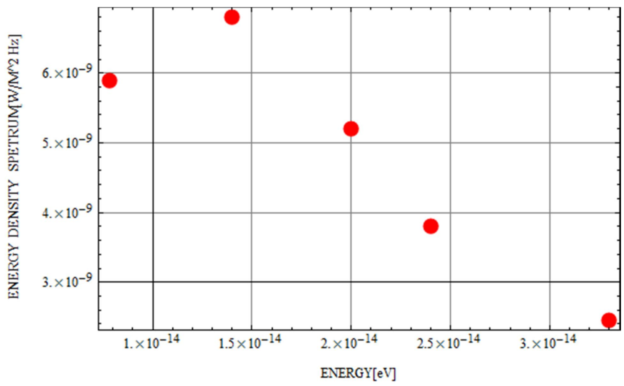

Figure 4. Energy density spectrum for Schumann waves, measured (Nikolaenko and Hayakawa, 2014).

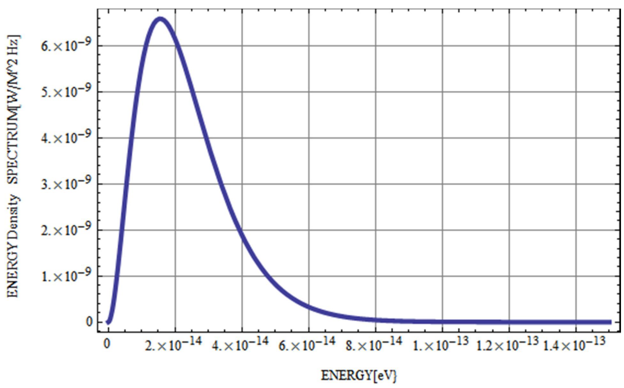

Figure 5. Energy density spectrum for Schumann waves, calculated.

As can be easily seen (Figures 1-6) we obtained the good agreement of the model calculations and measured energy density profiles. We conclude that both radiations are emitted from source which is in -equilibrium thermodynamic state (Planck-type formula). It is quite interesting conclusion for Universe is also in equilibrium state. The brain waves and Schumann waves are described by the same Planck formula but with different temperatures Temperature of CBR is much higher (10^{10} times) for that CBR do not interacted with Schumann and brain waves.

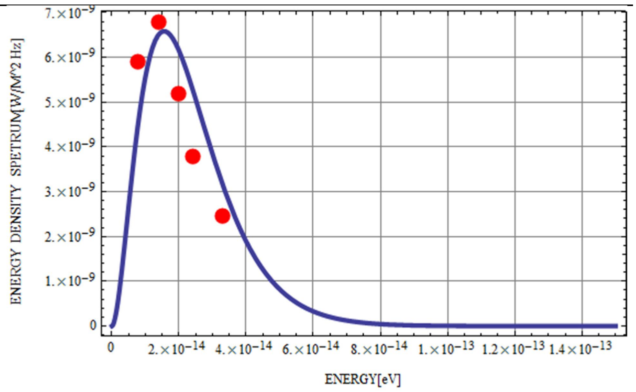

Figure 6. Comparison theoretical to measured energy density for Schumann waves. The blue line is the result of calculations.

6. Conclusions

In this paper we argue that both modes of electromagnetic radiation: brain waves and Schumann waves can be analyzed with the help of the Planck type formula. From our calculation we deduced the temperature of the source and the shape of the energy density. We obtained the good agreement with the measured energy spectra.

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