

# New insights into electromagnetic processes in water

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**Abstract.** Many biological processes operate on the water ion-H<sub>2</sub>O molecule structure. Consequently, it is important to understand the mechanism influencing this structure. The present study reveals that low frequency electromagnetic energy enforces resonance in water, thereby enforcing a (frequency) specific ion-H<sub>2</sub>O molecule structure. Water is a dielectric medium and can therefore be described using the theoretical model of an oscillator. This was confirmed by measurements on water salt solutions. Thus, water and some biological processes operating on water can be described, measured and influenced in a precise way, according to the laws of electrodynamics. The study describes a technique to measure the characteristics of water *in vitro* and *in vivo*.

*Key words:* resonance in water, water molecule structure, ELF resonance

## Introduction

Biological effects ascribed to electromagnetic energy gain increasing interest. The cell is often regarded as a protected Faraday cage [1]. Electromagnetic processes on cell level is often described as (quasi) static, hyperpolarization, depolarization, potentiated field-induced and rectifying current effects on ions (e.g. Ca<sup>2+</sup>, K<sup>+</sup>, Na<sup>+</sup>) [2-6] causing ions to cluster and drift through ion channels [7-10], the water channel [11] or operate on receptors [12-14]. EM (electromagnetic) processes are often described as the physical position of atoms (ions) relative to cells. A phenomenon can have many views and the above mirrors one view. However, a physicist can raise questions. Electrons are seldom present in this context, although the human body is full of electrons. In electrostatics and electrodynamics EM processes are represented by laws and equations describing

the exact relationship between charge and EM energy [15-18], not by positioning of atoms or ions. One very relevant question is whether EM processes on cell level are (quasi) static?

The present study proposes that a number of biological processes can be tracked to the EM characteristics of the water ion-H<sub>2</sub>O molecule structure. However, here arises a problem. It is impossible to analyze these EM processes based on simplified electrostatics theory as mirrored by state-of-the-art bioelectromagnetics. The author would like to clarify his view that some biological processes and important aspects of bioelectromagnetics are impossible to understand unless comprehensive electrostatics and electrodynamics theory is used.

Water has charge (the ions), mass (the atoms) and elasticity (the hydrogen bond) [19-21] and thus water is a dielectric medium. A dielectric medium can be

described as a forced damped oscillator according to Melrose and McPhedran [15], and which is described by its theoretical model and by mathematical equations [15-17]. Consequently, it should be possible to relate the ion-H<sub>2</sub>O molecule structure and biological processes operating on this structure to an exact EM process.

**Aim of study.** The aim is to describe water by a theoretical model and mathematical equations and where this model explains and facilitates measurement of EM processes in different types of organisms, cells and fluids, including human cells. More specifically, the following hypotheses are to be tested:

**Hypothesis 1.** Water can be described by the theoretical model of the forced damped oscillator implying that the characteristics of water can be described by equations and laws of electrostatics and electrodynamics. The present study describes how this is verified by a number of experiments performed on water salt solutions.

**Hypothesis 2.** Applied EM energy enforces and maintains resonance in water *in vitro* and *in vivo* and this process can be described by mathematical equations. This implies that water and biological processes operating on water can be measured, characterized and influenced with high precision. This is verified in the present study by measurements on salt solutions.

The theoretical model is central in the present study. The methodology and the experiments have been selected accordingly.

### Theoretical model

The essence of the present study can be summarized in the following simplistic way. Water contains ions (charge), connected to H<sub>2</sub>O molecule structures (mass) via hydrogen bonds (elasticity), Fig. 1. External alternating EM energy generates an alternating force on the ions; it makes the ions oscillate and which makes the ion-H<sub>2</sub>O molecule structure oscillate. The ion-H<sub>2</sub>O molecule structure is a mechanical resonance system consisting of mass and elasticity, equivalent to the classical mass connected to a spring.

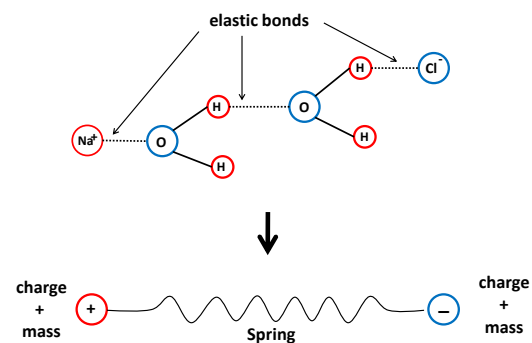


Figure 1. Theoretical model of resonance in water ion-H<sub>2</sub>O molecule structures. Water is a dielectric medium consisting of charge (the ions), mass (the atom weight) and elasticity (the hydrogen bond).

Water contains angular molecules having a negative charge ( $\delta^-$ ) on the oxygen atom and positive charges ( $\delta^+$ ) on the two hydrogen atoms. Hydrogen and oxygen atoms are joined by a single covalent bond consisting of an electron pair. Due to differences in electronegativity, the electrons are more attracted to the oxygen atom than the hydrogen atom. This creates a small residual or partial charge on the atoms [19] thus creating polarity in the water molecule. The polarized ends of a water molecule create a force between the water molecules called hydrogen bond [19], which is a special case of electrostatic dipole-dipole interaction [20] and this bond is elastic following Coulomb's law of force between charges  $q_1$  and  $q_2$  having the distance  $r$  [17]:

$$F = q_1 q_2 r / 4\pi\epsilon_0 r^3 \quad (1)$$

A large number of ionic substances can be dissolved in water as a result of the polarity of the water molecule. For example, sodium chloride, NaCl, dissolves in water with Na<sup>+</sup> attracted to  $\delta^-O$  and Cl<sup>-</sup> to  $\delta^+H$  [19]. Ions, such as Na<sup>+</sup>, are hydrated [21] because the ions are surrounded by a number of water molecules forming an inner and an outer hydration shell (solvation shield).

In the present study water is described as a dielectric medium having charge (the ions), mass (the atoms) and elasticity (the hydrogen bonds). According to Melrose and McPhedran [15] a dielectric medium can be described by the classical model based on a forced damped oscillator and consequently, that model was used in the present study. The classical forced damped oscillator

corresponds to a mass  $m$  with a charge  $q$  at a displacement  $\mathbf{X}(t)$  from its mean position. The frequency of the oscillator is  $\omega_0$  and it is damped with the decay constant  $\gamma$ . The oscillator is assumed to be enforced by an electric field  $\mathbf{E}(t)$ . The equation of motion [15] is:

$$\mathbf{X}''(t) + \gamma \mathbf{X}'(t) + \omega_0^2 \mathbf{X}(t) = q \mathbf{E}(t)/m \quad (2)$$

The mass oscillates at its natural frequency  $\omega_0$  at a small decay constant  $\gamma$ , where  $k$  is the spring constant [16]:

$$\omega_0 = \sqrt{k/m} \quad (3)$$

The absorbed current amplitude  $I(\omega)$  of the damped oscillator as a function of the frequency  $\omega$  of the electric field  $\mathbf{E}(t)$  ( $\Omega$  is a constant) [15] is:

$$I(\omega) = \Omega \gamma / ((\omega_0 - \omega)^2 + \gamma^2/4) \quad (4)$$

The quality factor  $Q$  is calculated based on the natural frequency  $\omega_0$  and the decay constant or damping  $\gamma$ , which is equal to the full width at the amplitude  $I(\omega_0)/\sqrt{2}$  in Eq. (4) [16]:

$$Q = \omega_0/\gamma \quad (5)$$

At the natural frequency  $\omega_0$ , the impedance  $Z$  of the oscillator [17] is:

$$Z = \text{constant} \cdot \gamma \quad (6)$$

According to the theoretical model, water can be described as a large number of parallel oscillators (i.e. ion-H<sub>2</sub>O molecule structures), where the number of oscillators is proportional to the water volume having resonance. Thus, water is described by its admittance. The admittance  $Y$  of  $n$  parallel-coupled oscillators each having the impedance  $Z$  [17] is:

$$Y = \Sigma 1/Z \quad (7)$$

According to Ohm's law [17]:

$$I = U/Z \text{ or } I = U \cdot Y \quad (8)$$

In the present study, the level of  $k$  (the spring constant) was used as a measure of the elasticity of the hydrogen bonds. The oscillator's natural frequency  $\omega_0$  was determined by its mechanical properties  $k$  and  $m$ , where  $m$  was the mass of the H<sub>2</sub>O molecules plus the ions involved in a particular resonance mechanism or resonance mode. The spring constant  $k$  (the elasticity of the hydrogen bond) is, according to the

theoretical model, Fig.1, proportional to the force  $\mathbf{F}$  in Eq. (1) [20].

A tetrahedral water molecule structure, as proposed by Chaplin [22] and Head-Gordon and Johnsson [23], was applied to the theoretical model. The theoretical model was based on the assumption that the tetrahedral molecule structure created resonance and had a natural frequency  $\omega_0$ , according to Eq. (3) and a small decay constant  $\gamma$ , according to Eq. (2). Some types of forced damped oscillators such as oscillating electric dipoles are adaptable at low frequency, reported by Giertz [24]. It is assumed that at low frequency, ions and H<sub>2</sub>O molecules have, within each cycle, sufficient time to rearrange and eventually to cluster into structures which create resonance with the applied energy. They strive to create structures where the absorbed energy is minimized, i.e. the loss is minimized which occurs at resonance. In the present study it was assumed that water molecule structures behave as adaptable oscillators, and that applied energy having the frequency  $\omega$  and deviating from  $\omega_0$ , would make ions oscillate causing the molecule structure to oscillate at the frequency  $\omega$ , thereby enforcing resonance and changing the molecule structure. Furthermore, it was assumed that the EM energy needed to enforce resonance and to change the molecule structure would be comparatively high since bonds within the ion-H<sub>2</sub>O molecule structure must be separated and arranged into new bonds.

Thus, water can be described by general principles and from an EM point of view there is little difference between water and oscillators (e.g. LC circuit) used in radio and telecom technology, which is obvious when analyzing Equations (4)-(8). Consequently, this study used measurement methodology developed within radio technique; a generator injected current, via a medium (e.g. a conductor), into the oscillator [17]. The oscillator characteristics were measured by means of the absorbed current as a function of different parameters such as generator amplitude and frequency as well as oscillator parameters. This methodology is reflected in the following section describing the measurement method and the oscillator parameters; water volume, temperature, salt type and concentration. It is also reflected in

the Results section describing the experiments and the generator parameters, i.e. amplitude and frequency. The purpose was to verify every parameter of the theoretical model. Measured data was compared with Eqs. (2), (3), (4), (5), (6), (7) and (8), as well as the assumption that water behaves as adaptable oscillators.

## Materials and methods

**Measurement method.** The model described in Fig. 2 was used. An electrode (I), i.e. a 3 cm wire positioned in the air, was connected to a low frequency (sinus wave) generator (II). This created a current in the air consisting of slowly propagating electrons. The forced damped oscillator O (III) had low impedance when the generator frequency,  $\omega$ , equaled its natural frequency  $\omega_0$ . This created a current I (IV) between the electrode (I) and the oscillator O (III). The current was enabled by presence of electrons in the air [25, 26] and measured as reported by Giertz [24]. Charge in the air constituted the return path. Two different types of measurement methods were used.

**Method A.** In Method A the water, constituting the oscillator O (III) was placed in position A, 4 m from the electrode (I) as shown in Fig. 2. Measurements were performed with O (III) in this position. Method A was used in experiments 1, 2 and 3.

**Method B.** The purpose with Method B was to enforce resonance in O (III), thereby changing the ion-H<sub>2</sub>O molecule structure. According to the theoretical model, the energy required to enforce resonance would be high, while the energy required maintaining the resonance would be low. In Method B, O (III) was initially placed in position B, less than 1 cm from the electrode (I), where it was exposed to relatively high voltage ( $U=100 \mu\text{V}$ ) during 5-10 sec., thus enforcing resonance in O (III), see Fig. 2. O (III) was then moved to position A, 4 meters from the generator and  $U=10 \mu\text{V}$ , after which the current I (IV) was measured. Method B was used in experiments 4, 5 and 6. In experiment 6 the generator was turned off and the solution stirred before measuring the current at the next frequency, the measurements starting again at position B.

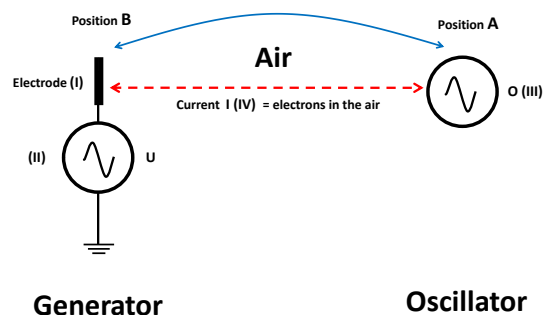


Figure 2. Measuring the oscillator O (III) using current (electrons) in the air. The oscillator O (III) was measured using current I (IV) in the air consisting of drifting electrons, created by the electrode (I) connected to the generator (II). Charge (electrons) in the air constituted the return path.

**Salt solutions studied.** The oscillators studied were water salt solutions of different concentrations, volumes and temperatures, listed in Table 1.

O (H <sub>2</sub> O + salt)	Parameters
deionized water	All Kemi, Norrköping
sodium chloride	2, 150, 2000 mM
sodium chloride	150 mM, 85°C
calcium hydroxide	150 mM
calcium carbonate	150 mM, saturated
aluminum potassium sulphate	150 mM

Table 1. The following salt solutions were included in the study.

Measurements on water solutions were performed on 1 dl solution in a glass container, unless otherwise indicated. The experiments were performed at 25°C as were the temperature of the solutions. As indicated in the table, one salt solution was measured at 85°C as well. The container could be of glass, porcelain or plastic. The current I (IV) propagated through all container walls, i.e. the electrons tunneled through glass, porcelain, as well as plastic and also through human tissue. No measurable differences in current amplitude were detected between the

different container types. The experiments on salt solutions described below used containers.

**Analysis.** The experiments were blind, random and repeated 3 times. One person performed the measurements and the second person selected salt solution and generator parameters as well as mapping the data in Excel. The results are presented using relative current (%). The reason being that absolute calibration can be avoided, which simplifies repetition of the experiments; however, the presented results were in the range 0.01-1 pA depending on experiment. Excel was used for calculations of standard deviations and plotting.

**Instruments.** Current measurements were performed using a high quality generator (Oltronix RCO-6) as well as an instrument measuring current in the air (i.e. a charge meter measuring the presence of electrons/charge in the air) (LC electronic SFT1).

## Results

### Results at 5.095 Hz, Method A.

**Measuring the frequency response.** The purpose of experiment 1 was to investigate whether water exhibits the characteristics of a forced damped oscillator using Method A. The generator voltage was  $U=100 \mu\text{V}$  RMS (Root Mean Square) and the current  $I$  (IV) was measured. A 1 dl solution of 150 mM (150 mmol/l) NaCl was measured while the frequency was increased in steps from 1 to 15 Hz. It was observed that the current  $I$  (IV) was zero at most frequencies except around 5.1 Hz. Therefore, the current  $I$  (IV) was measured again at frequencies between 5.070-5.120 Hz. The experiment was repeated with NaCl solutions of 2, 2000 mM at 25°C and 150 mM at 85°C. Deionized water was also measured. The measured data were inserted into Eqs. (4) and (5) to determine the theoretical frequency response and the quality factor  $Q$ . The results are shown in (Fig. 3).

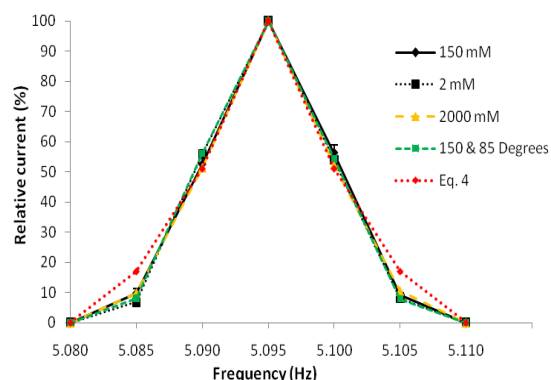


Figure 3. Current amplitude as a function of the frequency in salt solutions. The current was measured using salt solutions and solution temperatures listed in Table 1. The theoretical frequency response is denoted "Eq. (4)".

The current  $I$  (IV) was plotted as a function of the frequency. The results show that the NaCl solutions have a natural frequency at 5.095 Hz, independently of concentration and temperature. The damping,  $\gamma=0.006$ , was determined from the measured values displayed in Fig. 3, i.e. as the full width at 71 % amplitude (i.e.  $I(\omega_0)/\sqrt{2}$ ). Inserting  $\gamma$  and  $\omega_0$  into Eq. (5) gave a quality factor  $Q=5/0.006=800$ . The theoretical frequency response, was calculated according to Eq. (4), using  $\gamma=0.006$  with the measured amplitude at one point, i.e. at 5.090 Hz (at 51 % of the maximum current). The calculated theoretical frequency response is denoted "Eq. (4)" in Fig. 3. No resonance was measured in deionized water.

**Measuring linearity vs. voltage.** In experiment 2 the current  $I$  (IV) was measured as a function of  $U$  in the range of 0-0.4 mV. The frequency was 5.095 Hz and  $O$  (III) was a 1 dl NaCl solution (150 mM). Eq. (6) was used to investigate the correlation between  $U$  and current. The result is shown in Fig. 4.

The relative current  $I$  (IV) was plotted as a function of the voltage  $U$ . The straight line clearly shows a linear relation between the current  $I$  (IV) and  $U$  in the range of 0-0.4 mV. The standard deviation was 2 %.

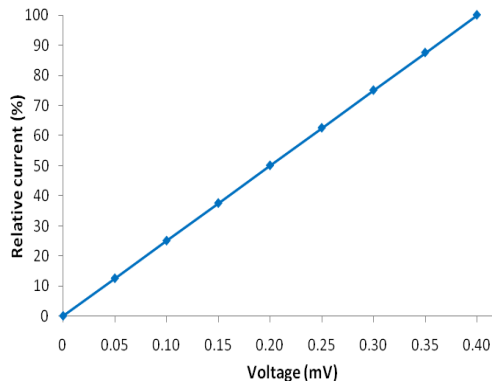


Figure 4. Current amplitude in water solutions as a function of the voltage  $U$ . 150 mM NaCl measured at 5.095 Hz and 25°C. The standard deviation was 2 %.

The relative current  $I$  (IV) was plotted as a function of the voltage  $U$ . The straight line clearly shows a linear relation between the current  $I$  (IV) and  $U$  in the range of 0-0.4 mV. The standard deviation was 2 %.

*Measuring linearity vs. water volume.* In experiment 3, the current  $I$  (IV) was measured as a function of the volume of a 150 mM NaCl solution. The volume was increased in steps of 50 ml, up to 500 ml. The frequency was 5.095 Hz and  $U=10 \mu V$ . Eq. (7) was used to study the correlation between the volume of O (III) and the current. The result revealed a linear relation between the current  $I$  (IV) and the volume of the solution, Fig. 5. The standard deviation was 1 %.

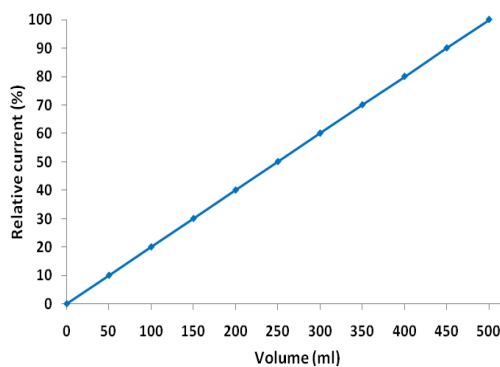


Figure 5. Current amplitude in water solution as a function of the volume. 150 mM NaCl measured at 5.095 Hz, 25°C and generator voltage 10  $\mu V$ . The standard deviation was 1 %.

*Results at 2-10 Hz, Method B.* To verify that water behaves as an adaptable oscillator resonance in O (III) was enforced and

maintained at frequencies other than its natural frequency (5.095 Hz). Method B was used in experiments 4, 5 and 6.

*Measuring stability.* In experiment 4, the stability of the resonance mechanism in the solution was investigated. Resonance was enforced in a 1 dl 150 mM NaCl solution in position B. The generator (II) frequency was 3.0 Hz. O (III) was then moved to position A, stirred with a spoon, or the generator was switched off for 1 sec. The current  $I$  (IV) was measured before and after stirring and similarly before and after interrupting the generator voltage. The result displayed that stirring the solution caused an immediate cease of the resonance in O (III) and so did a 1 sec. interruption of the voltage  $U$ .

*Measuring adaptability.* In experiment 5 adaptability of the oscillator mechanism in salt solutions was explored. O (III) was a 1 dl NaCl solution of 150 mM. Resonance was enforced at 3.000 Hz in position B, then O (III) was moved to position A, and  $U=10 \mu V$ . The frequency was changed in steps of 0.002/0.003 Hz within the frequency range 2.980-3.020 Hz while O (III) was maintained in position A. Resonance was maintained by the generator. The current  $I$  (IV) was measured as a function of the frequency. The damping  $\gamma$  was estimated based on the measured frequency response and the quality factor  $Q$  was calculated using Eq. (5). The result revealed that resonance can be enforced at frequencies around 3 Hz, Fig. 6.

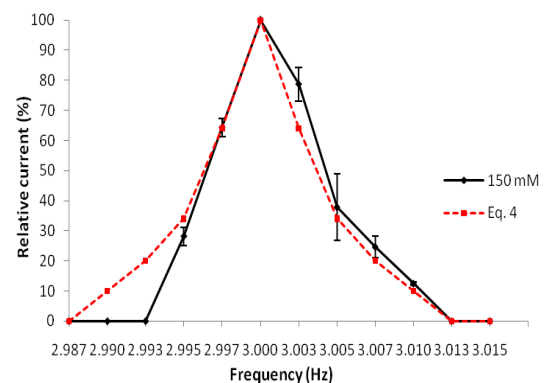


Figure 6. Current amplitude as a function of the frequency at 3 Hz. Resonance in a water solution, 150 mM NaCl, 25°C, was enforced at 3.000 Hz, where after the frequency was changed in steps of 0.002/0.003 Hz. The theoretical frequency response is denoted "Eq (4)".

The damping  $\gamma=0.006$ , was determined from the measured values displayed in Fig. 6. Inserting  $\gamma$  and  $\omega_0$  into Eq. (5) produced a quality factor  $Q$  of 500. The theoretical frequency response, according to Eq. (4), was calculated using  $\gamma=0.006$  and the measured amplitude at one point, i.e. at 2.997 Hz (at 64 % of the maximum current). The calculated theoretical frequency response is denoted "Eq. (4)" in Fig. 6.

*Measuring the frequency range.* In experiment 6 the salts listed in Table 1 were measured at frequencies in the range of 1-12 Hz. Resonance was enforced in position B and after that the current was measured in position A. The generator was switched off between each measurement and the method repeated at each frequency. The current  $I$  (IV) at each frequency was plotted as a function of the frequency.

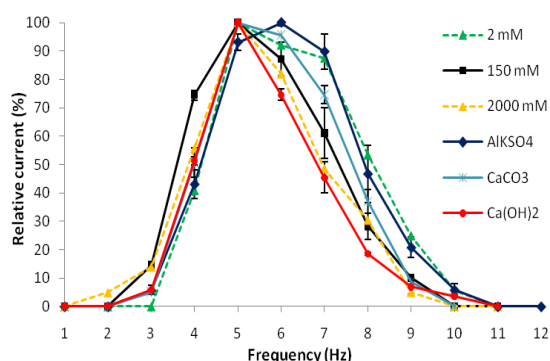


Figure 7. Current amplitude as a function of the frequency at enforced resonance in the 1-12 Hz range using different salt solutions and concentrations listed in Table 1. Solution of high salt concentration (2000 mM) displayed a somewhat lower frequency range, while low salt concentration (2 mM) displayed a higher frequency range.

The result is shown in Fig. 7, displaying that similar results were obtained regardless of the concentration or type of salt used, although the lower frequency range was extended somewhat at high salt concentration (2000 mM) while the upper frequency range was extended somewhat at low salt concentration (2 mM).

## Discussion and conclusions

*Discussion: Hypothesis 1 and 2.* The results suggest that water behaves as a forced damped oscillator. The most important

characteristic of such an oscillator is its rapid change in impedance and absorbed current  $I(\omega)$ , close to its natural frequency  $\omega_0$  according to Eq. (4). Experiment 1 (Fig. 3) and experiment 5, Fig. 6, indicate that water exhibits these basic characteristics, as the measured values were close to the theoretical values. Water also had low damping, giving a high quality factor (800) as defined by Eq. (5), which probably is the result of an efficient resonance mechanism and indicating a well-organized water molecule structure.

Further, forced damped oscillators have constant impedance at its natural frequency according to Eq. (6), which was confirmed by experiment 2, Fig. 4. The measured data inserted into Eq. (8) gave a constant impedance value  $Z$ , which is in agreement with the theoretical model according to Eq. (6). The standard deviation was 2 %, indicating that the theoretical model as well as the measurement method was accurate.

Experiment 3 displayed a linear relationship between current and water volume, within 1 % standard deviation. This is in agreement with the theoretical model, which according to Eq. (7) states that the admittance  $Y$  is proportional to the volume. Furthermore, according to Eq. (8),  $I$  was proportional to  $Y$  at a constant voltage  $U$ , i.e.  $I$  was proportional to the volume of the solution.

The theoretical model builds on the assumption that salt water solutions are dielectric media, whereas resonance can be described by Eq. (2). Experiment 1 showed that deionized water (which is not dielectric) did not create resonance while salt solutions (which are dielectric) did.

Experiment 1, Fig. 3, also confirmed that water had a natural frequency at 5.095 Hz, indicating that water had a basic molecule structure, assumingly tetrahedral [22, 23]. This experiment also showed that the natural frequency appeared independent of salt concentration or temperature, indicating that the natural frequency, Eq. (3), primarily may depend on the ion- $H_2O$  molecule structure, its mass  $m$  and elasticity  $k$ . It was assumed that ions converted applied EM energy into mechanical energy, in keeping with  $q\mathbf{E}(t)$  of Eq. (2).

The theoretical model describes water as adaptable, changing its molecule structure

and thereby minimizing the absorbed energy. This was confirmed by experiment 5, Fig. 6, and experiment 6, Fig. 7. It was assumed that this structural state would be unstable, existing only in the presence of EM energy, which was confirmed by experiment 4. In the absence of energy the resonance ceased suggesting that the created molecule structure disappeared.

The results in the present study displayed high accuracy, often within 2 %, indicating that the methods used were of good quality; however, also indicating absence of other types of resonance modes, e.g. Larmor precession described by Pilla [27], electron spin described by Symons [28], ion acoustic resonance described by Stix [29] and thermal effects/noise.

*Relevance to biological processes.* This study would be of minor interest if biological processes were static. However, the present paper suggests that biological processes operating on water are often dynamic and that low frequency EM processes enforce and maintain resonance in water, thereby altering the ion-H<sub>2</sub>O molecule structure. Biological processes can be investigated *in vitro* and *in vivo* using the theory and methods described in the present study. Giertz [30-33] describes how bacteria, Scc4 and CRL 2095 cancer cells and fibroblasts *in vitro*, as well as humans, bacteria, virus, autoimmune diseases, cancer tumours and metastases *in vivo* were measured and characterized using Method A, described in the present study. It provides a new insight into EM processes in organisms and diseases. Another example is measuring the influence *in vitro* and *in vivo* from low frequency EM energy radiated by electronic instruments. Alternatively current can also be injected *in vivo* in a controlled environment using a signal generator according to Fig. 2. The absorbed current is measured as a function of the anatomical localization and generator frequency, enabling possible discovery of biological processes unknown to science.

*Conclusions.* It is concluded that Hypothesis 1 and 2 are fulfilled. The overall conclusion of the present study is that the water molecule structure comprises a forced damped oscillator and consequently, the laws of electrodynamics apply to water as well as biological processes operating on water.

Thus, biological processes should be described in three closely related ways: firstly, "chemically", based on chemical reactions, secondly, "statically", based on reactions caused by static electric fields (e.g. by embedded atoms, charge) and thirdly, "dynamically", based on low frequency EM energy enforcing and maintaining resonance, creating specific ion-H<sub>2</sub>O molecule structures that interact with other biological processes. The resonance can be enforced by internally induced EM energy or by external EM energy. The present study shows that EM processes are very exact, also when operating on chemical matter (water). It is possible to mathematically describe parameters in a precise way. The implication is that some biological processes can be measured precisely, described precisely and also influenced precisely. It should be possible to mathematically calculate and to selectively control how biological processes are influenced (e.g. by injecting energy or by preventing processes). It has the potential to bring an element of accuracy into medicine, not possible to obtain with state of the art methods currently used in bioelectromagnetics and chemistry.

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Liquid water, as well as other liquids, exhibits characteristic vibrations upon excitation with electromagnetic waves over a wide spectral range. At frequencies which correspond to infrared light, vibrational motions within single molecules can be observed. At lower frequencies, in the Terahertz range, which is situated between the frequencies of the infrared light and microwave radiation in the electromagnetic spectrum, far more complex motions take place involving motions of whole water molecules relative to each other, explains Terahertz specialist Prof. Havenith-Newen. An international research team has gained new insights into how water molecules interact. For the first time, the researchers were able to completely observe all of the movements b more. Lightning bolt underwater. Found on this WEB site. New insights into electromagnetic processes in virus and autoimmune diseases. 2001. 15. enforced by resonance at 4. It is proposed that some biological processes which operate at higher level (e. Rycroft MJ. 1965. MacKinnon R. New insights into resonance in water caused by mobile phone. Giertz [15-17] has reported that infectious diseases and pathogens absorb EM energy present in the air with frequency deviating from 4. 2001. 16. 2000. 2001. Karlin A: Structure of nicotinic acetylcholine receptors. Giertz HW: New insights into electromagnetic processes in water. Available on this WEB site. Bleaney BL and Bleaney B: Electricity and Magnetism.