Is a Living System a Macroscopic Quantum System?

Cyril W Smith
Department of Electronic and Electrical Engineering
University of Salford, Salford M5 4WT, England.

Abstract

The development of the concept of coherence in biological systems is introduced through a summary of the work of Herbert Fröhlich. Those experimental aspects and consequences of coherence in living systems are presented which seem relevant to the recent developments in the understanding of the physics of water through quantum field theory.

Introduction

In the introductory chapter to his second "Green Book"[1], Fröhlich tells the history of his interest in the relations between theoretical physics and biology. In 1938, he first became aware that a biological membrane supported an electric field of 10 MV/m, which from his work on dielectrics he realised was in the forefront of electrical insulation technology. Having learned that a single idea does not produce a theory, he also estimated that the likely resonant frequency of a biological membrane was in the millimetre wave region of the electromagnetic spectrum, a frequency of the order of 100 GHz. From his work on superconductivity in 1968, he could postulate that a long range phase coherence in the frequencies of oscillations in active biological systems would account for the order present in them.

Research on the millimetre-wave spectroscopy of many biological systems was published by Devyatkov in 1974. It showed effects that were strongly frequency dependent, little dependent on the power, but significantly dependent on the time of irradiation—all factors consistent with the involvement of coherent excitations. Fröhlich was aware that physical order can express itself not only in spatial order but also in motional order. For example, in superfluid helium this order is expressed in terms of macroscopic wave functions, which impose a very subtle correlation on the equations of the motion of the helium atoms such that no disorder exists.

With these working hypotheses, he set out to investigate the possible role of phase correlations and coherence in biological materials. In 1972, he published a paper in which he considered the equations of motion for the interaction of two electric harmonic oscillators and showed that coherent excitations and long range interactions could arise if certain particular low-lying modes were excited with a sufficient number of quanta.

In Cooperation with Herbert Fröhlich

It was at about this stage in his work that I commenced my cooperation with Herbert Fröhlich. He had become interested in my work on the dielectric properties of biological molecules and materials.[2] Preliminary measurements had shown that moist proteins behaved like moist ferroelectrics. Humidification by exposure to water vapour gave different effects from those following the addition of an equivalent amount of liquid water, the first indications we had of the future importance of structural and memory effects in water.

Although according to conventional bio-physics there should not be any significant magnetic field interactions with biological dielectrics or water, a large anomalous magnetic effect was found in enzyme systems. Further experiments confirmed that diamagnetism was definitely involved and that the effect was 10^3 times higher than expected.[3] The effects disappeared above certain critical magnetic field strengths and with sterile materials and conditions, which eliminated any live enzyme substrate. Fröhlich was clear that this diamagnetic effect could only arise from the equivalent of a superconducting ring present in the living biological system and that this implied long range correlations and order, although not necessarily a zero-resistance phenomena. A suitable analogy would be in the properties of superconducting colloidal mercury, where the colloidal particles are smaller than the Debye length.

Is a Living System a Macroscopic Quantum System?

The measured activity of the enzyme lysozyme was found to be affected by weak magnetic fields. The enzymatic substrate used for its turbimetric assay is the *Micrococcus lysodeikticus*. In spite of using an assay protocol alleged to produce cell fragments, the substrate cells were not killed and the measured lysozyme activity was found to depend upon the available nutrition, the phase of the cell cycle, the geomagnetic field, and the wavelength and intensity of the spectrophotometer illumination. The lysozyme solutions appeared to be able to "remember" for long periods the electromagnetic fields to which they had been exposed.[4] A delay time for the onset of lysis was observed, a factor consistent with the need for a build-up of coherent oscillations. The reaction could be stopped by exposure to proton magnetic resonance conditions and restarted if they were removed.[5]

Nuclear magnetic resonance (NMR) involves the quantised nuclear angular momentum (unlike cyclotron resonance which is a phenomenon of classical physics). During *in vitro* experiments on bovine eye lenses, it was found that sub-capsular cataracts in the posterior cortex of the lens developed at very low intensities of microwave radiations if these were modulated at a frequency which satisfied proton magnetic resonance in the ambient magnetic field.[6] This result related a disease condition to a phenomenon in quantum physics.

The onset magnetic field strength for effects involving this lysozyme-substrate reaction was found to correspond to a single quantum of magnetic flux linking the measured cross-sectional area of the cells of *Micrococcus lysodeikticus*. Fröhlich immediately pointed out that while in superconductors the magnetic flux is quantised in units of Planck's constant divided by twice the electronic charge ($h/2e = 2.07$ fWb),[7] Felix Bloch had shown that flux quantisation is not restricted to superconductors, but in fact it is a completely general property of all materials. The reason that it is not usually observed is due to the small energy differences in neighbouring flux quantum numbers compared to thermal energy at ambient temperatures unless one is dealing with micron-sized systems such as are found in biology. The minimum dimensions of the coherence domains within such a system are determined by the threshold electromagnetic fields or else by flux quanta.[8]

At Salford University, I had set up a degree course in biomedical electronics which eventually produced graduates competent in the experimental techniques of biology an well as electronics. Some of these did their graduate research in my laboratory, which was set up for experimentation in electronics and cell biology under sterile conditions. With *Escherichia coli*, both the mean generation time and indole production were found to be affected by alternating ELF magnetic fields in a period manner with the field strength. Both the onset field strength and its periodicity corresponded to integer numbers of magnetic flux quanta linking the measured cell cross-section. The chance of the observed periodicity appearing at random in these experiments was one in two million.[9]

At the time that we were finding various effects relating to single flux quantum conditions, Fröhlich remarked that if a system is able to respond to a single magnetic flux quantum, then it has the necessary coherence to show the Josephson effect, a frequency-voltage interconversion at approximately 500 MHz/mV (= 2e/h) even at room temperature. In conductivity measurements on lysozyme solutions, there had been effects in which voltage steps appeared on current-voltage recordings.[10] On irradiating this system with the frequency calculated from the step voltage and the Josephson conversion factor, the DC conductivity immediately changed by an order of magnitude.

This result encouraged us in the search for radio-frequency emissions from actively dividing cells. We were concluding some dielectrophoresis experiments on yeast cells, *Saccharomyces cerevisiae* (normal diploid strain). Dielectrophoresis experiments involve collecting the cells at point electrodes under the electric field gradient of an applied alternating voltage. These had been used to demonstrate effects of NMR conditions on cell dielectrophoresis.[11] Voltage steps had been found in voltage-current measurements between the electrodes when the cells were attached; these steps appeared around one mean generation time after the culture had been started into synchronous cell division. The experimental conditions had to be adjusted so that the frequency of any Josephson emission would come within the range of the available spectrum analyser. Radio-frequency emissions were eventually detected after about four hours of incubation in darkness. They appeared at the time of cytokinesis and were in the region of the corresponding Josephson frequency of eight MHz. The bandwidth of the emission was initially about one MHz, but over a few minutes it narrowed to a minimum of about 50 Hz, a value corresponding to the Poisson distribution for coherent 8-MHz quanta, then it broadened again and disappeared.[12]

This was the last of the work done in our laboratory using cell cultures; it was done in 1983 on borrowed time. The book *Electromagnetic Man*[13] was written between 1984 and 1989. British universities had come under ever increasing financial pressure from the government since 1981, and it soon became necessary for us to encompass a different area of research (organic thin films) in order to survive at all. However, it remained possible to continue work on the fundamental properties of water using a different experimental approach as described later and to continue cooperation with Herbert Fröhlich until only a few weeks before he died on January 23, 1991.[14]

Electromagnetic Hypersensitivity

Since 1982 we had regularly cooperated with clinicians particularly in London, England, and Dallas, Texas, on the investigation and treatment of patients suffering from electromagnetic hypersensitivity,[15] the existence of which has been confirmed through double-blind trials.[16] Electromagnetic hypersensitivity appears to be the result of a failure in some patient-specific regulatory system and usually involves the autonomic nervous system. It is usually found in patients who have already suffered chemical damage leading to a chemical hypersensitivity condition. Of present relevance is that their hypersensitivity extends to frequencies of vector potential in their environment and to frequencies imprinted into water or some other potentisable medium, the equivalent of a homoeopathic remedy; such sensitivities are only explicable in terms of macroscopic quantum effects.

Magnetic Fields and Vector Potentials

Electric charge in motion generates a *magnetic field* in the space surrounding it. This follows from the theory of special relativity. If electric charge is accelerated (or decelerated) as can be done with an electrical oscillator, quanta of energy at the frequency of the fields travelaway at the velocity of light. This is *electromagnetic radiation* and the three quantities, electric field, magnetic field, and velocity are mutually perpendicular in (free) space.

There is yet another component to be considered. This is the *vector potential*, a potential function which is also a vector. It originally appeared in physics as a mathematical necessity to cope with the fact that magnetic fields always occur as closed loops with no free ends. It combines the electric field component as its time derivative with the magnetic field component as its 'curl'. Thus a changing vector potential induces an electric field which is what happens in an electrical transformer while a toroidal coil contains the magnetic field within the torus but generates a vector potential in the surrounding space in the direction of the current flow. In a quantum system the vector potential appears directly in the wave equation where it can behave like a chemical potential. It is capable of producing effects through this quantum field pathway even if its electric and magnetic field components are shielded.

We have long been advocating the use of a toroidal coil in biological experiments as a way of providing comparison with the magnetic fields generated by the usual Helmholtz or solenoidal coils to determine whether a given biological system is in classical or quantum physics. One such set of experiments by Mae-Wan Ho and her co-workers involving weak external magnetic-field-induced abnormalities in pattern formation in *Drosophila* embryos led them to remark that,

> "...The results with the toroidal coil are quite tantalizing. Despite the fact that the magnetic field is negligible, significant increases in abnormalities are found over matched controls, and both when the embryos are in place before or after the power supply is switched on...Our results suggest that indeed, the embryos may be sensitive to the vector potential in an essentially field-free region... The Aharonov-Bohm effect is so fundamental that it would require a great deal more experimentaton under most stringent conditions to be able to establish it for bio-

Is a Living System a Macroscopic Quantum System?

logical systems. If it is eventually confirmed, it would be by far the most definitive proof that the embryonic field is a highly coherent macroscopic quantum domain."[17]

Water Memory, Homoeopathy, and Long Range Order

We extended the techniques of dowsing to make the dowser into an inexpensive scientific instrument capable of detecting a vector potential and of measuring frequencies imprinted into water. Eventually, it was found to be possible to measure frequencies imprinted into water by electronic instrumentation and to identify the difficulties encountered as being in the conversion of what is a quantum field resonance into a time-varying voltage or current that electronic circuits will recognise.[18] The frequencies measured by instrumentation were exactly those found by the subjective dowsing technique. To adequately investigate resonances in living systems and homoeopathic potencies, it would be necessary for any instrumentation to cover all frequencies from millihertz to optical frequencies.

The Andreev reflection of coherence[19] should take place at a coherent water-to-metal interface and would give rise to a change in its electrical resistance. The small offset current at the input of a directly coupled preamplifier might convert this resistance change into a voltage signal without destroying the coherence. This might be one physical basis for the measurement of frequencies imprinted into water and homoeopathic potencies, and might also account for the resistance changes measured in electroacupuncture.

All living systems from human to single cells, have their own pattern of frequencies characterised by a degree of quasi-periodic variability.[20] The resonances may stimulate the frequency activity or depress it. In general, the lowest and highest frequencies are stimulatory, and the others alternate. The stimulatory frequencies are the therapeutic ones, the depressive frequencies are stressful.

With the above subjective technique, we found that for imprinting a frequency into water (*potentisation*), it is the alternating vector potential which carries the frequency information. However, a magnetic field is also needed to format the water to enable it to accept this vector potential information. Alternately water may be formatted by a mechanical shock wave (*succussion*, in homoeopathic parlance).[21] The lowest frequency that can be imprinted depends on the available volume of water.

This coherence of an imprinted frequency propagates as a slowly travelling wave with a velocity of the order of metres per second, which is dependent on the medium. Its propagation does not require a closed conducting circuit, but rather it is analogous to the propagation of heat (incoherence) along a metal bar. The velocity has been measured by a Fizeau type of experiment. Critical angles of total internal reflection were measured; these were in close agreement with the values calculated from the velocities of propagation in the media on either side of the interface.[22]

An Aharanov-Bohm effect was found for the electron and proton magnetic resonance signals in tubes of water either side of a solenoid. The phase of the detected signal reversed regularly in proportion to the current in the solenoid.[23]

The continued presence of the normal geomagnetic field is necessary for the retention of the imprinted frequency information in water (or homoeopathic potencies - liquids, pills, or tablets). Magnetically shielding a specimen by placing it in a steel (or mumetal) box with a good overlapping lid will immediately and completely erase all imprinting.

An absolute calibration of a vector potential from a coil or toroid can be carried out by determining the position for a null reaction between the coil and a wire of finite length carrying the same current that can be calculated. The local value for the geo-vector-potential has also been determined by this method. It seems to act as the environmental reference for the phase of the resonances imprinted into water.

Potentisation will transfer slowly by contact between water and water or between water and a metal without succussion. The time taken for the frequencies to imprint varies inversely with the frequency.[24]

Characteristic Resonances

Any oscillating charge, such as an atomic oscillator, generates a vector potential along its axis of motion. Any passive resonator such as an inductance-capacitance circuit or a microwave resonator can be stimulated by a vector potential alternating at its resonant frequency.

A chemical substance carries a characteristic frequency imprint or resonance, which is not erased if the geomagnetic field is shielded. An element has a single frequency; a simple compound like sodium chloride has three frequencies. More complex substances may have more frequencies. The frequencies seem to represent the chemical's ability to interact with traces of water, as, for example, through hydrogen bonds. For the n-aliphatic series, increasing the chain length extends the resonances to higher frequencies—the opposite of a balls-on-string model. If n-hexane is dried with silica gel, all the resonances disappear and only return when the water content reaches 14 ppm.

No frequency resonance was found for pure deuterium oxide (heavy water) nor for the completely chlorine substituted octachloronapthalene; nonachlorobiphenyl had one frequency resonance; heptachlorobiphenyl had three; hexachlorobiphenyl had five; tetrachlorobiphenyl has seven frequencies; trichlorobiphenyl may have three or five depending on the isomer; dichlorobiphenyl may have five or seven depending on the isomer; biphenyl itself had eleven frequencies.

We have obtained encouraging results using the frequency imprint for identification of toxic chemicals incubated with T-lymphocyte cell cultures and for the possible chemical toxic loading of electromagnetic hypersensitivity patients.[25]

We have carried out some experiments in the Graz, Austria, laboratory of Dr. Christian Endler[26] who prepared for us a series of potencies of thyroxin from D5 to D30. The D5 potency had only the frequency 0.07 Hz; each successive potentisation of the thyroxin added two more frequencies to those in the previous potency, one of each phase. The D30 potency contained all the frequencies of the D29 plus 7.8 MHz and 9.1 MHz. Tadpoles tested with a source emitting frequencies of a thyroxin potency showed more tendency to approach it than when there was no emission and showed more avoidance when tested with harmonics of the 50 Hz power supply.[27]

A long-range coherence interaction extending to 10-metre separation was found between pairs of tadpoles which had been synchronised to a common frequency pattern. Not only did the tadpoles need to be kept in optical contact, but interposing an optical filter with a cut-off above 550 nm would break the coherence. Similar effects were found between aliquots of frequency-imprinted water; in this case the long-range coherence only extended to distances of a few metres.

A resonance at the microwave oxygen lines (60 GHz) was found in water measurements which disappeared when the water was boiled to de-aerate it. The resonator containing the water had a glass plate separation corresponding to a half-wavelength at 2.5 mm; this is the free space value corresponding to 60 GHz. It shows that the refractive index of water was not involved so that the whole of the water must have been interacting as a single coherent entity.[28]

Macroscopic Quantum Properties of Water

These results do not fit the concepts of classical physics, which pictures electrons as small charged spheres moving at random under thermal agitation. In classical physics there can be no chemistry, and the only bio-effects will be thermal ones. Quantum physics adds a combined wave-particle description, and motion is seen in terms of allowed energy levels. The quantum concept was first introduced to explain atomic spectra. It is now needed to explain the many non-thermal interactions between radiation, water, and living systems, which are themselves mostly water.

Recent work on condensed matter (i.e. matter not in the gas state) by Preparata, Del Giudice, and co-workers has shown that coherence is a fundamental physical property of liquid water.[29] When water vapour is compressed it suddenly liquifies with a thousand-fold reduction in volume. To explain this, it is necessary to find the attractive force that produces the highly directional hydrogen bonds. Qualitatively, their argument goes like this.

1. Water is only weakly ionised (pH = 7), and any electrostatic forces would be masked by ions.
2. Water is very weakly magnetic and diamagnetic, which would yield only weak repulsive forces.
3. This leaves only the radiation interactions.

Is a Living System a Macroscopic Quantum System?

Analysing the interactions of an electromagnetic radiation field at the frequencies of the water vapour spectrum, Preparata found that if the vapour density is above a certain critical value, a very large coherent electromagnetic field of 84 GV/m at that frequency appears within the water vapour, which yields the necessary force of attraction for the water vapour to condense to a liquid.

This theory is based on quantum electrodynamical (QED) coherence and presents a picture of water as a completely ordered dynamical structure consisting of two distinct phases interspersed:

(a) an ice-like coherent phase consisting of coherence domains of water molecules all oscillating together coherently with an internal classical electromagnetic field from which develop attractive forces. These domains should have a spin and align themselves in the geomagnetic field but will not be penetrated by magnetic fields nor by any non-coherent molecules or particles.

(b) an incoherent (random) phase of water packing the spaces between these domains, having gas-like properties accounting for the thermodynamical properties, and containing all the ions and solutes.

The 84 GV/m coherence field giving rise to these domains has a wavelength corresponding to the 12.06 eV spectral line of water vapour. This is the 5-d transition from the ground state, which happens to give the smallest critical water vapour density at which the evolution of coherence domains can begin. At a temperature of 0 K these domains would be 75 nm. At the ambient temperature of 300 K they would be 50 nm, and the portion of incoherent water would then be 28%. Radiation becomes trapped within the coherence domains by total internal reflection. Frequency information could be stored as quantum field phase-coherence within clusters of these domains.

The physical accuracy of this model is demonstrated by its correct prediction of various physical constants for water.[30] The predicted critical volume is 57 cm^3/mole, which is close to the experimental value of 55.61 cm^3/mole. The predicted latent heat of vaporization is 40.8 kJ/mole, which is close to the experimental value of 40.3 kJ/mole. The anomaly in the specific heat and compressibility of supercooled water at -43 °C (230K) is correctly predicted. The temperature dependence of the specific heat and the relative density are in close agreement with experiment. The 4°C maximum density anomaly is explained qualitatively. Recent observations of like-charge attractions in metastable colloidal systems is explained by coherence among their surface electrons and suggests that similar mechanisms may exist on the membrane surfaces of living cells.[31]

Conclusions

A macroscopic quantum system is characterised by the microscopic effects of quantisation of energy and momentum at the atomic level extending into the macroscopic domain, showing long-range order effects outside classical physics, which are nonlinear, discontinuous, and describable in terms of a wave function or order parameter. They are strong effects, but they only weakly couple to electromagnetic fields and thus behave as if at a very low temperature; the vector potential appears to be the coupling pathway.

The experimental evidence for the existence of macroscopic quantum effects in living systems as described above suggests that the important features to be looked for are:

1. Water and living systems should be sensitive to a single quantum of magnetic flux, equal to Planck's constant divided by twice the electronic charge $h/2e = 2.07$ fWb).
2. Interactions between coherence domains should involve the Josephson effect yielding a voltage/frequency interconversion of approximately 500 MHz/mV (the reciprocal of the flux quantum).
3. There should be a sensitivity to the vector potential, which can interact through its involvement in the phase of the wave function, the Aharanov-Bohm effect.
4. The storage of frequency information occurs within the time domain as phase coherence.
5. The control of chemical reactions occur through the vector potential and chemical potential.

The outstanding experimental problems to be solved are the provision of more convincing evidence through objective instrumentation; a full theoretical explanation is likely to emerge. The implications of this explanation are: a deeper understanding of chemical and biological control mechanisms in living systems, improved diagnosis and therapy in the management of health and disease, and the possibility of inducing bio-effects at zero environmental electric, magnetic and electromagnetic fields through the interaction of the vector potential component.

References

[1] Fröhlich, H., 1988. *Theoretical Physics and Biology*. In: Fröhlich, H. (Ed.). *Biological Coherence and Response to External Stimuli*. Berlin: Springer-Verlag, 1-24.

[2] Smith, C.W., 1988. *Electromagnetic Effects in Humans*. In: Fröhlich, H. (Ed.). *Biological Coherence and Response to External Stimuli*. Berlin: Springer-Verlag, 205-232.

[3] ibid.

[4] ibid.

[5] Aarholt, E., Jaberansari, J., Jafary-Asl, A.H., Marsh, P.N., Smith, C.W., 1988. *NMR Conditions and Biological Systems*. In: Marino AA (Ed.) *Modern Bioelectricity*. New York: Marcel Dekker, 75-104.

[6] ibid.

[7] Fröhlich.

[8] Smith, C.W. 1989. *Coherent Electromagnetic Fields and Bio-Communication*. In: Popp F-A, Warnke U, König HL, Peschka W (Eds.). *Electromagnetic Bio-Communication*. Munich, Baltimore: Urban & Schwarzenberg, 1-17.

[9] Smith, C.W., 1988.

[10] Del Giudice, E., Doglia, S., Milani, M., Smith, C.W., Vitiello, G. 1989. Magnetic flux quantization and Josephson behaviour in living systems. *Physica Scripta* 40: 786-791.

[11] Smith, C.W. 1989.

[12] Smith, C.W., Jafary-Asl, A.H., Choy, R.Y.S., Monro, J.A. 1987. *The Emission of Low Intensity Electromagnetic Radiation from Multiple Allergy Patients and other Biological Systems*. In: Jezowska-Trzebiatowska B, Kochel B, Slawinski J, Strek W (Eds.). *Photon Emission from Biological Systems*. Singapore: World Scientific, 110-126.

[13] Smith, C.W., Best, S. *Electromagnetic Man: Health and Hazard in the Electrical Environment*. London: Dent, 1989,1990; New York: St. Martin's Press, 1989; Paris: Arys/Encre, 1995 (French); Bologna: Andromeda, 1997 (Italian).

[14] Smith, C.W. 1991. A Voyager of Discoveries, *Electromagnetics News* 2(1): 6-7. (P.O. Box 25, Liphook, GU30 7SE, U.K.).

[15] Choy, R.Y.S., Monro, J.A., Smith, C.W. 1987. Electrical Sensitivities in Allergy Patients. *Clinical Ecology* 4(3): 93-102; Smith, C.W., Choy, R.Y.S., Monro, J.A. 1990. The Diagnosis and Therapy of Electrical Hypersensitivities. *Clinical Ecology* 6(4): 119-128.

[16] Rea, W.J., Pan, Y., Fenyves, E.J., Sujisawa, I., Suyama, H., Samadi, N., Ross, G.H. 1991. Electromagnetic Field Sensitivity. *J. of Bioelectricity* 10(1&2): 241-256.

[17] Ho, M-W., French, A., Haffegee, J., Saunders, P.T. 1994. *Can Weak Magnetic Fields (or Potentials) Affect Pattern Formation?*. In: Ho, M-W., Popp, F-A., Warnke, U. (Eds.). *Bioelectrodynamics and Biocommunication*. Singapore: World Scientific, 195-212.

[18] Smith, C.W. *Electromagnetic and Magnetic Vector Potential Bio-Information and Water*. 1994. In: Endler PC, Schulte J (Eds.). *Ultra High Dilution: Physiology and Physics*. Dordrecht: Kluwer Academic, 187-202.

[19] van Wees, B., 1996. Superconducting semiconductors. *Physics World* 9(11): 41-45.

[20] Smith, C.W. 1995. Electromagnetic aspects of biological cycles. *Environmental Medicine* 9(3): 113-118.

[21] Smith, C.W., 1994.

[22] Smith, C.W. 1994. Coherence in Living Biological Systems. *Neural Network World* 3: 379-388.

[23] Smith, C.W. 1995. Measurements of the Electromagnetic Fields Generated by Biological Systems. *Neural Network World* 5: 819-829.

[24] Smith, C.W. 1994. Coherence in Living Biological Systems. *Neural Network World* 3: 379-388.

[25] Smith, C.W. 1997. *Basic Bioelectricity; Bioelectricity and Environmental Medicine*. 15th. Intl. Symp. on "Man and His Environment in Health and Disease", Dallas Texas, February 20-23, 1997. (Audio Tapes from: Professional Audio Recording, 2300 Foothill Blvd. #409, La Verne, CA 91750, U.S.A.).

[26] Smith, C.W., Endler, P.C. 1994. *Resonance phenomena of an ultra high dilution of thyroxin - Preliminary results*. In: Endler, P.C., Schulte, J. (Eds.). *Ultra High Dilution: Physiology and Physics*. Dordrecht: Kluwer Academic, 203-207.

[27] Spoerk, K., Pongratz, W., Endler, P.C. 1994. *Effects of typical thyroxin related frequencies on anaphilia - Preliminary results*. In: Endler PC, Schulte J (Eds.). *Ultra High Dilution: Physiology and Physics*. Dordrecht: Kluwer Academic, 215-218.

[28] Smith, C.W. *Electromagnetic and Magnetic Vector Potential Bio-Information and Water*. 1994. In: Endler.

[29] Del Giudice, E., Doglia, S., Milani, M., Vitiello, G. 1988. *Structures, Correlations and Electromagnetic Interactions in Living Matter: Theory and Applications*. In: Fröhlich, H. (Ed.). *Biological Coherence and Response to External Stimuli*. Berlin: Springer-Verlag, 49-64; Preparata, G. 1995. *QED Coherence in Matter*. Singapore: World Scientific; Del Giudice, E., Preparata, G. 1994. Coherent Dynamics in Water as a Possible Explanation of Biological Membranes Formation. *J. of Biological Physics* 20: 105-116.

[30] Preparata, G. 1995.

[31] Del Giudice, E., Preparata, G. 1997. *Electrodynamical Like-Charge Attractions in Metastable Colloidal Crystallites*. Milan: University of Milan, Dept. of Physics, Publ. MITH-97-2 (Accepted for publication in Modern Physics Letters B).