EXPERIMENTAL APPROACH OF THE ELECTROMAGNETIC EFFECTS IN VIVO DUE TO THE SOLITARY-WAVES RADIATED BY A CONFINED PLASMA ANTENNA

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Abstract

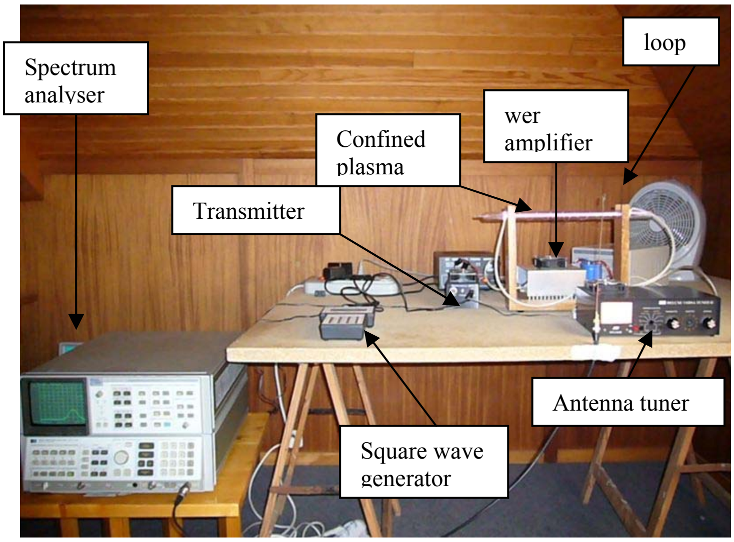
A confined plasma column antenna is able to produce electromagnetic solitary-waves from an ionic discharge. An electromagnetic field radiation is effective outside because the ionic discharge acts as a very small dipole antenna. These no dispersive waves are called <pseudo sonorous> owing to the slow speed of the argon ions .The soliton's theoretical magnitude has been expressed in terms of the Landau length, the mean distance between the two argon ions ,and the Debye screening length of the plasma.

With a spectrum analyser associated to a magnetic loop we measured the magnetic induction field radiated and deduced the whole electric and magnetic induction fields in air medium around the confined plasma antenna.

Knowing the complex index of refraction of a living medium ,we determine in vivo the electric field amplitude by means of surface or Zeneck waves, which are able to propagate along the body.

.Some electromagnetic effects in vivo are brought to the fore such has:
-At low frequencies cyclotronic resonances of various ions, and strong electric fields reradiated in a near environment by nervous fibers.
-Induced emission of ions in the ultra-violet and visible spectra.

Our confined plasma antenna can be used in a large environmental space with, in particular, the frequency and amplitude of the fields of the same values than those used by others ,who applied it by means of implanted insulated electrodes in vivo .In that case ,they inhibit the growth of dermal tumors in mice and others cancerous tumors in human (breast carcinoma,glioblastoma…..).



Solitary-wave device

1 The confined plasma antenna

The device is composed of a power amplifier fed by a transmitter at the fixed frequency f =27 MHz, modulated by a variable frequency square wave generator. An antenna tuner with a balun allows a correct matching between the confined plasma antenna and the amplifier output. The discharge is lighted by means of a spiral conductor located outside along the tube, connected to the impedance adapter. The pressure P_0 of the argon gas at the T ° temperature is such that (1):

$$n^0 = \frac{P_0}{kT^0} \quad (1)$$

k is the Boltzmann constant and $n°$ the neutral argon density. With P_0= 6,65.10^3 Pascals and $T°$=300 K we have: $n°=1.6.10^{24}/m^3$. We suppose a plasma without collisions. For a neutral gas, $n = 1.6.10^{22}$/m^3 is obtained with an ionization degree equal to 10^{-2},where n is the electronic and ionic densities .The soliton's theoretical magnitude Ψ has been expressed [2] and [3] in terms of the Landau length L ,the mean distance d between the two ions ,and the Debye screen wavelength D, of the plasma.

$$\Psi = \frac{(\Delta n)}{n} = (\frac{L}{d}\exp(\frac{-d}{\sqrt{2}D}))^3 \qquad (2)$$

The soliton is the solution of the non linear equation of Kortweg-de –Vries .

(Δn) is the ion density used to generate one soliton:

$$L = e^2.(4.\pi.\varepsilon.k.T_e)^{-1} \qquad (3)$$

T_e being the electron temperature, and e the electron charge. The vacuum permittivity is ε .

$$d = n^{-0.333} \text{ and } D = (8.\pi.L.n)^{-1/2} \qquad (4)$$

With $T_e = 3.10^4 K$, we obtain in micrometers: L=5.6 10^{-4}, d=0.04, D=0.067, and $\Delta n = 10^{16}/m^3$

From [2] and [3] we deduced the ion density used to generate the whole solitons during one pulse:

$$(\Delta.n)_f = \frac{E(r)^3 4.\pi.\varepsilon}{e.2h.V} \qquad (5)$$

E is the transversal electric field at the radial distance r in the median plane of the antenna plasma of length $2h$. V is the plasma tube volume. When $0.15<f<30$ KHz we have: $2.10^7 < E < 2.10^{11}$ volts per meter at r=0.4 m (see table 1),and then, with $2h$=0.5m , V=1 liter ,we obtain: $1.8.10^{18} < (\Delta.n)_f < 1.8.10^{22}$ /m3

These no dispersive waves are called "pseudo sonorous waves" owing to the slow speed of the argon ions. In fact the ion speed is equal to: $(\frac{2.k.T_i}{m_i})^{\frac{1}{2}}$

with Ti and mi which are the temperature and the mass of the argon ion. When Ti=300K the ion speed is equal to 352m/s.The phase speed of the no dispersive solitary wave is given by: $(\frac{k.T_e}{m_i})^{\frac{1}{2}}$ equal to 2500m/s.When $0.5<f<20$ KHz the wavelength of the solitary wave is comprised between 5 to 0.125 meters. The antenna length $2h$=0.5 meters, related to the wavelength corresponding to the frequency radiated: $0.5<f<20$ KHz, would be equal to: $0.08.10^{-5}$ to $3.33.10^{-5}$ So the designation of a 'very small antenna' is justified!

2. Experimental results

With a spectrum analyser coupled to a circular magnetic loop [1], we measured the magnetic induction field radiated at the modulation frequency f .We deduced the electric and induction magnetic fields E and B : ro and r are the radial distances of the loop and the observation point from the plasma column in its median plane.R is the loop radius, and Z is the normalisation resistance(5O ohms).P is the measured power .The speed light in vacuum is c. The spectral density$(u)f$ is expressed in: J.s/m3. Zo is the vacuum impedance.

$$(u)_f = \frac{1}{c}\frac{dP}{df}\frac{Z}{\pi^2.Z_0}\left(\frac{r_0}{R}\right)^4.\frac{1}{r^2} \qquad (6)$$

$$E = \frac{(c)^2.B}{2.\pi.f.r} \qquad (7) \qquad B = (\frac{r_0}{r})^2\frac{\sqrt{P.Z}}{\sqrt{2}.\pi^2.R^2.f} \qquad (8)$$

With R=6mm, Zo=377 ohms, r0=0.4 m, , we obtain the results shown in table 1 valid for r=0.4m.

f (KH)	P(W)	dP/df (W/Hz)	E(V/m) (7)	B(T) (8)	$(u)f$ J.s/m3
0.15	10^{-10}	10^{-11}	2 10^{11}	9 10^{-4}	6.10^{-14}
0.20	0.8 10^{-9}	1.3 10^{-10}	3.5 10^{11}	2 10^{-3}	7 10^{-13}
0.30	1.2 10^{-9}	6.10^{-11}	2 10^{11}	1.6 10^{-3}	3 10^{-13}
0.50	1.6 10^{-9}	1.5 10^{-10}	8 10^{10}	10^{-3}	8 10^{-13}
0.8	0.8$10^{-9}$	10^{-10}	2 10^{10}	5 10^{-4}	6 10^{-13}
2.1	10^{-9}	10^{-10}	4 10^{9}	2 10^{-4}	6 10^{-13}
10	0.8 10^{-9}	10^{-10}	1.4 10^{8}	4 10^{-5}	6 10^{-13}
20	1.2 10^{-9}	1.2 10^{-10}	4.3 10^{7}	2.5 10^{-5}	7 10^{-13}
30	1.2 10^{-9}	1.2 10^{-10}	2 10^{7}	1.6 10^{-5}	7 10^{-13}

Table 1 (r=0.4m).

Between 0.2 and 30 KHz the mean values for P and dP/df are equal to: 1.O75 10^{-9} and 1.1 10^{-10}.The spectral ray
beamwidth at 3 dB is then equal to 5 Hz.

Table 2 ,valid for r=0.4m, gives Pr(10), Pd(9), P(measurements),E(7),B(8), in terms of the harmonic range N of the frequency f:=10KHz.Pr is the mean whole power which is radiated ,and Pd is the radiated power density .Gm is the max gain of a short dipole antenna(1.5 let us be 1.76 dB).For a higher frequency f=30 KHz we have measured at 450 KHz (N=15) an electric field E=2000 V/m.

N	1	5	7	10	15
N.f(KHz)	10	50	70	100	150
E(V/m) (7)	$1.4\ 10^{8}$	$8\ 10^{5}$	$3\ 10^{5}$	$6\ 10^{4}$	$3\ 10^{4}$
B(T) (8)	4.10^{-5}	10^{-6}	$6\ 10^{-7}$	$2\ 10^{-7}$	10^{-7}
P(W)	$0.8\ 10^{-9}$	$2\ 10^{-11}$	10^{-11}	$0.2\ 10^{-11}$	$0.2\ 10^{-11}$
Pd (9) mW/cm²	$1.3\ 10^{-4}$	$3\ 10^{-6}$	$2\ 10^{-6}$	$3\ 10^{-7}$	$3\ 10^{-7}$
$P_R(W)$(10)	2.10^{-3}	$4\ 10^{-5}$	$2\ 10^{-5}$	$4\ 10^{-6}$	$4\ 10^{-6}$

Table2 (r=O.4m)

$$P_d = \frac{G_m.P_r}{4.\pi.r^2} \tag{9}$$

$$P_R = \frac{1}{G_m}\frac{4}{\pi}P\frac{Z}{Z_0}\left(\frac{r_0}{R}\right)^4 \tag{10}$$

For the wave carrier frequency of 27 MHz, with the measured P equal to -9dBm, we find P_R=279 Watt, and P_d=21mW/cm2. That is correct because the antenna tuner measurement, gives a power comprised between 225 and 300 watts following the frequency.

3 Electric and magnetic fields in vivo

For each organ they depend on the square modulus of the complex index of refraction which is expressed with the relative dielectric constant and the conductivity.[10].The electric field E is divided by: n^2+k^2 ([6] p 131 to 137).It is shown in table 3 for various organs, the induction magnetic field B being not modified because the presence of amagnetic medium.

$$n^2 + k^2 = \left|(\varepsilon_r)^2 + \frac{\sigma^2}{\omega^2.\varepsilon^2}\right|^{\frac{1}{2}} \tag{11}$$

Organ	Wet skin	Liver	Breast	Kidney	Grey matter
n^2+k^2 (11)	$4.\ 10^{4}$	$7.\ 10^{5}$	$4\ 10^{5}$	$2\ 10^{6}$	$2\ 10^{6}$
$E(V/m)$ Table 1	5.10^{5}	$2.\ 10^{4}$	5.10^{4}	10^{4}	10^{4}
$B(T)$ Table 1	5.10^{-4}	5.10^{-4}	5.10^{-4}	5.10^{-4}	5.10^{-4}

Table3 Fields E and B for f=1 KHz and r=0.4m

f (KHz)	0.2	1	10	20
Wet skin	$7\ 10^{4}$	$4.2\ 10^{4}$	$3\ 10^{4}$	$3\ 10^{4}$
Liver	$2.7\ 10^{6}$	$7.3.10^{5}$	$9.5\ 10^{4}$	$5.4\ 10^{4}$
Breast	$1.8\ 10^{6}$	$3.6\ 10^{5}$	$4.5.10^{4}$	$2.2.10^{4}$
Kidney	$9\ 10^{6}$	$1.8\ 10^{6}$	$2.7\ 10^{5}$	$1.3\ 10^{5}$
White matter	$9\ 10^{6}$	$1.8\ 10^{6}$	$2.2\ 10^{5}$	$9\ 10^{4}$

Table 4 n²+k² in terms of f for various organs

f (KHz)	0.15	0.5	2	10	20
n^2+k^2	$6.2\ 10^{4}$	$4.4\ 10^{4}$	$3.6\ 10^{4}$	$3\ 10^{4}$	$3\ 10^{4}$
$E(V/m)$ Table I	$3\ 10^{6}$	2.10^{6}	10^{5}	$5\ 10^{3}$	$1.4\ 10^{3}$
$B(T)$ Table I	$9\ 10^{-4}$	10^{-3}	$2\ 10^{-4}$	$4\ 10^{-5}$	$2.5\ 10^{-5}$

Table 5 Fields in the wet skin, r =0.4m.

f (KHz)	0.25	0.5	1	2	10	20
n^2+k^2	$4\ 10^{7}$	$2\ 10^{7}$	10^{7}	$5\ 10^{6}$	10^{6}	$5\ 10^{5}$
$E(V/m)$ Table I	$8\ 10^{3}$	$4\ 10^{3}$	10^{3}	10^{3}	10^{2}	10^{2}
$B(T)$ TableI	$2\ 10^{-3}$	10^{-3}	$5\ 10^{-4}$	$2\ 10^{-4}$	$4\ 10^{-5}$	$3\ 10^{-5}$

Table 6 Fields in the interstitial medium (12) r=0.4m.

The table 6 shows the fields in the interstitial medium ,valid for r=0.4m.The interstitial medium is similar to an aqueous one for which the relative dielectric constant and the conductivity are equal to 80 and 0.6 S/m [8].Then we have:

$$n^2 + k^2 = \frac{10^{10}}{f} \tag{12}$$

4 Assessment of electromagnetic radiations generated in vivo

From the previous measurements we have deduced some electromagnetic effects in vivo liable to activate biological reaction.

4.1 Cyclotronic resonances

The high values of the magnetic induction field B (see tables 3,5,6) may be taken into account to equalize the modulation frequency f with the cyclotronic one of some ions such as: $f = \frac{q_i}{m_i}\frac{B}{2.\pi}$ (13)

For some usual ions H+,Li+,Mg++,Ca++,I - we have:

$$5.10^6 < \frac{q_i}{m_i} < 10^8$$

q_i and m_i are the ion elementary charge and mass. Then for instance ,at r =o.4 m a cyclotronic resonance is possible when the modulation frequency f is comprised between 0.5 and 3 KHz.The cyclotronic resonance can produce biological efficiency effects[1].

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4.2 Free electrons excited by the electric field E in a viscous medium

The electron speed v activated by an alternative electric field E, of frequency f, is equal to (14):

$$v = \frac{eE}{\eta a}.(\cos(\omega t) - \exp(\frac{-\eta at}{m_e})) \qquad (14)$$

ηav is the viscosity strength, a the electron radius and m_e its mass.

e= 1.6.10^{-19} C, a= 10^{-15} m, η=7.10^{-4} SI.

The table 7 gives, with the table 5 for the wet skin, the max electron speed and its energy which is higher than the thermic one for low frequencies.

f (KHz)	0.15	0.5	1	2
E(V/m)	3 10^6	2 10^6	5 10^5	10^5
VM (V/m) (14)	7 10^5	5 10^5	10^5	2 10^4
1/2.m. VM)² (J)	3 10^{-19}	10^{-19}	5.10^{-21}	2 10^{-22}
1/2.m. VM)² (eV)	1.6	0.8	3 10^{-2}	10^{-3}

Table 7 Wet skin medium with r=0.4 meters.

These kinetic energies can be used to activate, control and explain the division of fibroblasts and the cancer mechanisms of human skin.

4.3 Nervous fiber reradiation in vivo, excited by an electric field

From [7]and [8]we find the diffraction electric field Ed reradiated by a nervous fiber at f=2000 Hz, the radius ,length of the nervous fiber and speed of the physiological signals being respectively equal to:1 micrometer,0.1m,and 10m/s.The table 8 is valid for r=1.2m.

H(cm)	1	2	5	10
$\lvert E_d \rvert$ (V / m)	2 10^8	6 10^7	8 10^6	10^5

Table 8

H is the distance from the observation point to the nervous fiber. The electric field of such value corresponds to high kinetic energies about free excited electrons.

4.4 Ultra-violet photonic emission in the interstitial medium

Inside the living matter ,the spectral energy density ,due to the solitary-waves allow to determine the probability of ions induced emission of N/m3 density [4].Inside the interstitial medium and at the wavelength resonance of the ions array we have for f=1KHz and r=0.4m a wavelength 0.158micrometre and a density N_r equal to : 7.14exp(45) per cube meter.

$$N_r = \frac{\sqrt{f}}{r}.3.2.10^{18} \qquad (15)$$

$$\lambda_r = (N_f)^{\frac{-1}{3}} \qquad (16)$$

The photon which is associated with the electromagnetic wave can be moved along the DNA with a high speed [5].

5 Conclusion

A recent paper [9] has shown that low intensity(1 to 2 V/m) and intermediate frequency (100 to300 KHz) fields inhibit, by an anti-microtubule mechanism acton, cancerous cells growth in vitro. Using external implanted insulated electrodes, these fields inhibit also the growth of dermal tumors in mice and others cancerous tumors in humans (breast carcinoma,glioblastoma …).
Our confined plasma antenna can be used in a large environmental space with, in particular, the same values, for the frequency and amplitude of the electric field, in vivo compared with those expressed in [9].

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