

Electromagnetic Frequency Patterns that are Crucial for Health and Disease reveal a Generalized Biophysical Principle: the GM scale

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Abstract

Solitons or polarons, as self-reinforcing solitary waves, interact with complex biological phenomena such as cellular self-organization. Such soliton models are able to describe a spectrum of electromagnetism (EM) modalities, that can be applied to understand the physical principles of biological effects in living cells, as caused by endogenous and exogenous electromagnetic fields, on the basis of quantum coherence. A bio-soliton model was earlier developed by us, that enables to predict which eigen-frequencies of non-thermal EM waves, are life-sustaining and which are, in contrast, detrimental for living cells. The particular effects of the proposed coherent wave pattern are exerted by a range of EM-wave eigen-frequencies of one-tenth of a Hertz till Peta Hertz, representing a pattern of twelve bands, that can be positioned on an acoustic frequency scale. The discrete pattern was revealed by a meta-analysis of 219 published papers of biological EM-radiation experiments, in which a spectrum of non-thermal EM fields were exposed to living cells and intact organisms. In follow-up studies, we analyzed 120 articles on cancer-promoting and inhibiting EM fields, of which the frequency patterns fully confirmed the inferred model. Finally we analyzed experimental data out of 27 recent publications on laser mediated radiation therapy, for a spectrum of disorders such as traumatic brain injury, depressive disorders and neurological defects, confirming the general predictive force of our life algorithm. It is postulated that long-distance control of cellular morphology and fine tuning of cellular networks by soliton-waves, is instrumental in providing a morphogenetic field that maintains cellular health. The latter also may have played a role in the initiation of first life in biological evolution. The particular parametric resonance may provide positional information and cues to regulate organism-wide system properties like anatomy, control of reproduction as well as gene expression and repair. In addition, potential damaging effects of non-ionizing electromagnetic fields on life systems can be counteracted by dedicated phyllosilicate (clay) nano-materials, that were shown by us to exhibit semi-conducting EM field properties. A related protective technology was designed on the principle of toroidal trapping, since torus geometry adequately generates a coherent field of frequencies and thereby induces coherent oscillations of macromolecules. Our papers, collectively, picture the rapidly growing and dynamic field of molecular electromagnetics, that currently shows promising clinical effects in the treatment of various sincere, and often, chronic diseases.

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The discovered frequency patterns might be interpreted as hidden variables in Bohm's causal interpretation of quantum mechanics theory. The life algorithm detected and called by us the GM-scale, may highlight a presently unknown bio-physical (de)stabilizing principle that underlies (de)coherence of quantum wave oscillations in animate and also some non-animate systems.

Key Words: Life algorithm, novel biophysical principle, coherent EM-scale, solitons and polarons, bio-solitons, coherent electromagnetic frequencies, beneficial and detrimental frequencies, meta-analysis of bio-medical literature, phyllosilicates, clay nano-materials, morphogenic resonance, non-thermal EM fields, anti-cancer therapy, first life in biological evolution, quantum entanglement, Fröhlich, Einstein-Podolsky-Rosen, Bohm

Introduction

We hypothesize that living organisms make use of algorithmic frequencies that unite the first, second and third harmonics of waves, and has an analogy with the science of sound. Our analysis of 240 different frequencies of biological electromagnetic experiments published in more than 300 papers, ranging from less than one Hertz till Peta Hertz, has been recently finalized. Based on this analysis we propose that the same type of intervals as found by Pythagoras can be discovered for living systems, cells and biomolecules, at which the frequency intervals are positioned at 1:2 and closely approaching 2:3. The discovered frequencies are organized in patterns forming a closed system of fifth's, in which the Pythagorean comma (being the intrinsic difference between twelve just perfect fifths and seven octaves in this classical music theory), has been evenly redistributed over two fifth's and thereby is virtually removed (Loy, 2011)

The frequencies analyzed for living systems show 12 "fifths" with a mean value of 1.498307, of which 5 fifths are precisely 2:3. Under these conditions a reference scale of 12 typical coherent frequencies can be defined: 256.00, 269.70, 288.00, 303.41, 324.00, 341.33, 362.04, 384.00, 404.54, 432.00, 455.12, 486.00 Hz.

Probably a new bio-physical principle has been found, revealing how nature installs coherence in living organisms, cells, and biomolecules, by uniting the first, second and third harmonics of waves.

There is abundant scientific literature on the influence of non-thermal electromagnetic radiation and related fields on biological systems (Fröhlich,

1975, Belyaev, 2015, Brizhik 2014, Cifra, 2010, Cosic and Lazar, 2015, Muehsam and Ventura, 2014, Sahu, 2013, Lundholm, 2015, Hammerschlag, 2015, Pang, 2016).

Constructive interference and quantum coherence have not only been shown for micro-states such as single proteins, but also for macro-processes such as photosynthesis, magneto-reception in birds, the human sense of smell as well as photon effects in vision; all showing a non-trivial role for quantum mechanisms (Davies, 2014) throughout biology (reviewed by Lambert et al 2013, Lloyd, 2014).

Lambert favors the idea that both these systems not only contain quantum coherence but also that this is used to gain a biological advantage. These features go beyond trivial quantum effects and may include harnessing quantum coherence on physiologically important timescales (Lambert, 2013; Engel, 2007; Gauger, 2011).

In the reviewed studies, it has been shown that phonon-mediated matrix vibrations can facilitate electron/exciton flux, either as such or in the form of phonon quasi-particles such as polarons/solitons (Huelga, 2013; Geesink and Meijer, 2016b).

We herewith propose a soliton model that is able to describe a spectrum of electromagnetic soliton frequencies that can be applied to study the physical principles of biological effects in living cells, as caused by endogenous and exogenous electromagnetic fields.

Our collective papers should be positioned in the framework of the current developments in Quantum Biology.

1 - The meta-analysis of bio-medical studies of EM-field and quantum information effects on life systems and summary of recent studies of the authors

1.1 Algorithm of life

An extensive meta-analysis of published biological/medical studies has been performed by us, in which living material (tissues, cells, and whole animals) was exposed to external electromagnetic (EM) radiation employing a wide spectrum of EM frequencies.

In these studies the various effects of the EM fields were reported as to their cell- and life-sustaining effects, as opposed to, detrimental actions. After collecting and scrutinizing these data, a striking coherent pattern of frequency bands was revealed (Figure 1).

The particular bands, representing the applied EM field frequencies, showed a discrete distribution pattern, plotted on an acoustic scale, in which the separation of the bands was complete and statistically significant on the 0.01 level. The cell and life stabilizing EM frequencies of the '*Life algorithm principle*' detected by us (Geesink and Meijer, 2016), might be modelled as spiral information trajectories using a toroidal geometry, as earlier shown in music theory.

We consider coherent resonances from the cellular to the organismal level that contains all typical electromagnetic activities, that has been called "*the electrome*" by De Loof, (2016).

The electrome concept stands for the totality of all types electromagnetic dimensions in an ionic environment of any living entity, from the cellular to the organismal level.

We postulate that living cells contain an internal oscillating apparatus, that can be excited by internal as well as external EM fields.

Through a process of resonance, the various features of the EM field can become expressed in life systems as coherent vibratory patterns that somehow influence the functional structure and/or metabolism of the exposed cell systems.

These internal oscillations mirror the typical eigenfrequencies used in a broad coherent frequency range of 0.1 Hertz – PHz, including the spectrum of far infrared wave packages.

This resonant coherency is analogous to the principles of Fröhlich-Bose-Einstein condensates as initially postulated by Fröhlich, (1968, 1975) and later elaborated by Davydov, (1977) and Pang, (2006).

The collective evidence points at an integral algorithm, and can be regarded as a set of collective Fröhlich condensate frequencies.

Of note, the far infrared frequency range we detected, is exactly in between the wave frequency ranges of the photon and the electron and can constitute both standing and longitudinal waves.

The internal oscillations are supposed to be carried by solitons, and can actually reabsorb energy in periodic cycles according to an algorithm of stabilizing frequencies within a typical band pattern (see our recent work in ArXiv, Geesink and Meijer, 2016b).

1.2 - EM fields and cancer

Physical and biological evidence was found by us for the hypothesis that *carcinogenesis* fits in a frequency pattern of electromagnetic (EM) waves, in which a gradual loss of cellular organization occurs.

We find that cancer can be initiated and promoted at typical frequencies of electromagnetic waves positioned in *decoherent* soliton frequency zones.

In contrast, the generation of cancer features can be inhibited and retarded by application of *coherent* soliton frequencies.

This concept was revealed by analyzing 200 different EM frequency data in a total of 320 different published biomedical studies. All frequencies, ranging from sub Hz till Peta Hertz, could again be normalized into 12 basic beneficial (anti-cancer) frequencies, and 12 basic detrimental (cancer promoting) frequencies, that exhibit a deviation from coherency and related geometry.

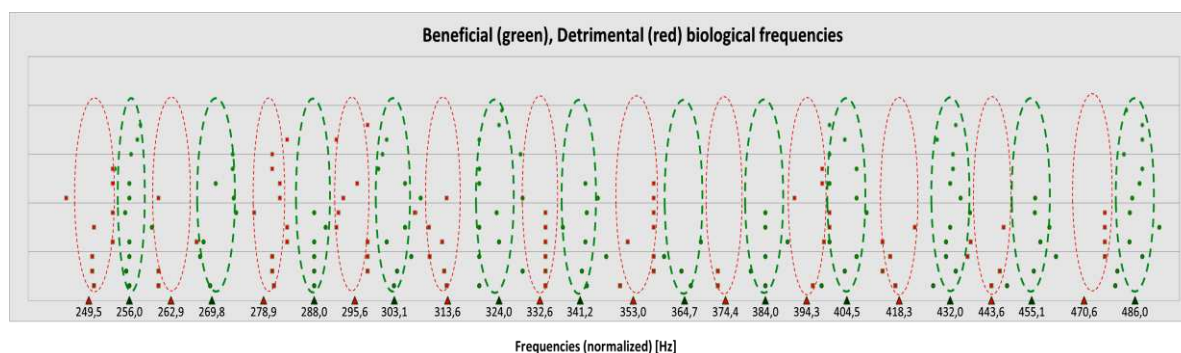


Figure 1: EM radiation frequencies, that were experimentally applied to living cells in vitro and in vivo as derived from 219 separate biological studies. All of the particular frequencies (green and red dots) were plotted on a logarithmic scale, according to an acoustic algorithm of which the calculated values are depicted on the X-axis. For clarity, points are evenly distributed along the Y-axis. The meta-analysis of the 219 biomedical reports, showed 12 apparent frequency bands of life-sustaining frequencies (148 green points), as opposed to detrimental frequencies (77 dots in red) positioned in between the beneficial frequency bands. The mean values of the green bands differ less than 1 % from the calculated acoustic values derived from the music-theoretical algorithm.

The particular beneficial, versus the detrimental EM frequencies zones are likely resonating with oscillations in the intact cell, that are features of a either a healthy state or a corrupted cell state.

As depicted by the data of 120 reported cases in Figure 2, the particular soliton wave frequency pattern fully confirmed our previously inferred model.

The supposed beneficial effects may include promotion of cell differentiation, anti-tumour signalling path ways and apoptotic cell death, whereas cancer inducing effects may be related to altered expression of pro-cancer genes, oxidative damage and inhibition of cell differentiation.

The observed pattern is, to our knowledge, the first that defines the entire EM spectrum related to cancer, and may provide a proper explanation of the many current successes, but also failures in EM therapies in clinical oncology. Of note, similar deviations in EM frequencies have been recently demonstrated in Alzheimer disease, bone degeneration and pain perception, indicating that coherent resonance may be central in determining health and disease (see the following).

Inhibiting of the cancer process, and even curing of the disease, could be further investigated by exposure to combinations of coherent EM fields.

Inhibition and retardation of the cancer process can take place through stabilization of intrinsic eigen-frequencies of the particular type of cancer.

Such coherent solitonic frequency zones can also be implemented in man-made therapeutic radiation technology [Vadala et al, 2016](#), (see also later).

1.3- Cognitive function and neurological disorders.

We also analyzed the work of [Xuan, Vatansever, Cassano, Iosifescu and Hamblin \(2012, 2014, 2016\)](#) on low-level laser therapy and transcranial photobiomodulation, applied within a frequency band range from 308 till 1600 nm.

Also these studies could be positioned at a scale of coherency ranging from coherent till highly coherent frequency bands, that have been addressed to improved cognitive function, enhanced learning, enhanced memory, restore of neuroprogenitor cells, reducing depressive

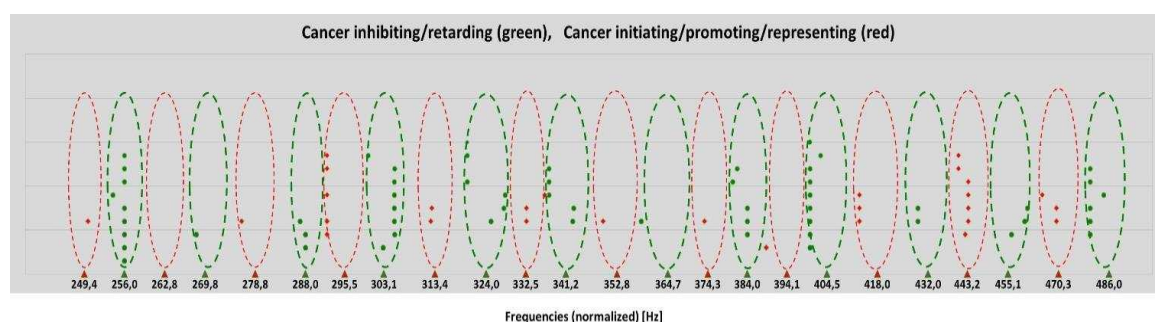


Figure 2. Cancer frequencies. EM field frequencies that were experimentally applied to living cells systems, in 120 studies are plotted on a logarithmic acoustic scale, are found to be patterned in 12 apparent frequency bands of coherent frequencies that were reported to inhibit/retard cancer (green points) and decoherent frequencies able to initiate or promote cancer or being measured directly in cancer tissue (red squares), that evidently are positioned between the cell-sustaining coherent frequency bands. Numerical values on the logarithmic X-axis represent frequencies according to the chosen acoustic algorithm as in fig 1.

disorders and neurological defects, (data recently included in Figure 1).

1.4 - General conclusion

From the collective data presented here we conclude that the discrete EM frequency bands identified, seem to represent a fundamental property of nature, influencing a broad spectrum of diseases, including the potential for their therapy.

Specific EM fields could also exert subtle effects on mental conditions such as awareness, cognitive functions and self-consciousness (Meijer and Geesink, 2017b, Keppler, 2013).

It is of interest that Gramowski et al (2015), reported on the enhancement of cortical network activity, being important for conscious perception, by stimulation with selective EM fields that confirmed the frequency algorithm proposed in our studies on biophysics of consciousness (Geesink and Meijer, 2015, 2016, Meijer and Geesink, 2016 and 2017b).

2 - Further support for an EM field algorithm promoting or endangering life conditions

A large variety of scientific observations support this discrete frequency pattern as found by us in the present meta-analysis of biological and clinical literature, as indicated above.

In general, supportive bio-physical evidence can be derived from the following observations:

- Cellular functions are sensible to low-level sinusoidal-modulated signals of different frequencies and various pulse modulations. In many biological studies, windowing, both with regard to frequency and amplitude domains, has been found and decoherent modulations of signals have a greater influence on biological properties than unmodulated signals (Belyaev, 2015).

- Specific EM frequencies cause vibrational resonance with macromolecules in the cell such as DNA/RNA, ion-channel proteins, micro-tubular proteins and/or cytosolic proteins, that apart from their chemical signalling may communicate through their vibrational character (Cosic, 1997, 2015).

One example of this is the 0.42 eV energy, released under hydrolysis of ATP molecule, as studied by Davydov (1973) and Pang (2001). Solitons have also been suggested to be instrumental in protein folding (Meijer and Geesink, 2017, Melkikh and Meijer, 2017).

- Direct experimental evidence has been found for Fröhlich condensation, providing a mechanism for long range quantum coherent states of proteins and DNA in life systems (Lundholm et al., 2015, Nardecchia et al, 2017) and several

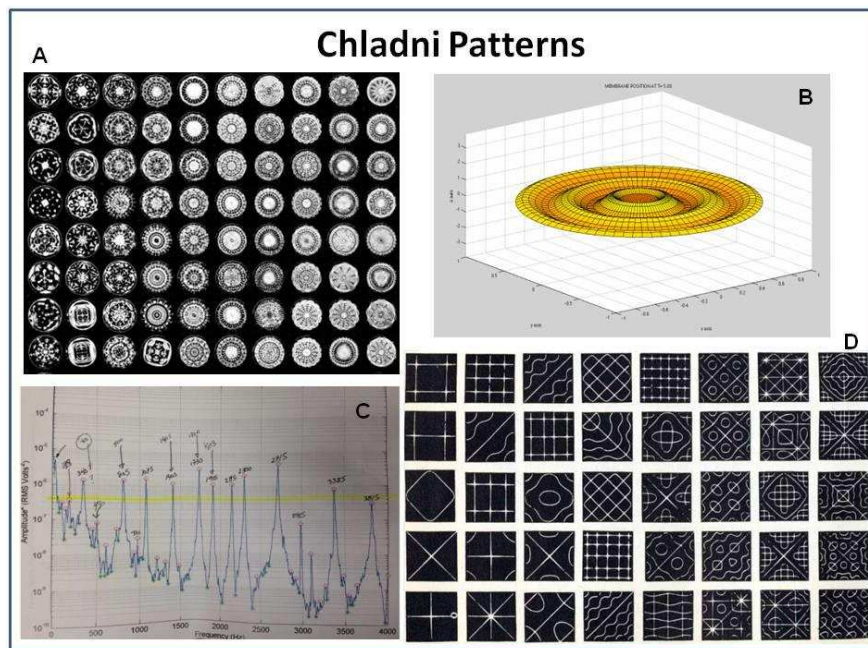


Figure 3: Geometric Chladni patterns of water set in motion by sound, induced on a vibrational plate (A); Vibration of a Chladni disk, Matlab., W. Xiao, 2010 (B); Frequency response plot of a Chladni plate (University of Illinois, 2015) (C); Vibrational geometric patterns of sand particles measured by Chladni, 1787 (D)

advanced optical methods are available now for detection of responses and collective modes of such large biomolecules in the terahertz frequency range (Markelz, 2008), including NMR frequencies.

- The particular pattern of twelve basic frequency intervals (Figure 1) precisely fitted, and was adequately described by an *acoustic* algorithm, and in our opinion, can be regarded as a morphogenetic code, accommodating an acoustic scale, indicating a harmonic like vibration modality (Geesink and Meijer, 2016, Meijer and Geesink, 2016).

- The EM field eigenvalues over a whole range of Hz to PHz values (see Figure 1) have a relation with the earlier mentioned toroidal “Neo-Riemannian Tonnetz”, used in music theory (Meijer and Geesink, 2016). In the central cavity of the torus all waves can converge as well as may diverge at discrete frequencies that are experimentally defined. It is possible therefore, that during the entire history of the planet, pre-biotic and real life systems have been exposed to a natural tonal set of

EM radiation fields, that can be viewed upon as a kind of harmonic- like musical type of excitation.

- A part of the EM frequencies at stake, were shown by others to be involved in phonon and soliton- (and thus sound-) mediated steering of cellular functions (Pang, 2016, Davydov, 1973, 1977, Dotta, 2009). It was inferred by us that the discrete frequency bands (also called *eigenvalues*), as identified in the meta-analysis of the life studies, likely reflect a cellular regulation and communication system that may have an evolutionary origin, realizing that due the composition of our planet, EM fields are basic properties of the planetary environment.

This idea is supported by a spectrum of earlier cell studies that are based on the concept of the electromagnetic cell (Sinkala, 2006, Adamatzky, 2013, Brizhik, 2014, Cifra, 2010 and 2011, Pereira, 2011, Levin, 2012, Muehsam, 2014, Hammerschlag, 2015, Cosic, 2016, De Loof, 2016), see Fig. 5.

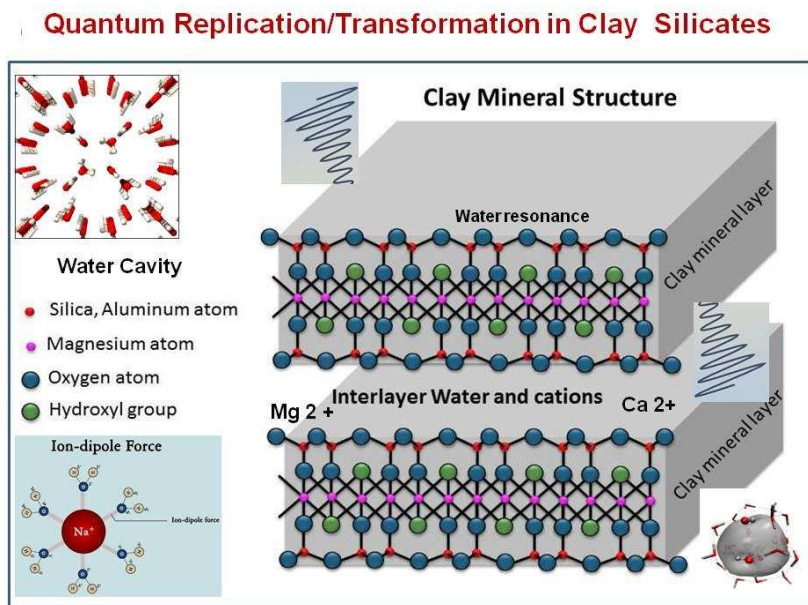


Figure 4. Example of phyllosilicate-layers, with tetrahedral and octahedral structures, as present in natural clay material. The material have been shown to act as a semiconductor, that can absorb EM radiation and transmits coherent discrete EM frequency bands. Instrumental in this property are clustered water molecules that provide resonance cavities (left above) and various doped inorganic cations such as Ca²⁺, Na⁺, Mg²⁺ etc.

- The importance of EM excitation/resonance of cell components via the detected discrete EM frequency bands are in line with almost identical eigenvalues, calculated by Ritz (1909), of the *sound induced geometric/fractal patterns* produced by measured sound excitation of vibrating membranes/plates as reported by Chladny (1817) and three subsequent follow up studies from 1950 up to the present (see: Figure 3 and Meijer and Geesink, 2016).

- The same discrete coherent frequency patterns are also manifest in other inanimate systems, as already predicted by Fröhlich in 1960 and Davydov in 1973.

We found previously that coherent natural and permanently operating wave pattern phenomena are present in typical selected clay minerals, that have semi-conductive like properties (Geesink and Meijer, 2016a,b): identical EM field eigenvalues could be measured in these materials by one of us (HG) (Figure 4). Of note, these types of clay minerals are, apart from being present in soil, also abundantly suspended in the universe, including planet earth (so called cosmic, or extraterrestrial dust) and have been

suggested to provide a semi-conductive medium that produces selective EM wave patterns following excitation by external energy sources (Adamatzky, 2013). It is of interest also that such silicates have been reported to be candidates for the facilitation of oligo-nucleotide synthesis in the creation of first life in biological evolution (Hashizume, 2012). The selected silicates act probably as a quantum replicator, specifically emitting EM radiation at coherent frequencies in a surrounding of ordered water molecules.

Such silicate quantum replicators, therefore may have been instrumental in the initiation of first replicating life, cells at the edge of pre-biotic evolution (see also Melkikh, 2014).

- The EM frequencies that were reported to exhibit *detrimental instead of favorable* effects on life systems are generally located on the normalized acoustic scale, exactly *in between* the pro-life frequencies (see Figure 1, red points, Geesink and Meijer, 2016b). These wave modalities induce de-coherence or, may disturb functional resonance that is instrumental in cellular communication of protein vibration networks (Cosic, 1997, 2015, see Figure 5).

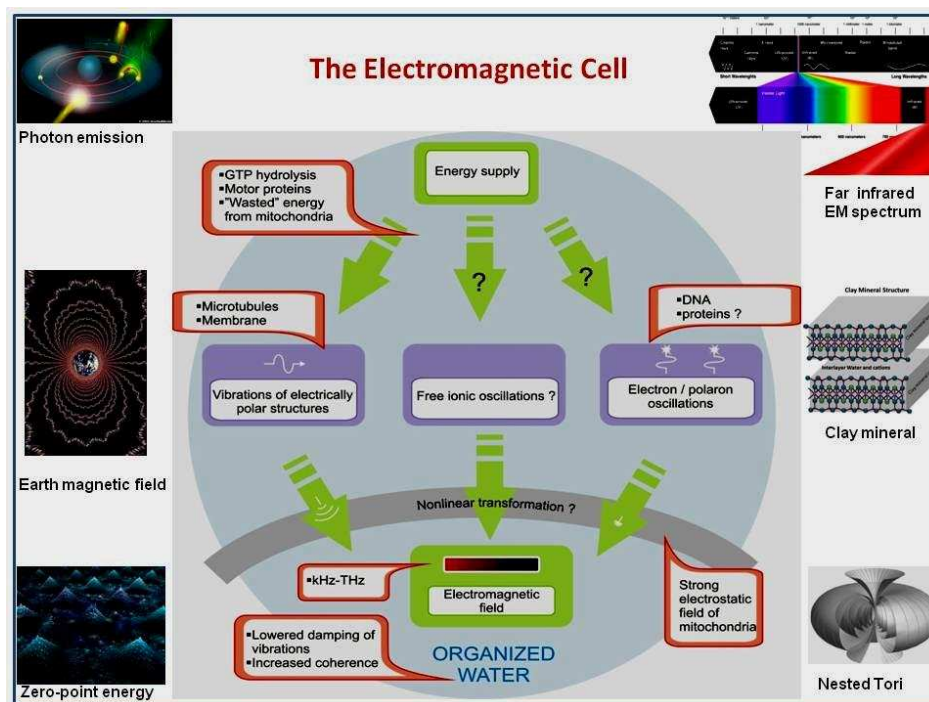


Figure 5. The supposed components of the electromagnetic cell structure and potential interactions with external forces and fields as depicted in the various insets

- Recently [Henry \(2016\)](#), derived the characteristic frequencies involving inorganic ions in aqueous solution. This was done on a universal quantum-mechanical basis, by relating the molecular weight M of any solvent or solute species to a frequency F using the mass-energy equivalence coupled to the Planck-Einstein relationship. Expressed in quantum frequencies, F was transposed to 76 octaves, in order to get a frequency range corresponding to musical sounds. Interestingly, a water molecule was characterized by $M=18 \text{ g}\cdot\text{mol}^{-1}$, leading to a characteristic frequency $F=54 \text{ Hz}$ (or according to octave hierarchy: 432 Hz).

Consequently, common ions in biology can be related to water from a purely harmonic like viewpoint. The 432 Hz value of water molecule is remarkably similar to the central frequency in our proposed sequence of coherent eigenfrequencies.

Quantum states of water dipoles and (in)-organic ions, also related to discrete infrared and far-infrared waves, therefore, can be considered as co-instrumental in the fractal and geometric

organization of the information flux in living material ([Del Giudice et al, 1989](#), [Meijer and Geesink, 2016](#)), and in particular in the astrocyte/glia/neuronal networks that may play a role in cognitive processes (see [Pereira and Furlan, 2007](#)).

In this respect the inter- and intracellular Ca^{2+} gradients and ion-oscillations may play a pivotal role since Ca^{2+} , due to its outer empty electron shell, can function as an outstanding information carrier ([Pereira and Furlan, 2007](#); [Meijer and Geesink, 2016](#); [Meijer, 2015](#)).

- Especially, the established spiral wave movements of Ca -ions, called cyclotron modes, are highly promoted by terrestrial magnetic fields ([Zioutas, 1996](#)). Cells that are normally rather refractory for external EM wave modalities, become very sensitive to such radiation via perturbation of cytosolic Ca^{2+} oscillations. Rotating spiral Ca^{2+} waves have been reported in many studies (see for references [Zioutas, 1996](#)) and photon energy is transformed in kinetic energy of the gyrating ion (gyro-resonance).

Calcium ions couple extracellular stimuli to cellular responses (Figure 4) and the generated Ca^{2+} waves carry encoded photon wave information.

This metabolic event is also supposed to be central in the long distance communication of the neuronal network, (Meijer, 2015).

This is also being supported by Ca^{2+} waves related to the other cell types and likely includes the generation and flux of biophotons.

We hypothesize that, through the toroidal coupling of *coherent* soliton/phonon/photon wave packages, neuronal activity may be selectively modulated in this manner and thereby provide a fundamental basis for a *partially phonon and soliton guided conscious perception* (Meijer and Geesink, 2016, Geesink and Meijer, 2015, 2016).

Twenty-three studies have shown that voltage-gated calcium channels (VGCCs) may mediate various EMF effects, such that the L-type or other VGCC blockers, greatly lower diverse EMF effects (Pall, 2013).

Thus, the voltage-gated properties of these channels clearly provide biophysically plausible mechanisms for EMF biological effects.

In addition, 26 different calcium channel blocker studies confirm this idea, since they specifically block EMFs biological effects.

This also makes sense looking at a large number of such effects, being produced by known "downstream effects" of VGCC activation.

The apparent direct target of the EMFs is what is called the voltage sensor, a part of the VGCC structure that produces its activation to a partial depolarization of the plasma membrane.

The voltage sensor is made up of 4 alpha helices. When electrical changes activate the VGCCs, the 4 helices pull out into the extracellular space, opening up the channel in the middle of the structure, allowing calcium ions, chelated to 4 different glutamate side chains, to rush into the cell (personal communication dr. Pall).

Interestingly, some very low frequencies, mostly down below 10 Hz, seem to stabilize the VGCCs, making them less susceptible to activation. From our meta-analysis we detected some activating frequencies related to Ca-channels from five different studies (Rao et al, 2008, Lisi et al, 2006 and 2008, Yao et al, 2008 and Kumar et al 2016): 7 Hz, 50 Hz, 1Hz pulsed 10 MHz, 800 MHz, 400 Hz modulated 2.45 GHz. According to our mathematical analyses, all these frequencies are coherent (see the green points in the graphs), implying that they are biologically activating and depending upon the exposed energy, were defined by us as stabilising and/or beneficial.

3 - Potential mechanisms for cell and life disturbing effects of specific EM radiation frequencies

How can one explain the observed intermediate EM frequencies that were associated with *adverse and detrimental* effects on living matter (red points in Figure 1, 2).

If this pattern also should be regarded as an evolutionary element that is build into cells, the following question is evident: why should evolution conserve an ability to sense life damaging wave/radiation modalities?

First of all, one may realize that the "negative effects" may be a part of a regulatory mechanism of life protective and life damaging effects in which the "negative" aspects are possible and that the *natural coherent balance* was thereby disturbed.

For instance the process of apoptotic cell death can be conceived as a destructive process, yet rather offers the opportunity for the organism to remove dysfunctional, damaged or even dangerous cells, thereby allowing the formation of new cells in organs where necessary.

Alternatively, from a more mathematical point of view, apart from ordering living cells in a coherent way, cells can also be steered temporarily in an non-coherent way, due to the fact that

beneficial (coherent) and detrimental (non-coherent) frequencies could succeed each other in an alternate fashion (see Figure 1.).

It is worthwhile to mention that much of the man-made radiation to which we are exposed on a daily basis in our high tech society, can also produce non-coherent EM effects.

Another important point is that in biological evolution living matter was also exposed to coherent as well as incoherent EM fields, that were partly in the polarized form, due to scattering effects in the atmosphere (Panagopoulos et al, 2015).

Consequently, it is not excluded that the cells of our organism, in principle, have the property to be sensitive to non-coherent radiation.

Yet, a minimal damaging influence is only reached if the dose of radiation exceeds a certain critical value. Among others, such exposure to radiation can result in irregular gating of electro-sensitive ion-channels in cell membranes, being coupled to a plethora of metabolic processes (Panagopoulos et al, 2015) and influences on mesenchymal stem cells and DNA repair foci in cells (Belyaev, 2015).

It is further considered that Bohm's quantum potential (Bohm, 1952), has an analogy with the concept of rational control of shape by soliton-waves and to the proposed "coherent wave pattern" observed in physical and biological experiments, as related to electromagnetic waves and quantum resonances.

It is envisaged that the discovered "coherent wave pattern" and the "twelve eigenfrequency functions" may represent "hidden variables" in Bohm's causal interpretation of quantum mechanics.

It is presently also considered by us that the EPR (Einstein-Podolsky-Rosen, 1935) argument may fit in the proposed eigenfrequency functions concerning the measurements centred around the testing of Bell's theorem (Bell, 1964, Reid, 2009).

4 - A mathematical calculation of a biological verified 12-number scale

In our most recent paper (Geesink and Meijer, 2017c), adequate arithmetical expressions for the earlier detected discrete patterns of electromagnetic frequencies are derived based on a modified interpretation of tone scale's and number theory, from which the total spectrum of discrete EM frequencies can be directly calculated.

The particular arithmetical scale uses 12-number sequences of unique products of integer powers of 2, 3 and a factor $\sqrt{2}$.

This Hertz-scale was coined by us the GM-scale (generalized electromagnetic scale of Geesink and Meijer, 2017).

Interestingly, these coherent patterns of numbers were also reported for 1) resonances of nucleotides in aqueous solution, 2) a candidate RNA-catalyst, 3) sound-induced vibrations evoked in thin vibrating membranes, and 4) colours expressed in nanometre wavelengths.

The collective evidence thus points at an integral universal algorithm, that is a novel concept in biophysics.

As mentioned earlier, the confirmed number theory also bears a close relation with a resonance system that has been described by soliton waves (self-reinforcing solitary waves) and a tone-network called Tonnetz.

We propose that the coherent waves interact with complex biological phenomena, such as resonant self-organisation and coherent wave condensates that are instrumental in the intra- and intercellular signalling and communication (see Figure 5).

5 - Potential counter measures against damaging effects of EM radiation

In relation to the potential problems of environmental radiation (Salford et al, 2017), it is envisioned by us that semiconducting nanomaterials, will become available in the near future to

produce discrete stabilizing EM eigenfrequencies, characteristic of well functional cells. Such nano-materials may prevent the potential disturbing EM influences by converting the non-coherent frequencies to more life-compatible values.

In potential, the present man-made electromagnetic technologies could be further improved in this manner, by which the adverse an-harmonic radiation is suppressed to obtain a more bio-compatible radiation spectrum.

Such a technology can be based, for instance, on the principle of toroidal trapping, by which detrimental EM frequencies of man-made electromagnetic signals can be overall converted to rather beneficial radiation modes.

The latter developments can potentially make use of our toroidal model for phonon/bio-soliton guided biology, as proposed in more detail recently (Meijer and Geesink, 2016, Geesink and Meijer, 2016).

The concept of EM sensitive life processes, including brain function (Meijer and Geesink, 2017b), partly being guided by discrete coherent electromagnetic waves, is fully in line with the current spectrum of pre-clinical and clinical studies on the application of EM radiation, as adequately reviewed earlier (Brizhik, 2014; Pereira, 2011; Levin, 2012; Muehsam and Ventura, 2014; Hammerschlag, 2015; De Loof, 2016; Fröhlich F, 2014; Sahu and Bandyopadhyay, 2013, 2014; Persinger, 2015).

Our papers, collectively, picture the rapidly growing and dynamic discipline of *electromics*, that shows promising pre-clinical and clinical effects in the treatment of various sincere and often chronic diseases, and should be seen in the framework of the current developments in quantum biology.

The broad scientific material analyzed, provides a generalized electromagnetic field model for health and disease on the basis of a bio-soliton algorithm of discrete EM frequency bands, that invites further studies on

improved therapeutic measures and advanced nano-technological protective materials.

6 - Potential biophysical mechanism for the proposed Life algorithm

The mechanisms behind the life-sustaining and life-disturbing field effects of the spectrum of externally applied EM frequencies (including some directly measured values in normal and diseased tissues), as reported in the biomedical publications analyzed by us, can in principle be described on the basis of current biophysics:

1. The particular EM frequencies resonate with discrete vibratory macromolecules in the cell, producing domains of coherent wave patterns in proteins, cell water and/or DNA (Del Giudice et al, 1989; Fröhlich, 1968; Pang et al 2016; Meijer and Geesink, 2016, 2017a; Melkikh and Meijer, 2017).

Coherence is a fundamental property of quantum mechanics and can be defined as the physical congruence of wave properties within wave packets and is a property of stationary waves (i.e. temporally and spatially constant) that enables a type of wave interference, known as constructive.

This can lead to stabilizing internal vibratory patterns crucial for life conditions, as may have also been selected in biological evolution.

Thereby, these waves are instrumental in beneficial influences on cell metabolism, intercellular information transfer and morphogenetic stimuli.

The detrimental frequencies, detected by us, may cause decoherent resonance by destructive resonant interference.

It should be stipulated here that the life disturbing frequencies found were called by us de-coherent or non-coherent, yet this should not be confused with the term decoherence as the loss of quantum coherence due to interaction with the environment.

The supposed coherent wave patterns (Fröhlich, 1968), and dual (symmetric) wave/matrix interactions (see Pang et al, 2016) have been demonstrated by spectroscopic methods among others in proteins (Lundholm, 2015; Bandyopadhyay, 2014).

Such coherent vibration patterns can explain the long-range interactions between distant cell groups, as reviewed by Cifra (2010).

2. The experimentally applied EM fields may mimic naturally occurring, terrestrial electro-magnetic patterns of the atmosphere and typical minerals present in the top-layer of the earth, probably including pre-mordial modalities, that have influenced the informational and structural organization of pre-biotic and first life cells as well as in present life organisms (Melkikh and Meijer, 2017, Melkikh, 2014).

As discussed in the present paper, especially polarized and cyclotron-like waves can directly perturb ion-channel proteins as demonstrated for Ca^{2+} , an ion that is central in cell regulation (see section 4.2.2).

3. The particular wave modalities could both have a quantum and classical character, the latter if sufficient cellular energy is supplied (Nardecchia et al, 2017).

Potential quantum coherence in life cells can occur if the quantum process is sufficiently shielded from decoherence in the complex environment of the cell, an aspect that was intensively debated (Tegmark, 2014; Hagan et al. 2002; Kauffman, 2010). Yet more recent studies in quantum biology clearly indicate that such coherent processes can in principle occur in warm and wet systems (reviewed by Lambert, 2013; Lloyd, 2014; Huelga, 2013).

At this time, the most promising candidates for function quantum biology are photosynthetic units and magnetoreception (see Lambert, 2013. Lloyd, 2014).

In the latter reviews, it has been shown that phonon-mediated matrix vibrations can facilitate electron/exciton

flux, either as such or in the form of phonon quasi-particles such as polarons/solitons (Huelga et al. 2013; Meijer and Geesink, 2016).

Schrödinger suggested that coherent interaction of waves is coupled to entanglement as “*the characteristic aspect of quantum mechanics*” and that “*eigenstates*”, also called “*preferred states*”, are able to survive interaction with the environment. Einstein-Podolsky and Rosen (EPR) discovered in 1935 the nonlocal correlations in quantum phenomena.

The related particle positions in these quantum phenomena are determined by inherent information correlation.

They can, tentatively, be interpreted by the so called “*hidden variables*” in the Bohm’s causal interpretation of the quantum mechanics, as earlier conceptualized by Louis de Broglie.

The particle positions that play a role in the Bohm’s theory are conceptually independent of their intrinsic wave function and have their own pilot wave steered dynamical motion (Singh, 2008).

It is considered in our papers that the discovered “coherent wave pattern” with the twelve “*eigenfrequency functions*” could represent the “*hidden variables*” in Bohm’s causal interpretation of the quantum mechanics (Bohm, 1952, see also point 5).

4. In addition, EM effects could be envisioned as mimicking quantum field-mediated processes (Vitiello et al. 2001).

Coherent behavior in the meaning of quantum field theory (QFT) and, specifically quantum electrodynamics coherent behavior, is a collective emerging phenomenon occurring under specific conditions, whose happening and permanence, however, is not obvious a priori.

In quantum field theory, quantum mechanical interactions among particles, are described by interaction terms among the corresponding underlying quantum fields.

Dirac described the quantization of the electromagnetic field as an ensemble of harmonic oscillators.

Yet, the “*twelve eigenfrequency functions*”, identified by us, rather seem an ensemble of oscillators with harmonic, non-harmonic and also irrational parameters.

5. It has been proposed that life systems potentially can select appropriate information frequencies through resonance with the zero point energy field, leading to phase-locked cellular information attractors, functionally separated by non-coherent wave activity (Keppler, 2013; Meijer and Geesink, 2017b).

The latter could explain the function of “coherent”, balanced by “non-coherent” EM/quantum values in a sort of regulatory cycling process.

Bohm in his “*quantum equilibrium*” hypothesis, on the ensemble of particle trajectories and pilot waves, according to his ontological and causal interpretation of QM, envisioned a holographic interference of supposed implicate and explicate orders (space-time domains).

In this theory, the wave function provides a partial description of the system and a specification of the actual positions of the particles.

The latter evolve according to the “*guiding equation*”, which expresses the configuration of a system of particles evolves via a deterministic motion, choreographed by the wave function including the velocities.

Bohm makes use of the term quantum potential that is an informational effect shared by the surroundings particles/waves that depends on its form/shape and this quantum potential, that is derived from the ψ -field (Bohm, 1952; Peat, 1997).

As mentioned above, in this respect the discrete EM frequency bands, inferred by us, might be interpreted as hidden variables that have a pilot function in nature.

References

- Adamatzky A. (2013) *Game of Life on Phyllosilicates: Gliders, Oscillators and Still Life*. Physics Letters; 377: 1597-1605.
- Bell J. (1964) *On the Einstein Podolsky Rosen Paradox*. Physics. 1 (3): 195–200.
- Belyaev I. (2015) *Biophysical Mechanisms for Nonthermal Microwave Effects*. In: *Electromagnetic Fields in Biology and Medicine*. pp 49-67.
- Bohm D. (1952) *A Suggested Interpretation of the Quantum Theory in Terms of 'Hidden Variables' I*. Physical Review. 85 (2): 166–179; doi:10.1103/PhysRev.85.166.
- Brizhik L. (2014) Biological effects of pulsating magnetic fields: role of solitons. arXiv:1411.6576 [physics.bio-ph].
- Cassano P, Petrie SR, Hamblin MR, Henderson TA, Iosifescu DV. (2016) *Review of transcranial photobiomodulation for major depressive disorder: targeting brain metabolism, inflammation, oxidative stress, and neurogenesis*. Neurophotonics; 3(3), 031404 (Jul–Sep).
- Chibeni SS. (2012) *A logico-conceptual analysis of the Einstein-Podolsky-Rosen argument*. <http://www.unicamp.br/~chibeni/public/epr.pdf>.
- Cifra M, Fields JZ, Farhadi A. (2010) *Electromagnetic cellular interactions*. Progress in Biophysics and Molecular Biology; xxx: 1-24, doi:10.1016/j.pbiomolbio.2010.07.003.
- Cifra M, Pokorny J, Havelka D, Kucera O. (2010) *Electric field generated by axial longitudinal vibration modes of microtubule*. BioSystems; 100: 122–131.
- Cosic I. (1997) *The Resonant Recognition Model of Macromolecular Bioactivity Theory and Applications*. Birkhäuser Verlag, 1997 - Science - 143 pages, ISBN: 978-3-0348-7477-9.
- Cosic I, Cosic D, Lazar K. (2015) *Is it possible to predict electromagnetic resonances in proteins, DNA and RNA?* Nonlinear Biomedical Physics; 3: 5 DOI 10.1140/s40366-015-0020-6.
- Davies PCW. (2014) *Does quantum mechanics play a non-trivial role life?* BioSystems; 78: pp. 69–79.
- Davydov AS. (1973) *The theory of contraction of proteins under their excitation*. Journal of Theoretical Biology. 38 (3): 559–569, doi:10.1016/0022-5193(73)90256-7. PMID 4266326.

- Davydov AS. (1977) *Solitons and energy transfer along protein molecules*. Journal of Theoretical Biology; 66 (2): 379–387, doi: 10.1016/0022-5193(77)90178-3. PMID 886872.
- De Loof A. (2016) *The cell's self-generated "electrome": the biophysical essence of the immaterial dimension of Life?*; <https://www.researchgate.net/publication/304712940>.
- Del Giudice E, Doglia S, Milani M, Smith CW, Vitiello G. (1989) *Magnetic flux quantization and Josephson behaviour in living systems*. Physica Scripta; Volume 40, Number 6.
- Dotta BT, Mulligan BP, Hunter, MD, Persinger MA. (2009) *Evidence of macroscopic quantum entanglement during double quantitative electroencephalographic measurements of friend's vs strangers*. NeuroQuantology; 7: 548-551.
- Einstein A, Podolsky B, Rosen N. (1935) *Can Quantum-Mechanical Description of Physical Reality be Considered Complete?*, Physical Review.; 47 (10): 777–780.
- Engel GS, et al. (2007) *Evidence for wavelike energy transfer through quantum coherence in photosynthetic systems*. Nature 446. 7137: 782-786.
- Fröhlich F, McCormick, DA. (2013) *Endogenous electric fields may guide neocortical network activity*. Neuron; 67: 129–143. doi:10.1016/j.neuron.2010.06.005.
- Fröhlich H. (1968) *Long-range coherence and energy storage in biological systems*. Int. J. Quantum Chem.; 2: 641–649.
- Fröhlich H. (1975) *The extraordinary dielectric properties of biological materials and the action of enzymes*. Proc Natl Acad Sci USA; 72(11):4211-5.
- Gauger EM, et al. (2011) *Sustained quantum coherence and entanglement in the avian compass*. Physical Review Letters 106.4: 040503.
- Geesink JH, Meijer DKF. (2016a) *Quantum Wave Information of Life Revealed: An algorithm for EM frequencies that create stability of biological order, with implications for brain function and consciousness*. NeuroQuantology. 14: 106-125.
- Geesink JH, Meijer DKF. (2016b) *Novel Integral Soliton Model Describing Distinct Non-thermal Electromagnetic Radiation Frequency Bands, that either Stabilize or Destabilize Life Conditions*. <https://arxiv.org/ftp/arxiv/papers/1610/1610.04855.pdf>
- Geesink JH, Meijer DKF. (2017a) *Cancer Is Promoted by Cellular States of Electromagnetic Decoherence and Can Be Corrected by Exposure to Coherent Non-ionizing Electromagnetic fields. A Physical Model About Cell-sustaining and Cell-decaying Soliton Eigen-frequencies*. ResearchGate; https://www.researchgate.net/publication/316058728_Cancer_is_promoted_by_cellular_states_of_electromagnetic_decoherence_and_can_be_corrected_by_exposure_to_coherent_non-ionizing_electromagnetic_fields
- Geesink JH, Meijer DKF. (2017b) *Mathematical structure of the GM algorithm, a non-conscious hidden variable at work. Paper under preparation*.
- Gramowski-Voß A, Schwertle H-J, Pielka A-M, Schultz L, Steder A, Jügel K, Axmann J and Pries W. (2015) *Enhancement of cortical network activity in vitro and promotion of GABAergic neurogenesis by stimulation with an electromagnetic field with a 150 MHz carrier wave pulsed with an alternating 10 and 16 Hz modulation*. Front. Neurol. 6: 158. doi: 10.3389/fneur.2015.00158.
- Hagan S, Hameroff SR, Tuszynski JA.(2002). *Quantum computation in brain microtubules: Decoherence and biological feasibility*, Phys. Rev; 2002: E. 65, 061901.
- Hammerschlag R, Levin M, McCraty R, Bat BA, Ives JA, Lutgendorf SK, Oschman JL. (2015) *Biofield Physiology: A Framework for an Emerging Discipline*. Global Adv Health Med.; 4 (suppl): 35-41. DOI: 10.7453/gahmj.015.
- Hashizume H, (2012). *Role of Clay Minerals in Chemical Evolution and the Origins of Life*; DOI: 10.5772/50172. <http://uu.diva-portal.org/smash/get/diva2:935529/FULLTEXT01.pdf>.
- Henry M. (2016) *Hofmeister series: The quantum mechanical viewpoint*. Current Opinion in Colloid & Interface Science; 23-119–125.
- Huelga SF, Plenio MB. (2013) *Vibration, Quanta and Biology*. Contemporary Physics; 54, 181 and E-print: arxiv: 1307.3530.
- Kauffman, S. (2010). *Is There A 'Poised Realm' Between the Quantum and Classical Worlds?* https://www.npr.org/sections/13.7/2010/03/is_there_a_poised_realm_betwee.html.
- Kepler, J. (2013) *A new perspective on the functioning of the brain and the mechanisms behind conscious processes*. Front Psychol.; 4: 242.
- Kumar M, Singh SP, Chaturvedi CM. (2016) *Chronic Non-modulated Microwave Radiations in Mice Produce Anxiety-like and Depression-like Behaviours and Calcium- and*

- NO-related Biochemical Changes in the Brain*. *Exp Neurobiol*. 25 (6): 318-327. doi: 10.5607/en.2016.25.6.318. Epub 2016 Dec 19.
- Lambert N, Chen, YN, Cheng, YC, Li CM, Chen GY, Nori, F. (2013) *Quantum biology*. *Nature Physics* ; 9 (1): 10–18, doi:10.1038/nphys2474.
- Levin M. (2012) *Molecular bioelectricity in developmental biology: new tools and recent discoveries: control of cell behavior and pattern formation by transmembrane potential gradients*. *Bioessays*; 34:205–217.
- Lisi A, Ledda M, Rosola E, Pozzi D, D'Emilia E, Giuliani L, Foletti A, Modesti A, Morris SJ, Grimaldi S. (2006) *Extremely low frequency electromagnetic field exposure promotes differentiation of pituitary corticotrope-derived AtT20 D16V cells*. *Bioelectromagnetics*. 27: 641–51.
- Lisi A, Ledda M, Flavia E, Carlo F, Foletti A, Giuliani L, D'Emilia E, Grimaldi S. (2008) *Calcium Ion Cyclotron Resonance (ICR) Transfers Information to Living Systems: Effects on Human Epithelial Cell Differentiation*, *Electromagnetic Biology and Medicine*. 27: 230–240.
- Loy G. (2011) *Musimathics: The Mathematical Foundations of Music* (MIT Press) (Volume 1) Paperback.
- Lloyd, S. (2014) *Better Living Through QuantumMechanics*.
<http://www.pbs.org/wgbh/nova/blogs/physics/2014/03/quantum-life>
- Lundholm IV, Rodilla H, Wahlgren WY, Duelli A, Bourenkov G, Vukusic J, Friedman R, Stake J, Schneider T, Katona G. (2015) *Terahertz radiation induces non-thermal structural changes associated with Fröhlich condensation in a protein crystal*. *Struct Dyn*. 13; 2(5): 054702. doi: 10.1063/1.4931825.
- Markelz AG. (2008) *Terahertz Dielectric Sensitivity to Biomolecular Structure and Function*. *IEEE journal of selected topics in quantum electronics*. vol.14, No.1.
- Meijer DKF. /2014) *The Extended Brain: Cyclic Information Flow, in a Quantum Physical Realm*. *NeuroQuantology*. vol. 12, pp 180-200. Full paper available at: https://www.researchgate.net/profile/Dirk_Meijer4/contributions
- Meijer DKF, Geesink JH. (2016) *Phonon Guided Biology. Architecture of life and conscious perception are mediated by toroidal coupling of phonon, photon and electron information fluxes at discrete eigenfrequencies*. *NeuroQuantology*. pp 718-755. <http://www.neuroquantology.com/index.php/journal/article/view/985>.
- Meijer DKF, Geesink JH. (2017a) *Protein folding: the Role of Long- and Short Range Electromagnetic Pilot Mechanisms*. Available at: ResearchGate: https://www.researchgate.net/publication/315706536_The_Folding_of_a_Life_Proteins_On_the_role_of_long-and_short_range_electromagnetic_pilot_mechanisms
- Meijer D. K.F. and Geesink J.H (2017b). *Consciousness in the Universe is Scale Invariant and Implies an Event Horizon of the Human Brain*. *NeuroQuantology*. 15 (3), pp. 41-79. doi: 10.14704/nq.2017.15.3.1079 <https://www.neuroquantology.com/index.php/journal/article/viewFile/1079/852>
- Melkikh AV. (2014) *Quantum information and the problem of mechanisms of biological evolution*. *BioSystems*. 115: 33-45.
- Melkikh, A V, Meijer D.K.F. (2017). *On a generalized Levinthal's paradox: the role of long- and short range interactions on complex bio-molecular reactions, including protein and DNA folding*. *Progress in Biophysics and Molecular Biology*. pii: S0079-6107(17)30084-6. doi: 10.1016/j.pbiomolbio.2017.09.018.
- Muehsam D, Ventura C. (2014) *Life Rhythm as a Symphony of Oscillatory Patterns: Electromagnetic Energy and Sound Vibration Modulates Gene Expression for Biological Signaling and Healing*. *Glob Adv Health Med*. 3(2): 40-55.
- Nardecchia I, Torres J, Lechelon M, Giliberti V, Ortolani M, Nouvel P, Gori M, Donato I, Preto J, Varani L, Sturgis J, Pettini M. (2017) *Out-of-equilibrium collective oscillation as phonon condensation in a model protein..* <https://arxiv.org/pdf/1705.07975.pdf>.
- Pall ML (2013) *Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects* *J. Cell. Mol. Med*. 17 (8) pp. 958-965
- Panagopoulos DJ, Johansson O, Carlo GL. (2015) *Polarization: A Key Difference between Man-made and Natural Electromagnetic Fields, in regard to Biological Activity*. *Scientific Reports*; 5, Article number: 14914 doi: 10.1038/srep14914.
- Pang XF, Chen XR. (2001) *Distribution of Vibrational Energy Levels of Protein Molecular Chains*. *Commun. Theor. Phys*. (Beijing, China) 35, pp. 323–326.
- Pang XF, Chen S, Wang X, Zhong L. (2016) *Influences of Electromagnetic Energy on Bio-Energy Transport through Protein Molecules in Living Systems and Its Experimental Evidence*. *Int. J. Mol. Sci.*; 17, 1130.

- Peat FD. (1997) *Infinite Potential: The Life and Times of David Bohm*. Basic Books (first published October 1996).
- Penrose R. (2000) *The Large, the Small and the Human Mind*. Cambridge University Press, Cambridge, England.
- Pereira A, Furlan FA. (2007) *Biomolecular Information, Brain Activity and Cognitive Function*. ARBS Annual Rev of Biomedical Sciences; 9: 12-29.
- Persinger MA, Lavallee CF. (2010) *Theoretical and experimental evidence of macroscopic entanglement between human brain activity and photon emissions: implications for quantum consciousness and future applications*. J. Cons. Explor. Res. 1: 785–807.
- Rao VS, Titushkin IA, Moros EG, Pickard WF, Thatt HS, Cho MR. (2008) *Nonthermal effects of radiofrequency-field exposure on calcium dynamics in stem cell-derived neuronal cells: elucidation of calcium pathways*. Radiat Res. 169 (3): 319–29. doi:10.1667/RR1118.1.
- Reid M, Drummond P, Bowen W, Cavalcanti E, Lam PK, Bachor H, Andersen, Lund U, Leuchs G. (2009) *Colloquium: The Einstein-Podolsky-Rosen paradox: From concepts to applications*. Reviews of Modern Physics, DOI: 10.1103/RevModPhys.81.1727.
- Sahu S, Ghosh S, Ghosh B, Aswani K, Hirata K, Fujita D. (2013). *Atomic water channel controlling remarkable properties of a single brain microtubule: correlating single protein to its supramolecular assembly*. Biosens Bioelectron. 47:141–8.
- Sahu S, Ghosh S, Fujita D, Bandyopadhyay A. (2014) *Live visualizations of single isolated tubulin protein self-assembly via tunneling current: effect of electromagnetic pumping during spontaneous growth of microtubule*. Scientific Reports. 4:7303. DOI: 10.1038/srep07303.
- Salford LG, Nittby H, Brun A, Grafström G, Malmgren L, Sommarin M, Eberhardt J, Widegren B, Persson BRR. (2008) *The mammalian brain in the electromagnetic fields designed by man- with special reference to blood-brain barrier function, Neuronal damage and possible physical mechanisms*. Prog Theor Phys Suppl. 173: 283-309 <http://ptp.ipap.jp/link?PTPS/173/283/>.
- Singh V (2008). Bohm's realist interpretation of Quantum mechanics. arXiv:0805.1779v1 [quant-ph] 13 May.
- Sinkala Z. (2006) *Soliton/exciton transport in proteins*. Journal of Theoretical Biology. 241, 919–927.
- Tegmark M. (2000) *Importance of quantum decoherence in brain processes*. Phys. Rev. E 61 (2000) 4194.
- Vadalà M, Morales-Medina JC, Vallelunga A, Palmieri B, Laurino C, Iannitti T. (2016) *Mechanisms and therapeutic effectiveness of pulsed electromagnetic field therapy in oncology*. Cancer Medicine. 5(11):3128–3139.
- Xuan W, Vatansever F, Huang L, Hamblin MR. (2012) *Transcranial low-level laser therapy enhances learning, memory, and neuroprogenitor cells after traumatic brain injury in mice*. Journal of Biomedical Optics 2014; 19(10), 108003.
- Vatansever F, Hamblin MR. (2012) *Far infrared radiation (FIR): its biological effects and medical applications*. Photonics Lasers Med. 4: 255–266. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3699878>.
- Vitiello G. (2001) *My Double Unveiled: The Dissipative Quantum Model of Brain*. John Benjamins Publishing.
- Yao C, Mi Y, Hu X, Li C, Sun C, Tang J, Wu, X. (2008) *Experiment and mechanism research of SKOV3 cancer cell apoptosis induced by nanosecond pulsed electric field*. Proceedings of 30th Annual International IEEE EMBS Conference, Vancouver, British Columbia, Canada.
- Zioutas K. (1996) *On the interaction of extreme-low-frequency (ELF) radiation with living matter's coherent spiral states*. arXiv:patt-sol/9601001v1.