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Schumann Resonances and Their Potential Applications: a Review Article

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Introduction. Schumann resonances is an important topic gains great interest in research areas which has extensive use of Schumann resonances in a variety of desplines such as biological evolutionary processes, the optimal functioning of the human brain waves and lightning-related studies.
Materials and Methods. This dictates the major emphasis on economic, environmental, and engineering applications and hazard assessments in the form of earthquake and volcano monitoring.
Results. This review is aimed at the reader generally unfamiliar with the Schumann Resonances. It is our hope that this review will increase the interest in SR among researchers previously unfamiliar with this phenomenon.
Discussion and Conclusions. In this review paper, a brief introduction about Schumann resonances is presented. A general description of Earth's ionosphere is outlined**.** The electromagnetic waves spectrum from lightning is discussed. The history of Schumann resonances is briefly presented. The connection of man with nature through Schumann resonances is introduced. Present Schumann resonances researches are briefly outlined. Schumann (global) electromagnetic resonances in the cavity Earth – ionosphere play a critical role in all biological evolutionary processes. However, there is a great need for independent research into the bio-compatibility between natural and manmade signals. Serious attention must now be paid to the possible biological role of standing waves in the atmosphere. Being a global phenomenon, Schumann resonances have numerous applications in lightning research.

Keywords: earth ionosphere, Schumann resonance, electromagnetic waves, information waves, global lightning, cavity

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Резонансы Шумана и их потенциальное применение: обзорная статья

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Введение. Резонанс Шумана является важной темой, вызывающей большой интерес в исследовательских областях. Эффект резонанса Шумана используется в различных сферах, например, биологических эволюционных процессах, оптимальном функционировании мозговых волн человека и исследовании молний. *Материалы и методы.* Авторы статьи делают акцент на экономическое, экологическое и инженерное использование резонанса Шумана, в том числе при оценке возможных опасностей в виде предсказания землетрясений и мониторинга состояний вулканов.
Результаты исследования. Данный обзор предназначен для читателей, не знакомых с резонансом Шумана. Авторы выражают надежду, что эта статья повысит интерес к резонансу Шумана среди исследователей, ранее не знакомых с этим явлением.
Обсуждение и заключения. В данной обзорной статье представлено краткое описание резонансов Шумана; дано общее описание ионосферы Земли; описывается спектр электромагнитных волн, идущих от молнии; кратко представлена история резонанса Шумана; обрисована связь человека с природой посредством резонанса Шумана; кратко изложено современное состояние исследования данной проблемы. Глобальные электромагнитные резонансы Шумана в ионосфере играют критическую роль во всех биологических эволюционных процессах. Тем не менее, существует большая потребность в независимом исследовании биосовместимости естественных и искусственных сигналов. Необходимо обратить серьезное внимание на возможную биологическую роль стоячих волн в атмосфере. Будучи глобальным явлением, резонансы Шумана имеют множество применений в исследованиях молний.

Ключевые слова: ионосфера Земли, резонанс Шумана, электромагнитные волны, информационные волны, глобальная молния, полость

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Introduction

The surface of the Earth and the lower edge of the ionosphere about 55 kilometers up defines a cavity in which electromagnetic waves propagate. When the cavity is excited by broadband electromagnetic sources, such as, lightning, a resonant state can develop provided the average equatorial circumference is approximately equal to an integral number of wavelengths of the electromagnetic waves. This phenomenon, known as Schumann Resonance (SR), corresponds to electromagnetic oscillations of the surface-ionosphere cavity, and has been used extensively to investigate atmospheric electricity [1].

This electromagnetic cavity seems to be related to electrical activity in the atmosphere, particularly during times of intense lightning activity. Such activities produce quasi standing electromagnetic waves that exist in this cavity and have to be ‘excited’ to be observed. They are not caused by anything internal to the Earth, its crust or its core. They occur at several frequencies; specifically 7.8, 14, 20, 26, 33, 39 and 45 Hertz, with a daily variation of about +/- 0.5 Hertz [2].

These frequencies are called The Schumann Resonances. So long as the properties of Earth’s electromagnetic cavity remain about the same, these frequen-

cies remain the same. However, there is some change due to the solar sunspot cycle as the Earth's ionosphere changes in response to the 11-year cycle of solar activity [2].

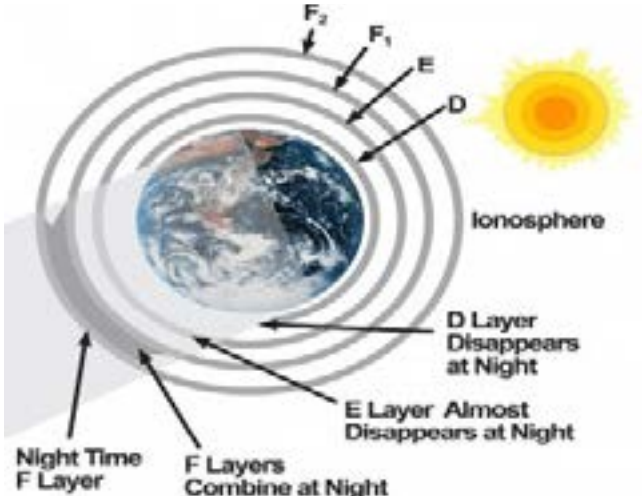
At any moment, the total charge residing in this cavity is 500,000 Coulombs. There is a vertical current flow between the ground and the ionosphere of 1–3 x 10^{-12} Amperes per square meter. The resistance of the atmosphere is 200 Ohms. There are about 1 000 lightning storms at any given moment worldwide. Each produces 0.5 to 1 Ampere and these collectively account for the measured current flow in the Earth's electromagnetic cavity [2]. The characteristics of Schumann Resonance frequencies depend on the characteristics of their source, location of the observation point with respect to the source, and ionospheric electron density/conductivity behavior [3].

It has been well established that the resonance frequencies contain information about space time distribution of lightning strokes around the globe. The intensities of Schumann Resonances reflect global thunderstorm activity, which excite transverse magnetic normal modes of earth ionosphere cavity [4].

Materials and Methods

The Earth's atmosphere and ionosphere.

The ionosphere is defined as the layer of the Earth's atmosphere that is ionized by solar and cosmic radiation. It lies 75–1 000 km above the Earth. (The Earth's radius is 6 370 km, so the thickness of the ionosphere is quite tiny compared with the size of Earth). The ionosphere is composed of three main parts, named for obscure historical reasons: the D, E, and F regions. The electron density is highest in the upper, or F region. The F region exists during both daytime and nighttime. During the day it is ionized by solar radiation, during the night by cosmic rays. The D region disappears during the night compared to the daytime, and the E region becomes weakened [5]. Fig. 1 shows the Earth's atmosphere and ionosphere.

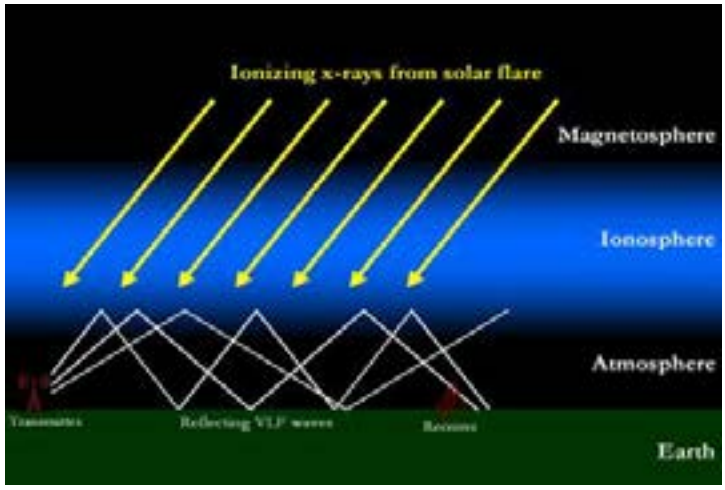


F i g. 1. The Earth's atmosphere and ionosphere [6]

Because of the high energy from the Sun and from cosmic rays, a solar flare (fig. 2), the atoms in the ionosphere have been stripped of one or more of their electrons, or "ionized", and are therefore positively charged. The ionized electrons behave as free particles [5].

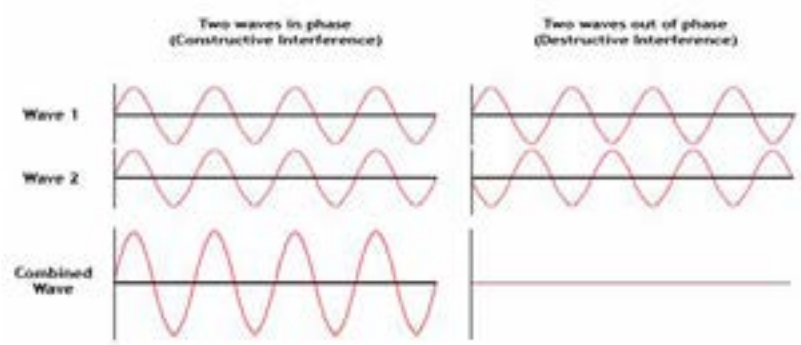
F i g. 2. A solar flare's X-ray energy increases the ionization of all the i*onosphere* layers [5]

The Sun's upper atmosphere, the corona, is very hot and produces a constant stream of plasma and UV and X-rays that flow out from the Sun and affect, or ionize, the Earth's ionosphere. Only half the Earth's ionosphere is being ionized by the Sun at any time [5]. During the night, without interference from the Sun, cosmic rays ionize the ionosphere, though not nearly as strongly as the Sun. These high energy rays originate from sources throughout our own galaxy and the universe (rotating neutron stars, supernovae, radio galaxies, quasars and black holes). Thus the ionosphere is much less charged at nighttime, in which a lot of ionospheric effects are easier to spot at night and take a smaller change to notice them [5]. Fig. 3 shows the Earth's ionosphere and ground through which very low frequency (VLF) radio signals can propagate or "bounce" around the Earth [5].



F i g. 3. The Earth's ionosphere and ground form a "waveguide" through which VLF radio signals can propagate or "bounce" around the Earth [5]

The signal strength usually increases because the waves don't lose energy penetrating the D layer. However, the VLF wave strength during a flare can either increase or decrease due to wave's interferences, as seen in fig. 4.



F i g. 4. Constructive and destructive interference of waves [5]

Electromagnetic waves from lightning

Lightning discharges produces electromagnetic fields and waves in all frequency ranges. In the extremely low frequency (ELF) range below 100 Hz, the global Schumann Resonances (SR) are excited within the Earth-ionosphere waveguide at frequencies of 7.8 Hz, 14.1 Hz, 20.3 Hz, etc. (fig. 5). Since this important topic (SR) gains great interest in research areas which has extensive use of Schumann resonances in a variety of lightning-related studies, and connections to global climate change and extraterrestrial lightning, it is worth introducing some historical and theoretical background about this relevant topic.

The significance of the research supports the theory that a thunderstorm and its lightning discharges create disturbances in the ionosphere that perturb and distort radio signals and impact communications with orbiting satellites. This suggests that lightning's electric fields enhance electron attachment to molecular oxygen and reduce electron density in the lower ionosphere. Due to the low electron density in the lower ionosphere, active probing of its electron distribution is difficult. Therefore, the perturbative effects from thunderstorms are poorly understood. Theoretical simulations support the theory that tropospheric thunderstorms create ionospheric disturbances through the influence of the electric field associated with the lightning [7].

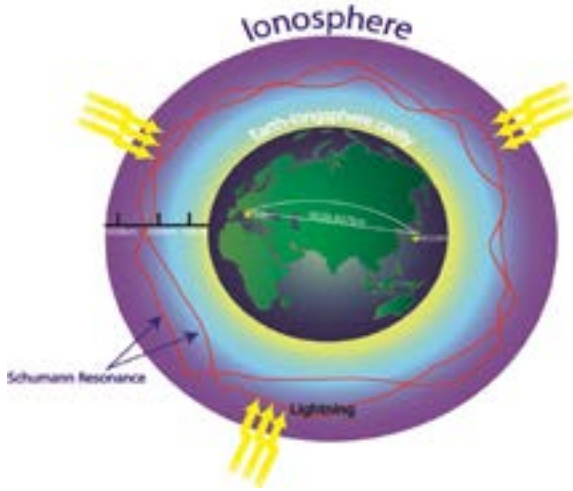
F i g. 5. A thunderstorm and its lightning strokes in the troposphere affect the ionosphere [8]

The history of the Schumann Resonances (SR) is an interesting story. While Schumann gets most of the credit for the first prediction of the existence of the SR, the idea of natural global electromagnetic resonances were first presented by George F. Fitzgerald in 1893, and then again by Nikola Tesla in 1905. However, while others formulated the idea before Schumann, it was Schumann, together with Köning, who attempted to measure the resonant frequencies for the first time, unsuccessfully. It was not until measurements made by Balser and Wagner that adequate analysis techniques were available to extract the resonance information from the background noise [7].

Literature Review

Lightning discharges are considered as the primary natural source of SR. The vertical lightning Channels behave like huge antennas that maximum radiated energy occurs around 10 kHz. Lightning signals below 100 Hz are very weak, and hence the electromagnetic waves from an individual discharge can be propagated a number of times around the globe before decaying into the background noise.

For this reason, the Earth-ionosphere waveguide behaves like a resonator at ELF frequencies, and amplifies the spectral signals from lightning at the resonance frequencies due to constructive interference of EM waves propagating around the globe in opposite directions (see figure6). The resonance peaks occur when the wavelength of the ELF waves is comparable with the Earth's circumference ($\lambda = c/f \sim 40{,}000$ km), with the direct waves resulting in constructive interference at the SR frequencies [7].



F i g. 6. Satellite observations of Schumann resonances in the Earth's ionosphere [10]

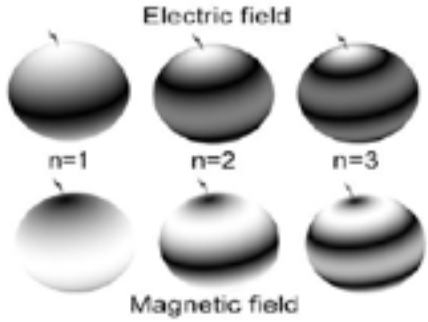
A very rough approximation to describe the properties of the Schumann resonances is an assumption of the ideal conductivity of both the Earth's surface and of the ionosphere E-layer.

Schumann has predicted an extremely low frequency (ELF) resonance in the earth-ionospheric waveguide. The resonance occurs between the electromagnetic wave, generated by lightning and thunderstorm, traveling along ground surface and returning to the starting point. Assuming the perfectly conducting Earth and ionospheric boundaries made of two perfectly conducting concentric spheres separated by a height, which is much smaller than the Earth's radius R_e. Then the resonant frequencies f_n are determined by the Earth's radius and the speed of light c and can be derived from the following relation [7].

$$f_n = (c / 2\pi R_e) (n(n+1))^{1/2}, \quad (1)$$

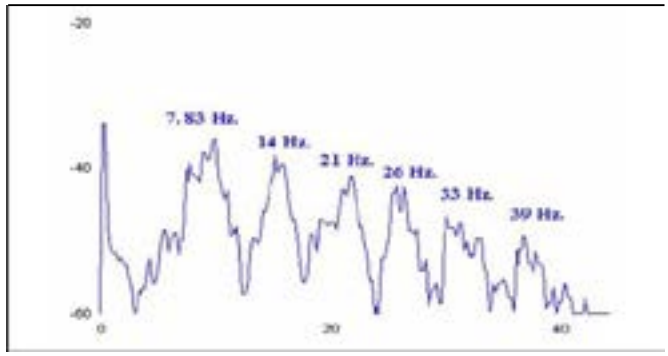
where n is an integer (n = 1,2,3,…), c is the velocity of light and R_e is the radius of earth. According to Eq. (1), the first five resonance frequencies are 10.6, 18.4, 26.0, 35.5 and 41.1 Hz. Even Schumann made these assumptions and arrived at the expected SR first mode of 10 Hz. The Schumann resonances (SR) are a set of spectrum peaks in the extremely low frequency (ELF) portion of the Earth's electromagnetic field spectrum. Schumann resonances are global electromagnetic resonances, excited by lightning discharges in the cavity formed by the Earth's surface and the ionosphere [7].

For a single lightning discharge, the E-field always has a maximum at the location of the flash, while the magnetic field (orthogonal to electric) has a minimum at the same locations, regardless of the mode. This feature follows from the conservation law of the total electromagnetic power which is equally distributed in the cavity, so that a maximum in one field occurs at the minimum of the other field [7]. The resulting fields are shown in fig. 7 for the first three SR modes.



F i g. 7. Electric and magnetic fields of the first three SR modes. White shading implies field maximum, while black shading implies field minimum [7]

The ionosphere is not a perfectly conducting medium and energy losses due to its finite conductivity reduce the resonance frequencies to 7.8, 14.1, 20.3, 26.3 and 32.5 Hz [3–5]. Fig. 8 shows the first seven SR vibrations. The basis, or fundamental, for these resonances is 7.83 Hz (cycles per second), which is a standing wave in the cavity between the ionosphere and Earth [9].

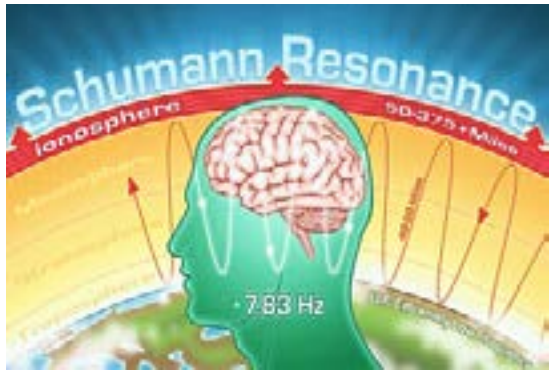


F i g. 8. The fundamental SR [9]

Because this rhythmic pattern lies within the human brainwave range, various authors have speculated that this aspect of the Earth's electromagnetic field may act as a kind of global mind, with the capacity to organize and influence human consciousness. While such speculations may seem farfetched, there is a growing body of scientific evidence suggesting that: The Earth's magnetic field may influence and mediate psychic phenomena. The 7.83 Hz rhythmic pattern (varying from 7 to 8 Hz) plays a significant role in psychic phenomena, DNA formation and physical and mental health in humans [9]

Schumann Resonance-Connection of man with Nature

Schumann discovered that this electromagnetic field oscillates at a resonant frequency of 7 to 10 beats per second. The highest-intensity waves of the Schumann Resonance occur at a frequency of 7.83 Hz. This is the Earth's "heartbeat". How interesting it is that this frequency is identical to the optimal functioning of the human brain waves (fig. 9). All things in this world have their own natural frequency which they are most comfortable with [11].



F i g. 9. SR occurs at a frequency identical to the optimal functioning of the human brain wave [11]

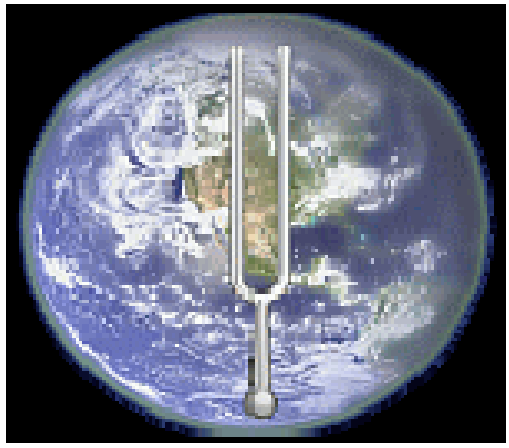
When something is subjected to an external force, that object wants to resonate at its specific frequency (the frequency that is natural to the object). This phenomenon manifests throughout the universe. This natural frequency of a body is known as its "Resonant" frequency and the phenomenon is known as "Resonance". Humans also have many such resonances due to complex cell makeup of our bodies [11].

However, recently unnatural radio waves and electromagnetic waves have been disturbing the Earth's frequency of 7.83 Hz. In industrial regions and cities, this natural field is being disturbed, obstructed, is weak, and may even be missing. This impairs the wellbeing of every living creature in that region (people, animals, and vegetation). It is said that the absence of the Schuman resonance will make living things ill. Although popular literature suggests that the Schumann Resonance value is rising and has jumped from 7.83 Hz to 11 Hz over the past few years, research done at the Northern California Earthquake Data Center proves that the frequency has been and continues to be stable at the 7.8 Hz range. It can be said that the problem is due to all the man-made interference, it is getting harder to accurately measure this signal, since

it can be obscured by electrical noise pollution [11].

Since life began, the Earth has been surrounding all living things with this natural vibration. These naturally occurring Schumann Waves are an essential ingredient of all biological life on Earth. Research seems to suggest that our biological system is "tuned" into the Schumann Frequency of our planet [6]. Scientists have confirmed that these Vibrations are not only an essential ingredient of life, they in fact have shaped our life, and thru the eons of time have determined the frequency spectrum of the human brain. That is to say, the frequencies of these naturally occurring signals in the atmosphere have determined the "evolution" and development of the frequencies of the human brain [6]. This is a very important fact that binds us to the Earth. It is a natural occurrence.

This electromagnetic field has always been there right from the moment of creation. The resonance is essential to the proper functioning of the human brain. All life has evolved with it, and is meant to live in harmony with it. From the basics of "Tuning Fork". If you have two tuning forks, when one tuning fork is struck, the other one will also vibrate at the same frequency. This is due to wave motion resonance. Now think of the Earth as one tuning fork constantly vibrating, and yourself as the other one receiving the resonances (fig. 10). When the Earth is vibrating, it induces a similar vibration in all of us which promotes well-being [11].



F i g. 10. When the Earth is vibrating, it induces a similar vibration in all (people, animals, and vegetation), which promotes well-being [11]

Results

Schumann Resonance Research

Researchers have established a scientific fact that Schumann Resonance is not merely a phenomenon caused by lightning in the atmosphere, but a very important electromagnetic standing wave, acting as background frequency and influencing biological oscillators within the mammalian brain. At the time when Schumann published his research results in the journal "Technische Physik", Dr H. König, a physician, who became Schumann's successor at Munich University, demonstrated a correlation between Schumann Resonances and brain rhythms and found that the main frequency produced by Schumann oscillations is very close to the frequency of alpha rhythms. Dr König carried out further measurements of Schumann Resonance and eventually arrived at a frequency of exactly

7.83 Hz, which is even more interesting, as this frequency is one which applies to mammals. For instance, septal driving of the hippocampal rhythm in rats has been found to have a minimum threshold at 7.7 Hz [12; 14].

Although Schumann Resonance could easily be confirmed by measurements at the time of its discovery, it is no longer so obvious due to our atmosphere being filled with manmade radiation noise at different frequencies. This is almost drowning out the natural signals – signals that have been there through a eons of evolution. It is possible that these signals act like a natural tuning fork, not just for the biological oscillators of the brain, but for all processes of life.

With the advent of new wireless technology, in particular microwaves pulsed at frequencies close to Schumann Resonance as in mobile telephony, another threat is emerging. We may be creating an environment that is literally `out of tune' with Nature itself. And it is at this point that there is an urgent need to understand how everything alive responds to the most subtle changes in magnetic and electromagnetic fields surrounding us. For instance, we need to examine the possible interaction between magnetite crystals within cells and manmade magnetic fields in the environment.

In Brainwave Evolution: L. B. Hainsworth has hypothesized that the electromagnetic frequencies in the Earth-ionisphere cavity have played a governing role in the evolution of human and mammalian brainwave patterns, particularly the Alpha pattern which the Schumann Resonance falls within. Commenting on the unique correlations of Alpha brainwave activity and its relationship to the Earth-ionispheric cavity resonance, Hainsworth has said, "As human beings we have extraordinary potentials we have hardly begun to study, much less understand. Creative gifts, intuitions and talents that are unpredictable or emergent may become stabilized in generations to come. Hopefully, we can learn to understand both our emergence from an essentially electromagnetic environment and facilitate our potential for healing, growth and non-local communication"[13].

In DNA Formation**:** Dr. L. Montagnier conducted an experiment in which he filled two test tubes with pure water and placed piece of heavily diluted bacterial DNA into one of the test tubes. After surrounding both test tubes with a weak electromagnetic field pulsing at 7 Hz for 18 hours, DNA was detectable in the glass that originally had nothing in it but water. It would appear that the 7 Hz played a substantial role in extracting the DNA information from the one test tube and communicating it into the other test tube [13].

In Psychic Communication Phenomena: Dr. M. Persinger has conducted research in which two people in separate rooms were presented with identical magnetic fields at approximately 7 Hz. When one of these individuals drew a picture, the other person could roughly approximate that drawing, even though they were in separate rooms). Further research has shown a strong correlation between geomagnetic activity and psychic phenomena [13].

However, recent collected data brought an evidence suggests that the proliferation of manmade electromagnetic fields has given rise to a kind of electromagnetic chaos that now seems to be affecting the fundamental Schumann Resonance, effectively raising it and adding to the chaos experienced by living systems. If this is the case, it would suggest that (1) Integrating the fundamental Schumann Resonance in human living environments would be beneficial in establishing optimal physical and psychological health; and (2) With the continuing rise of electromagnetic technology, the future health of all living systems seems to necessitate the emergence of an organic technology that can decrease and/or completely reverse the detrimental

effects of synthetic electromagnetic technology [13].

However, there is a great need for independent research into the bio-compatibility between natural and manmade signals. By linking together the potential importance of Schumann Resonance and the dangers posed by manmade pulsed frequencies, it will become apparent that unless we find a way to use bio-compatible signals to power new technology, we may expose all life to dangers previously not encountered. We may have to pay a high price for this shortsightedness. Serious attention must now be paid to the possible biological role of standing waves in the atmosphere, so that we do not overlook the importance of oscillations in nature that may be central to consciousness and life itself [14].

In Communications, when we consider that the ionosphere surrounding our planet is electrically positive charged whilst the earth's surface carries a negative charge, we must conclude that this amounts to a prevailing electrical tension within the earth/ionosphere cavity. This tension is discharged when thunderstorms develop in this cavity. The inside of the ionosphere layer is used in wireless information transfer to bounce off radio waves emitted by transmitters on the earth's surface. In this way the information can be transferred over large distances.

Following Schuman's landmark paper in 1952, there was an increasing interest in SR in a wide variety of fields. Due to the low attenuation of ELF waves in the SR band (~0.5 dB/Mm) it was discovered that not only lightning can produce SR, but any large explosion in the atmosphere will also induce SR transients. Hence, until the ban of atmospheric nuclear explosions in the 1960s, there was great interest in using the SR to monitor nuclear explosions in remote parts of the globe. Another application of ELF waves related to the SR, due to the low attenuations of the ELF waves, was the man-made transmission of these waves for long range communications with submarines. However, due to the extremely long wavelengths at ELF, such transmitters need to be huge (> 200 km length), with huge power outputs due to very low efficiencies of these transmitters [15].

Electromagnetic Field Frequency Memory in Water

There is sufficient evidence that water exposed to electromagnetic (EM) field undergoes structural changes and the water remembers the field memory for extended period of time as discovered by some eminent Scientists. Electromagnetic radiation can be trapped within water molecules in much the same way as electric fields are trapped and stored within the dielectric placed between the two metal plates of a capacitor and treated water with electromagnetic radiation exhibits some memory characteristics [16].

Water consists 70 % of human body. Water reaches every tissue of human body within 30 minutes after drinking. It even flows through blood brain barrier and has almost no side effect. If water itself could work as a radical scavenger, it would be an ideal antioxidant. It was revealed that every matter has its accompanying wave. The wave part of the matter contains Information (called information wave), and can be transferred to water physically by shaking or tapping, and thus serially diluted water have been used to stimulate natural healing power in traditional homeopathy. This way of transferring the wave part of the mater to water has been already demonstrated by Benveniste and researchers [17].

A new electronic device was developed which could replace time-consuming homeopathy to activate water. The device uses 7.8Hz frequency as a carrier which is the resonance frequency of the Earth. Using the device information wave of hormones and other cytokines could be transferred to water and even to other medium like ceramic balls. Information wave of the hormone or cytokine transferred to ceramic balls could be passed

to water indirectly by contacting water. Such water containing information wave of the matter functioned like hormone for human [17].

The human brain is a biological organ and has developed over hundreds of millions of years in the environment that has contained in the Schumann Resonance signal for over 3 billion years. On one hand it is soft, flexible and adaptive, but is relatively stable and coherent with well developed.

Intelligence. In order to retain intelligent thinking in a soft and adaptive organ there needs to be a constant, globally available, synchronization system that continuously stabilizes the brain wave activity. Rapid intelligence and reactions requires an electromagnetic signaling system, supported by a biochemical system. The Schumann Resonance signal provides a brain frequency range matching electromagnetic signal, providing the synchronization needed for intelligence [18].

New scientific research resulted in that humans can get into resonance with the earth and with other organisms via their different body-own electromagnetic fields. Therefore, the electromagnetic waves produced by the human brain are the main field of interest. The investigation of the earth resonance frequencies, called Schumann waves is the key for the new scientific realizations [19].

It was suggested by L. Montagnier that the association of DNA with water is known since the deciphering of its double helical structure by X-Ray diffraction in 1953. However the power of DNA for organizing water seems to go far beyond the direct filling of water molecules within the grooves of the double helix. It was stated by Luc that recently discovered some DNA sequences – so far belonging to pathogenic bacteria and viruses – are able to induce specific structures of Nano metric size in water. When sufficiently diluted in water, these structures are emitting a spectrum of electromagnetic waves of low frequencies (ranging from 1,000 to 3,000 Hz). This is a resonance phenomenon which is dependent on excitation by very low frequency electromagnetic waves, usually provided by the ambient background. In agreement with recently obtained evidence that some specific DNA sequences can be transmitted through waves in water. This raises the interesting possibility that living structures are able to communicate through waves [20].

For such theoretical considerations, there are already medical applications of the phenomenon: In the blood of patients suffering of chronic diseases, electromagnetic signatures of DNA from infectious microorganisms remaining in a latent state can be detected. In the case of HIV/AIDS, the DNA signature appears after antiretroviral therapy, revealing a niche of the virus resistant to this treatment [20].

Discussion and Conclusions

Schumann (global) electromagnetic resonances in the cavity Earth – ionosphere play a critical role in all biological evolutionary processes. However, there is a great need for independent research into the bio-compatibility between natural and manmade signals. Serious attention must now be paid to the possible biological role of standing waves in the atmosphere, so that we do not overlook the importance of oscillations in nature that may be central to consciousness and life itself. Being a global phenomenon, Schumann resonances have numerous applications in lightning research.

SR is one of the most promising tools in a variety of fields related to lightning electromagnetics, earthquakes, and impacts of extra-terrestrial disturbances on the Earth-ionosphere cavity. SR can also provide a global geo-electric index for monitoring global climate change parameters such as land surface temperature.

Since electromagnetic skin depth in Earth depends on frequency and conductivity, SR can be used as a tool for conductivity studies which is sensitive to mineral composition, salinity, temperature, fluids, water, and melt, and for other

suitable Earth targets. The discovery of Schumann resonances in the Earth's ionosphere offers new remote sensing capabilities for the detection of similar phenomena at other planets and moons of the solar system with ionospheres.

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