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CHIRAL MULTIPHOTON ABSORPTION AND INVERSE SKIN EFFECT IN WLAN SYSTEMS

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RESUMEN

Un modelo formado por bioplasma quiral con un conjunto de macromoléculas de ADN, que representa la estructura interna de la cabeza humana, hace posible analizar su comportamiento, cuando es irradiada por campos electromagnéticos de microondas de teléfonos celulares o sistemas WLAN a frecuencias de 2.4 y 5.2 GHz. El método de diferencias finitas en el dominio del tiempo, FDTD, en régimen de multifotones deducido de las ecuaciones de Maxwell es usado. Los resultados numéricos de la taza de absorción específica SAR muestran el comportamiento de la SAR en función de la potencia de entrada y del factor quiral. Las principales conclusiones de nuestro trabajo son: a) la absorción de microondas es aumentada comparada con modelos clásicos, cuando valores del factor quiral normalizado son del orden de la unidad, que aparecen bajo régimen multifotónico; b) Un fenómeno de efecto pelicular inverso en 5.2 GHz con respecto a una fuente de 2.4 GHz fue observado; c) En la región metamaterial mostramos que la absorción siempre es positiva.

Palabras clave: Quiralidad, tejido cerebral, FDTD, Maxwell, SAR.

ABSTRACT

A model formed by chiral bioplasma with a set of macromolecules of DNA, which represents the human head inner structure, makes possible to analyze its behavior, when it is radiated by a microwave electromagnetic field from cellular phones and WLAN's at frequencies of 2.4 and 5.2 GHz is presented. The finite difference time domain, FDTD, numeric technique is used under multiphoton regime deduced from Maxwell equations. The numerical results of the Specific Absorption Rate, SAR, show the SAR behavior in function of input power and the chirality factor. The main conclusions of our work are: a) the microwave absorption from cellular phones or WLAN's is enhanced, compared with classical models, when values of the normalized chiral factor are of order of one which appear under multiphoton regime ; b) a phenomena like an "inverse skin effect" in 5.2 GHz, with respect to a 2.4 GHz source, was observed. c) In the metamaterial region we show that the absorption rate always is positive.

Keywords: Chirality, brain tissue, Maxwell, FDTD, SAR.

INTRODUCTION

Cellular phones and mobile wireless communications systems are being introduced into society at very rapid rate. There are now about one billion mobile phones in use worldwide, and it is expected to reach more that 2 B lines by year 2005. In many countries, penetration rates of more than 50% have been reached. This has resulted in public concern about the health hazards of microwaves electromagnetic fields emitted by these devices. These microwaves are known to penetrate exposed tissues and induce energy absorption and though mobile telephone handsets transmit low power (2 W maximum), the user's body absorbs power from the handset antenna, thus the head of the user is submitted to the highest localized RF exposure [1]. Even though a lot of work has been done, there is still no complete assessed knowledge about this item. However, there is a general agreement [2] about the relevance of the correct evaluation of the mechanisms of interaction between electromagnetic fields and biological systems. It is important to assess the risk, if any, of the wireless revolution and determine if need exists for the establishment of new regulations. It seems clear that RF fields can have some effects on tissue and it still

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remains to be determined whether these effects are functionally and pathologically significant [3].

The different models of human head range from simple models, such as homogeneous sphere to heterogeneous anatomically correct models based on magnetic resonance (MR) imaging [4]. The finite-difference time-domain (FDTD) method has been used extensively over the last decade for bio electromagnetic dosimetry [5]-[8]. In this paper a new FDTD method to determine the absorption of RF waves emitted by cellular phones is presented. It is based in the multigrid FDTD and considering the neurological behaviour of brain tissue under microwave radiation of cellular telephony. We propose to use a simple chiro-electrodynamical model, which takes into account the main interaction between the bioplasma of the brain neurons and the microwave radiation of mobile phone systems. To address the problem and on the basis of our previous experience [10]-[18], our method consist of the following three main steps: 1) modelling of human head through MRI, 2) evaluation of the electromagnetic fields distribution inside the biological target, considering the brain tissue as chiral bioplasmatic media, and 3) SAR simulation for to evaluate both the thermal effect and resonant absorption together. A explanation of the theoretical base of the technique used and description of the models are given in section 2. Results comparing the computed SAR values in the different models are shown and discussed in the section 3. Finally, conclusions are presented.

FUNDAMENTALS AND MODELS

Torres-Silva et al. [12] have studied unbounded chiroplasma and magnetized chiroplasma with an approach where the normalized chiral parameter must be smaller than one. Here, the Faraday chiral media may be used for the chirality control and may have other potential applications as to explain new configurations, which exhibit a force-free morphology [13]. In these works, an unbounded chiral plasma demonstrate a number of new and interesting features i.e., in the case of high frequency waves which propagate parallel to an external magnetic field, new mode conversion and bifurcation of waves appear, where the energy of the electron obtained from the right circularly polarization wave at the electron cyclotron frequency can be transferred to the ions. By using a Born-Fedorov approach [11, 17], where the normalized chiral parameter can be bigger than one, the mode conversion appears in the soliton production. By looking a special natural chiroplasma like a citoplasma in the human brain the new mode conversion can provide a new approach of the old problem of the magnetite biomineralization in the human brain, dominated to date by speculations [16, 19]. On the other hand, the polarization reversal and intermode coupling can explain the molecular wring resonances in chain molecules explained qualitatively by others authors [20]. Here the eigenfrequency of collective twist excitation in proteins, DNA and other biological chain molecules can be in the gigahertz range [21-26].

Here, we assume that the electrons within chiral molecules oscillate along a helix and from the averaged electric current [27, 28] we can find the polarization (P) and the magnetization (M) [12, 13] which in a helical geometry may be proportional to $\nabla\times\boldsymbol{E}$ ($\nabla\times\boldsymbol{H}$) respectively, (see eqs 1, 2 below). For typical double helices, giving the moment of inertia per unit length, the torsional factor and the length of a typical chain (I, tor, L), and following [20], For double stranded DNA we estimate I = 300 auA°, torsion constant of 0.8 ev/A°, and L between 200 A° and 2000 A° the frequency falls in the interval between 1 GHz and 10 GHz [29]-[31]. Similar results we can obtain using the Ford's model [32].

Accordingly, resonance states can be obtained at specific frequencies, and phenomena that involve structural properties can take place. However, the question: do electromagnetic fields interact directly with DNA?, have not a single answer, because other authors are found that the resonant coupling must generally be very small and thus the absorbed energy is so strongly limited that such resonances cannot affect biology significantly at f<10 GHz [12], or the resonances appear at high frequencies (f>50 GHz) [33].In this work we propose that when the multiphoton effect is taked into account, this microscopic problem is reflected at macroscopic level as thermal absorption combined with resonant absorption. Our approach overcomes this problem because as the SAR is related to the intensity of the internal electric field, this concept can be used independently of the nature of the interaction mechanism responsible for biological effects. Here, besides the tissue conductivity and dielectric permittivity we considerer the chiral effect caused by the interaction of microwaves and biomolecules of DNA. By considering the above discussion, here we make the hypothesis that only chiro electromagnetic waves [12] can be the eigenwaves of these interactions.

In connection with this, the bulk chiro transverse waves with the vector electric field parallel to the magnetic field [14, 15], can be the basis to explain the interaction and the interconversion of enantiomers of helically molecules with either left or right circular polarized light in the interior of microtubules (tubulins dimers which are the basis of the human brain activity). The chiral wave

propagation in bounded helical structures may support mode excitation, mode interactions, mode conversion and amplification of molecular chirality by eigenwaves in a bioplasma [33]-[35].

This chiral effect in the brain is considered in this work as a macroscopic mechanism where the typical cell membrane of brain is a fluid bilipid layer with a lot big chiral protein molecules embedded in it. Every protein molecule is polar and will tend to align itself with an electric field and often helical rotate in its socket, so any volume of brain tissue must have a lot of cells bearing protein molecules that happen to resonate at its eigenfrequency which can be similar to the microwave frequency f or when there are n- multiphoton interaction the eigenfrequency can resonate with nf. By contrast with ionizing radiation which damage to genetic structures of cells, microwave may span thousands of cells with a single wavelength. Microwaves set up current in tissue, and any noticeable effect of such current would involve many, many of the relatively weak microwave photons, damage, if any, would be all over the path of the current and would be numerous cells in extend, so damage to general cytoplasm, mitochondria, and so forth would seem likely to be more salient than damage to genetic structure.

Our model is based in that the brain tissue is made up neurons. The brain's neurons are organized by integrated networks of protein polymers called the cytoskeleton [36]. The cytoskeleton consists of microtubules (MTs). The MTs are hollow cylinders, 25 nanometers in diameter, whose lengths vary and may be quite long within some nerve axons. MT cylinder walls are comprised of 13 longitudinal protofilaments which are each a series of subunit proteins known as tubulin. The tubulin dimer subunits within MTs are arranged in a hexagonal lattice which is slightly twisted, resulting in differing neighbor relationships among each subunit and its six nearest neighbors, and helical pathways which repeat every 3, 5 and 8 rows [36]. Since the dimmers alpha and beta can exist in these two different geometric configurations or conformations, which correspond to the electric polarization states of dimmers whose helicoidal structure can be right (R) or left (L), the hypotheses that it corresponds to chirality R and L-handed is made. Then, since the protein medium is chiral, an electromagnetic wave in this medium necessarily will rotate its polarization plane in accordance with the dominant biological structure.

Accordingly with the above discussion, the chiro-electrodynamical model suggests to not only use the standard techniques to characterize the electromagnetic radiation-biological tissue (MR images, FDTD, SAR), otherwise to show consideration that the brain tissue is a chiral bioplasma and we apply the Maxwell´s equations to sets of microtubules and helical molecules embedded in a substrate, characterized by a global chirality factor, T, (equation 1). Chiral media are examples of media responding to both magnetic and electric polarization of electric or magnetic excitation. They thus belong to the general class of bianisotropic media. Chiral media can be characterized by a generalized set of constitutive relations in which the electric and magnetic fields are coupled. Different expressions exist for the constitutive relations. In linear, isotropic, non dispersive and chiral materials we can relate D with E, H and B with E, H. In this paper, we consider the Born-Fedorov constitutive equations 1 and 2

$$\boldsymbol{D} = \varepsilon\left(\boldsymbol{E} + T\nabla\times\boldsymbol{E}\right) \tag{1}$$

$$\boldsymbol{B} = \mu\left(\boldsymbol{H} + T\nabla\times\boldsymbol{H}\right) \tag{2}$$

where ε, μ and T (meter) are the permittivity, permeabilitty and the chiral scalar respectively. Solving Maxwell' equations for a plane electromagnetic wave of frequency ω ($\omega = k_t v = 2\pi f$, k_t is the tissue wavenumber and v is the phase velocity) propagating in a chiral medium, it can be shown that the left- and right hand circularly polarized waves have different wavenumbers, $k = k_t/(1+k_tT)$, $k = k_t/(1-k_tT)$ respectively [11]. Metamaterial effect appears when k<0, it means that one of the two eigenwaves is a backward wave, because its phase velocity is negative but the energy transport velocity is positive. In our case, at an interface between a usual isotropic material (bone) and such medium negative refraction (chiral brain) takes place for this polarization (waves of the other polarization refract positively). The chiral parameter T has the dimension of a length, which in an exactly solvable two helical model for a set of oriented handed molecules, is proportional to $\beta N h^2 a\rho$. Here, β is some coefficient determined by the internal elasticity of a molecule, N is the number density of molecules of radius and a pitch h with the charge ρ per unit length of each [9,10].

Here, the rotor of polarization plane can be predicted from Maxwell equations, considering that the ***P (M)*** vector has a proportional additional term to $\nabla\times\boldsymbol{E}$ ($\nabla\times\boldsymbol{H}$) respectively [12, 13]. If it is assumed that the medium is isotropic, non-permeable and non dispersive, the Cartesian field components are [37, 5, 10]:

$$D_{x,y,z} = \varepsilon_0 \varepsilon_r E_{x,y,z} + \varepsilon_0 \varepsilon_r T \left[\frac{\partial E_{z,x,y}}{\partial y, z, x} - \frac{\partial E_{y,z,x}}{\partial z, x, y} \right] \quad (3)$$

$$B_{x,y,z} = \mu_0 H_{x,y,z} + \mu_0 T \left[\frac{\partial H_{z,x,y}}{\partial y, z, x} - \frac{\partial H_{y,z,x}}{\partial z, x, y} \right] \quad (4)$$

Using the MKS system of units, the following system of scalar equations is the set of Maxwell's equations in the rectangular coordinate system (x, y, z):

$$\frac{\partial H_{x,y}}{\partial t} = \mp \frac{1}{\mu} \frac{\partial E_z}{\partial y, x} \pm T \frac{\partial^2 H_z}{\partial y, x \partial t} \quad (5)$$

$$\frac{\partial H_z}{\partial t} = \frac{1}{\mu} \left(\frac{\partial E_x}{\partial y} - \frac{\partial E_y}{\partial x} \right) + T \left(\frac{\partial^2 H_y}{\partial x \partial t} - \frac{\partial^2 H_x}{\partial y \partial t} \right) \quad (6)$$

$$\frac{\partial E_{x,y}}{\partial t} = \pm \frac{1}{\varepsilon} \frac{\partial H_z}{\partial y, x} \pm T \frac{\partial^2 E_z}{\partial y, x \partial t} - \sigma E_{x,y} \quad (7)$$

$$\frac{\partial E_z}{\partial t} = \frac{1}{\varepsilon} \left(\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} \right) + T \left(\frac{\partial^2 E_y}{\partial x \partial t} - \frac{\partial^2 E_x}{\partial y \partial t} \right) - \sigma E_z \quad (8)$$

where σ (mho/m) is the tissue electrical conductivity.

In the above system of differential equations we see that the vectorial components of the electric flux are related with the respective electric field components and furthermore are proportional to the partial derivative of their orthogonal components. The main difficulty for an analytic treatment of this system is in the partial derivatives of space and time in which the chiral parameter T is present. For this reason, equations (5)-(8) can't be reduced to a typical differential equation with known solution.

The FDTD method, initially proposed by Yee, is commonly used in the resolution of Maxwell equations. Through the FDTD method the discretization of above equations is performed. In our formulation, the second order approximation of Mur is used for the near-field irradiation problems in an achiral-chiral interface case [37]. After calculation of the induced chiral electric field by the FDTD method, the local specific absorption rate SAR, is calculated as

$$SAR_{i,j}(T) = \frac{\sigma_{i,j} \left. E_T^2 \right|_{i,j}}{2\rho_{i,j}} \quad (9)$$

where

$$E_T\big|_{i,j}(T) = \sqrt{\frac{1}{n} \sum_1^n \left(\left. E_y^2 \right|_{i,j}^n + \left. E_x^2 \right|_{i,j}^n + \left. E_z^2 \right|_{i,j}^n \right)} \quad (10)$$

In these equations, the electric (magnetic) fields depend not only on E (resp. H) but also on the transverse components. In this way, a new difficulty appears: the impossibility of knowing both variables at the same time. This is solved delaying one of the fields when the wave insides in the achiral-chiral interface, then the fields at the steps n and $(n-1)$ are stored for the evaluation of the respective $(n+1)$ field.

SAR SIMULATION AND ANALYSIS OF RESULTS

For the numerical calculation we normalize the chiral factor as kT where k is the wave number in the tissue layer, in some case it may be $k_t = nk_0$, ($k_0 = \omega / c$ is the vacuum wave number), with n = 1, 2, 3…n. It is necessary to take into account the multiphoton absorption when the resonance absorption at macromolecular level become important. For the brain we considerer $k = k_b / (1 - k_b T)$ because, the clusters of DNA molecules have eigenwaves like right hand circularly polarized waves and for the rest of tissues we considerer $kT = k_t T = 0$. The values for kT are choose by considering $T \approx \beta N h^2 a \rho \approx 1 - 10 \mu m$, $k = k_b / (1 - k_b T) >> k_b \approx k_0 \sqrt{\varepsilon_b}$, $k_0 T$ is of the order of $10^{-4} - 10^{-3}$ so when the multiphoton effect appears, $k_b T \approx n k_0 T$, $1 - n k_0 T \leq 1$ and then kT is of order of one. Here we suppose that the macromolecules vibrations of the helical structures inside typical brain cells are likely to lead to reasonably absorption enhanced by the proteinic water in which these molecules are immersed (induced chirality).

Stages of the bioplasmatic model for SAR determination are show in reference [10]. Using the linear FDTD algorithm with chirality, obtained from equations (5)-(8), simulations for the mobile phones

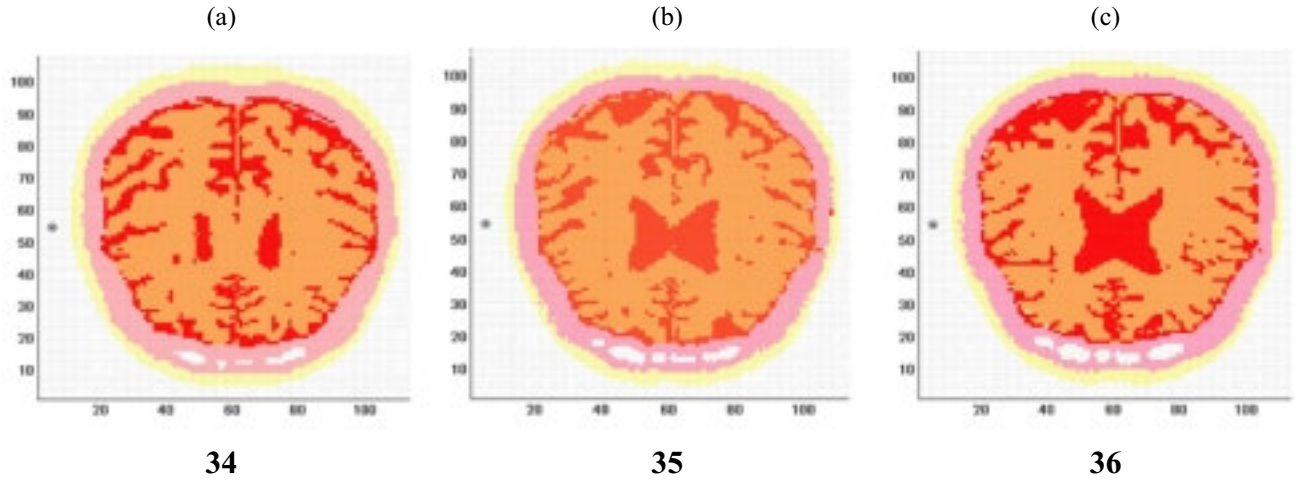


Fig. 1 (a) The structure of layer 34th. (b) The structure of layer 35th. (c) The structure of layer 36th.

microwave spectrum are made. The model of human head was constructed with 540,000 cubic cells of 2.5 mm side each. The total number of layers, counted from the bottom of head, used in this model was 54. Here we choose the layers 34, 35 and 36, because there are great concentrations of brain tissue. The figure 1 shows these layers in digitalized version (matrix of 100x100), likewise is exhibited the antenna position. Both, the dielectric constant and the conductivity of the brain were obtained from literature [27, 28] (Table 1).

Table 1 The tissues parameters for 2.4 and 5.2 GHz.

		2.4 GHz		*5.2 GHz*		
Tissue	*Medium*	ε_r *(F/m)*	σ *(S/m)*	ε_r *(F/m)*	σ *(S/m)*	ρ *(g/m³)*
Air	*0*	*1*	*0*	*1*	*0*	*1000*
Skin	*1*	*42.9*	*1,56*	*39,36*	*3,76*	*1000*
Bone	*2*	*5,39*	*0,09*	*9,94*	*1,23*	*1200*
Brain	*3*	*48,99*	*2,50*	*44,86*	*4.31,*	*1050*
Blood	*4*	*58.35*	*2,51*	*53,7*	*5,67*	*1000*

In order to study and isolate the chiral effect, calculations are made for plane wave assumption [34, 35], powers of 0.125 and 0.250 W were used, at frequencies of 2.4 and 5.2 GHz respectively having the cellular phone antenna or WLAN's antenna an impedance of 120 ohms. Four types of tissues (skin, bone, blood and brain) are considered. Simulations were made in a systematic way, in order to determine the effect that the variation of the chiral coefficient had over the absorption of coefficient SAR and results, for layer 35th, are shown in figures 1-5. Owing to the different electromagnetic properties of the tissues the power absorption is not a monotonically decreasing function of depth. For $kT = 0$, absorption is highest in the skin, low in the skull, but higher again in the brain. These curves were obtained performing similar simulations and then obtaining a statistical average of the SAR. In all curves (2.4 and 5.2 GHz), as the wave penetrates the head, it traverses the different parts of which the head model is made and the value of the SAR is attenuated quickly due to the change in medium and the increase of the distance from the emitting source (antenna). It is important to say that the SAR maximum (hot point) is in outer part (skin). After passing through the bone level, the SAR is much attenuated (between cells 5 and 10) and around cell 10, the SAR increases at brain level. Here, starting on cell 10 approximately is important to analyze the performance of our bioplasmatic model.

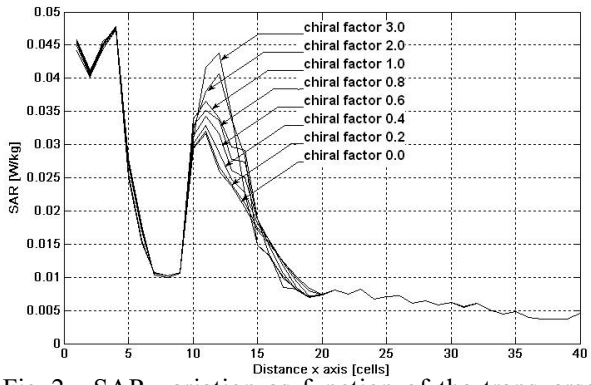
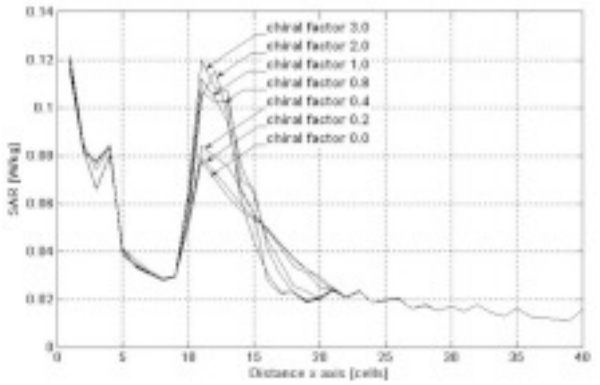


Fig. 2 SAR variation as function of the transverse distance, for $0 < kT \leq 3.0$ at 2.4 GHz. Layer 35th.

The profile of the SAR for 35th layer, at 2.4 GHz, as function of distance for different values of chiral factor kT, is showed in figure 2, where the variation is observed for $0 < kT \leq 3.0$ values of chiral factor. A SAR of 0,032

W/kg, is observed in the brain region, for a null chiral factor ($kT = 0$). For $kT = 1$ the SAR found was 0,036 W/kg, an increase of 12.5% with respect to the achiral case ($kT = 0$) and a SAR of 0.043 W/kg was found for $kT = 3.0$, with an increase 36%. This increase corresponds to the power absorbed by the head.



distance, for $0 < kT \leq 3.0$ at 5.2 GHz. Layer 35th.

Figures 3 shows the distribution of the SAR for 35th layer, as function of distance, for different values of the chiral factor when the work frequency is 5.2 GHz. The maximum SAR found, in the blood-brain region, was 0.08 W/kg for to $kT = 0$ and 0.116 W/kg for $kT = 1$, i.e. an increase of 47% with respect to the achiral case. For a high value of chiral factor, $kT = 3.0$, the maximum SAR found was 0.12 W/kg with an increase of 52%. Also, this increase corresponds to the power absorbed by the head. Following the same procedure, results for the layers 34 35 and 36 are obtained and a comparison amongst SAR maximum values for kT= 1,4, as function of chiral factors are shown in Table 2, for 2.4 and 5.2 GHz respectively. Here with kT=4 we have an enhanced multiphoton effect which is reflected in strong absorption, SAR=1.94.

Table 2 SAR maximum values for layers 34 35 and 36 at 2.4 and 5.2 GHz respectively.

	SAR @ 2.4 GHz; 0,125 W		*SAR @ 5.2 GHz; 0,125 W*	
Layer	*kT = 1*	*kT = 4*	*kT = 1*	*kT = 4*
34	*0,045*	*0,047*	*0,09*	*0,629*
35	*0,036*	*0,045*	*0,12*	*1,94*
36	*0,033*	*0,047*	*0,1*	*0,404*

The analysis of all curves shows that the medium chirality produces a significant increase of the microwave absorption. Figure 4 and 5 show the SAR as function of kT, with kT between ±1 at 2.4 GHz and 5.2 GHz for differents power. The region with negative kT corresponds to wave propagation in the metamaterial condition. Here we show that the absorption is always positive [38]. If we considerer for the brain only clusters of proteins (aminoacids), then we must take into account that $k = k_b / (1 + k_b T)$. Apparently the SAR appears to increase as the square root of the power, because in the numerical calculation as initial condition we start with an initial varying electric field $E_i = (V / \Delta)\sin \omega t$ where the voltage is proportional to the square root of the power with constant impedance [5]. Other important results are the values of SAR obtained for 5,2 GHz, where a remarkable characteristic is found: in this frequency the absorption is bigger in the brain tissue where a lower absorption by skin effect was expected.

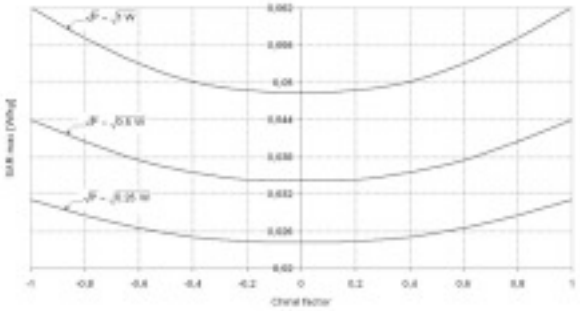


Fig. 4 SAR as function of kT between ±1 at 2.4 GHz for power of 0.25 ; 0.50 and 1 W.

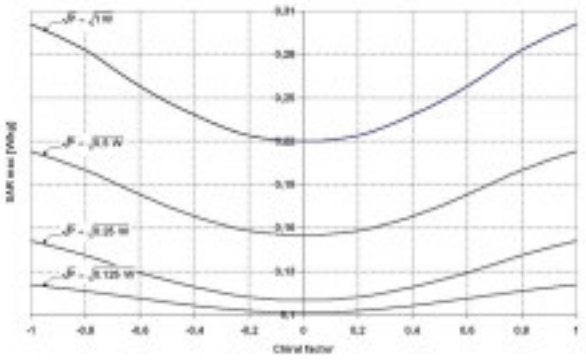


Fig. 5 SAR as function of kT between ±1 at 5.2 GHz for power of 0.125 ; 0.25 ; 0.50 and 1 W.

The classical skin effect is a well-known phenomenon, in a wire of circular cross-section, the radial distribution of the current density is a Bessel function of argument proportional to the square root of the frequency At d.c., the density is uniform, whereas at high frequency the current is approximately concentrated in a peripheral

sheet of thickness $\delta = \sqrt{2/(\mu\sigma\omega)}$, called the *skin depth*. Qualitatively, the preceding results hold for massive conductors of any cross-section with a smooth boundary, the only difference being that the tendency of the current density to concentrate towards the surface is more marked at the points where the curvature is greatest. For instance, in a conductor of elliptic cross-section like a human head, the density at the ends of the major axis will ultimately be larger than at the ends of the minor axis. However this effect does not occur in our simulation, because the effective induced current penetrate inside the head where the multiphoton resonance is active.

This "inverse skin effect" phenomenon is verified in the brain layers, as shown in Table 2 and figures 2 and 3, where it is possible to observe that in all cases, for any chiral factor and input power values, the maximum SAR at 5,2 GHz is larger than at 2,4 GHz. The results of figure 4 and 5 are similar to the reference [39].

The results obtained with the chiral bioplasmatic model in the determination of the magnitude and the distribution of the SAR coefficient (Figs. 3-5), when the chiral factor is null, is similar to those obtained by others authors [40, 41] using different models than the one used in this work.

CONCLUSIONS

A bioplasmatic chiral model of the human head has been presented that allows determination and evaluation of the absorption induced by the radiation of cellular phone. After having obtained the digitalized layers of correspondent MR images, the electromagnetic fields radiated were determined firstly by means of the FDTD technique and then the specific absorption coefficient (SAR). It is shown that the use of a more realistic model of the human head, derived from the magnetic resonance of images allows for improved determination of the chiral near fields induced in the head.

Using the proposed bioplasmatic chiral model, the simulation of SAR distribution in layers with high quantity of brain tissue (layers 34, 35 and 36) was made. These results shows that the power absorbed by the head increases with the chiral factor. At 2.4 GHz, when the $kT = 1$, the results shows that the power absorbed by the head (blood-brain region) increases until 12.5% with respect to $kT = 0$ and for $kT = 3.0$ the increase is 36%. At 5.2 GHz the augmentation was 47% for $kT = 1$ with respect to $kT = 0$ and for $kT = 3.0$ the increase was 52%. Other important result found is that the absorption at 5.2 GHz, in the brain tissue, is larger that at 2.4 GHz, therefore there is an effect like an "inverse skin effect" phenomenon. In this calculation it is not possible that chain molecule can alter their conformation and a breaking of the chain can result having in mind the restricting forces which are higher than the EM forces [25].

Here we are studied a more elaborated model of the head (with chiral effect), but with a simple model for the antenna. For real antennas the proximity of tissue clearly alter the radiation pattern, the antenna gain and the input impedance a more general numerical simulation techniques and an accurate model have to be developed. However for left-hand circular, right-hand circular and helical antennas, now available for isotropic and omni-directional radiation, our analysis on SAR have correct conclusions regarding the chiral effect.

To have validation of our simulations at least for $kT < 1$, measurements could be performed in a generic twin phantom filled with brain simulating sugar solution and chiral inclusions, that is, modeled as little helices of cooper coated wires so the a, h and N parameters encompass the n-harmonic resonance. These preliminary results are important because the consideration that the brain structure is chiral means great increase of the absorption of radiation emitted during the use of cellular phones. Certainly for systems to greater frequencies (wirelessLANs) the chiral effect will be more pronounced This makes it worth to check the first results by means of still more advanced models.

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