THEORECTICAL LOW FREQUENCY ACOUSTIC RESONANCES OF VARIOUS RIFE-BARE PLASMA DEVICE ANTENNAS, UPON THE DESTRUCTION OF *BLEPHARISMA* AND *PARAMECIUM* MICRO-ORGANISMS

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ABSTRACT

We have given a cellular architecture to explain resonances of biological cells at audible frequencies [2]. From experiments we deduced the acoustic ion pressures inside the antenna tube of the RIFE-BARE plasma device in terms of the frequency modulation [1]. Now to explain numerous experimental results, obtained upon the destruction of micro-organisms, we introduce the theoretical resonance frequencies of various antenna tubes which are excited by the inside modulated pressure. The tube resonances are much more high-pitched than the cells one's. For a given tube (cylindrical or spherical) the resonance frequencies depend on the gas kind and its original pressure.

INTRODUCTION

The creation of solitary electromagnetic waves or solitons is explained by the non linear effects produced inside a confined plasma tube excited by a low frequency square pulsed signal [1]. These non dispersive waves are called "pseudo sonorous" owing to the slow speed of the ions. The soliton's theoretical magnitude and the ion density used to generate it, have been expressed in terms of the Landau length, the mean distance between two ions and the Debye screen length of the plasma. The radiation is effective because the plasma ionic discharge column is equivalent to a very small dipole antenna in the field area. In effect the discharge length related to the solitary wavelength is comprised between 0.1 and 4 when the modulation frequency varies between 0.5 and 20 KHz. In that case the used gas was argon. With a spectrum analyzer, associated to a magnetic loop, we measured the magnetic induction field of the transversal magnetic wave around the ionic discharge and in air medium.

From the deduced electric field we find the ion density used to generate the whole solitons in one pulse, and the ion acoustic pressure W_f applied on the internal surface of the plasma antenna tube [1].

This pressure can be expressed by the formula (1) deduced from [1] :

$$W_f = \frac{T_i \sqrt{P}\ 3.10^5}{2h\, V_t\ f^2} \qquad (1)$$

T_i is the argon ion temperature, P the power measured by the spectrum analyzer, 2h and V_t are the length and volume of the cylindrical antenna tube of the Rife-Bare device. With $2h = 0.45m, V_t = 0{,}17.10^{-3} m^3$ and $T_i = 300K$ we obtain from (1) :

$$W_f = \frac{1{,}18.10^{12}\ \sqrt{P}}{f^2} \qquad (2)$$

P is in watts and f in Hertz.

The next table 1 shows the ion pressure W_f in terms of the frequency modulation.

f (Hz)	150	200	300	500	800	10^3	10^4
P (W) (measured)	10^{-10}	0.810^{-9}	1.210^{-9}	1.610^{-9}	0.810^{-9}	10^{-9}	0.810^{-9}
W_f (pascals)	524	834	454	189	52	37	0,3

Table 1 : Valid for an argon cylindrical tube with initial pressure : $P_0 = 6{,}65.10^3$ Pascals

The acoustic ion pressure applied upon the inside surface of the antenna tube is decreasing from 834 to 37 Pascals when the modulation frequency is increasing from 200 to 1000 Hz. It creates strong outside acoustic waves thanks to the equalization of the modulation frequency with the resonance antenna tube one's.

The Reference Sound Pressure (RSP) equal to 2.10^{-5} Pascal at f=1KHz is equal to a sound level (SL) of 0 dB, which corresponds to a power density (PD) of 10^{-13} Mw/cm^2. This RSP=2.10^{-5} Pascal is the sensitivity limit of a good ear. The mean threshold of pain given by several authors is a SL equal to 137.5 dB let us be 150 Pascal .

For us at f=1KHz a RSP=37 Pascal corresponds to a SL =125.3 dB and a PD=0.34 mW/cm^2.It is a strong level inside the tube which does not take the glass thickness into account. Outside the tube the drop with the distance is, for instance, equal to 46 dB when passing from 0.01 to 2 meters. The large attenuation by the tube itself depends on its mechanical vibrations which has not been studied.

When a living medium is taken into account ([2] [3]) we can calculate the orthogonal component of the electric field amplitude *in vivo*, which is reduced by the square modulus of its complex index of refraction. For low modulation frequencies the electric and magnetic induction field amplitudes are high and the spectral density is very low. So we can neglect any thermic effects, being in a quasi stationary state.

We studied the biological cell fragility due to acoustic waves when it is assimilated to a Helmholtz opened resonator [2] and photo 1. This spherical opened resonator has its resonance frequency f_r equal to :

$$f_r = (1/2\pi)\, V\ s\ (U\ u)^{-1/2} \qquad (3)$$

V is the sound speed, $s = \pi\ r^2$ is the right section of the cylindrical ajutage of length L and volume $u = Ls$, R is the radius of the opened resonator and U its volume : $U = (4/3)\ \pi\ R^3$.

The formula (3) is valid if : $r << L < R$ (4).

For the sea water at 15°c we have : $V = 1504\ m/s$. Then from (3) we deduced :

$$r = f_r\ R^{3/2}\ L^{1/2}\ /\ 207 \qquad (5)$$

r , R and L are in meters and f_r in Hz.

The spherical cell of radius R, with a membrane thickness equal to L and a pore of $2r$ diameter, is assimilated to the Helmholtz opened resonator. The justification has been done firstly thanks to experiments of cell explosions due to acoustic resonance [4]. The author only gaves for each *Paramecium* specimen R, L and the explosion frequency f .

We have determined the theoretical radius r (5) equalizing f with f_r (see table 2).

The validity for our proposed model is insured by the double condition (4).

The small values obtained for r are in good agreement with the cell pore sizes.

Specimen	$R\ (\mu m)$ Exp. [4]	$L\ (\mu m)$ Exp. [4]	$f = f_r$ (KHz)	$r\ (nm)$ (5)
Caudatum	71.4	8.60	1.2	10.3
Bursaria	41.6	4.24	1.7	4.5
Calkensi	45.4	7.32	1.9	7.6
Aurelia G's	39.8	5.77	3.3	9.6
Aurelia 51	38.2	5.62	3.5	9.5
Aurelia 81a	34.0	6.80	4.1	10.2
Tritium	29.2	5.81	7.2	13.3

Table 2 : Various *Paramecium*

Ackerman [4] has shown that the breakdown parameter K is a mechanical fragility of the particular organisms traited with sonic vibrations. The larger K is, the more rapidly the organism breaks down under the sonic pressure. The smaller cells are much tougher than the big one's. The results of measurements of the relative mechanical fragility K of various cells are shown in table 3 (after [4]).

Cell species	Mechanical fragility K	Approximate average diameter (microns)
Paramecium Aurelia G's	16	80
Paramecium Caudatum	4	150
Human red blood cell	1	6
T-2 bacteriophage	0.2	0.01
Staph. Albus	0.07	1
E. coli	0.15	1
Baker's yeast	$<3.10^{-4}$	5

$K = 1$ is related to the human red blood cells.

Table 3

For instance, the T-2 bacteriophage of 0.01 microns diameter is 80 times tougher than the *Paramecium Aurelia* G's of 80 µm diameter.

Related to the sea water the wavelength of sound is equal to 1.25 m, that is 10^4 times the *Paramecium* size. We concluded that this optimum breakdown rate is not due directly to the sound wave. Thus the K appears to be due to a resonance of the cellular architecture that we have shown [2] and hereby recalled by the Helmholtz opened resonator.

Now to explain numerous experiments results obtained with the Rife-Bare device [5,6,7] upon the destruction of micro-organisms, we introduce the theoretical resonance frequencies of various antenna tubes which are excited by the inside modulated ion pressure. The tube resonances are much more high-pitched than the cell one's. For a given tube, equivalent to a closed resonator, these resonance frequencies depend on the gas kind and its initial pressure.

The wave propagation speed V_S inside the gas is given by the Laplace formula :

$$V_s = \left(\frac{\gamma\, P_0}{p_0} \right)^{1/2} \qquad (6)$$

P_0 is the initial gas pressure, p_0 its specific mass and γ the ratio of its two compressibilities equal to 1,402 for perfect gases.

So for a dry air at 20°C, at a normal pressure of $P_0 = 1.013\,10^5$ Pascals with p_0 = 1,293 kg/m^3 we obtain from (6) : V_S = 331,4 m/s.

For the argon gas at 20°C with p_0 = 3.587 kg/m^3 we obtain from (6), for P_0 = 6650 Pascals (ou 50 mm de

Hg) : V_S = 51 m/s.

For the helium gas at 20°C, with p_0 = 0.359 kg/m^3 we obtain for P_0 = 6650 Pascals : V_S = 161 m/s.

1. Resonance frequencies for a closed spherical cavity

For a spherical cavity of radius R, the various resonance frequencies, which are not harmonics one another, are solution of the following equation :

$$tg\left(2\pi \frac{R}{V_s} f_r\right) = 2\pi \frac{R}{V_s} f_r \qquad (7)$$

The successive frequencies of resonance are given by:

$$\left(f_r\right)_1 = 0.71515 \frac{V_s}{R}, \ \left(f_r\right)_2 = 1.22951 \frac{V_s}{R},$$

$$(f_r)_3 = 1.73545 \ V_s/R \quad \left(f_r\right)_4 = 2.23870 \frac{V_s}{R},$$

$$\left(f_r\right)_5 = 2.74077 \frac{V_s}{R}$$ and so on…

The table 4 shows the various resonance frequencies related to a "phanotron" tube (photo 2) assimilated to a sphere of $R = 0.05$ m , filled with helium gas in terms of initial pressure P_0 .

P_0 (mm) P_0 (Pascals)	10 1330	20 2660	30 3990	50 6650
V_S (m/s) (6)	71	101	124	161
$\left(f_r\right)_1$ (KHz)	1.016	1.445	1.774	2.303
$\left(f_r\right)_2$ (KHz)	1.746	2.484	3.049	3.959
$\left(f_r\right)_3$ (KHz)	2.464	3.507	4.304	5.589
$\left(f_r\right)_4$ (KHz)	3.179	4.523	5.552	7.209
$\left(f_r\right)_5$ (KHz)	3.892	5.538	6.797	8.825

Table 4 : "Phanotron" (Photo 2) : theoretical resonance frequencies (helium)

One experiment [5] upon *paramecium caudatum* (January 2008) with the Rife-Bare plasma device, has given two destroy frequencies equal to 1.168 and 1.170 KHz (Ackerman had obtained 1.2 KHz, see table 2).

Upon *Blepharisma* several destroy experimental frequencies has been found : 0.930, 0.926, 0.931, 0.927 KHz.

Taking into account the helium pressure unknown, we can say that the destruction of the micro-organisms frequency is involved with the tube resonance one's. The more likely theoretical resonance frequency is $\left(f_r\right)_1$.

The table 5 shows the theoretical results for a similar phanotron tube filled with the argon gas. The frequencies are much lower. The max explosion efficiency is obtained when one of the gas resonance frequencies is confused or near the cell one’s and that for a small value of n. In effect the resonance amplitude is decreasing when the harmonic order n is increasing.

2. Resonance frequencies for a closed cylindrical cavity

For a cylindrical cavity of the discharge length L, the various resonance frequencies, which are harmonics one another, are solution of the following equations :

$$\left(f_r\right)_n = \frac{n\,V_s}{2L} = \frac{n}{2L}\sqrt{\frac{\gamma\,P_0}{p_0}} \qquad (8)$$

n is the whole number : 1, 2…

The table 6 shows the various successive frequencies of resonance $\left(f_r\right)_n$ in KHz for P_0 = 50 mm = 6650 Pascals, related to two gas argon (with *L*=34 cm) and helium (with *L*=20.5 cm).

P_0 (mm) P_0 (Pascals)	10 1330	20 2660	30 3990	50 6650
V_S (m/s) (6)	23	32	39	51
$\left(f_r\right)_1$ (KHz)	0.33	0.47	0.55	0.73
$\left(f_r\right)_2$ (KHz)	0.57	0.78	0.96	1.26
$\left(f_r\right)_3$ (KHz)	0.80	1.11	1.35	1.77
$\left(f_r\right)_4$ (KHz)	1.04	1.44	1.74	2.28
$\left(f_r\right)_5$ (KHz)	1.26	1.75	2.14	2.79

Table 5 : "Phanotron" theoretical resonance frequencies (argon) (R=0.05 m)

Gas	p_0 (Kg/m^3)	V_S (m/s)	$\left(f_r\right)_1$	$\left(f_r\right)_2$	$\left(f_r\right)_3$	$\left(f_r\right)_4$	$\left(f_r\right)_5$
Ar	3.587	51	0,074	0,148	0,222	0,296	0,370
He	0.359	161	0.393	0.785	1.179	1.572	1.965

Table 6 : Cylindrical resonance frequencies in KHz (P_0 = 50 mm)

The choice of : L =20.5 cm , not far from the measured discharge length for helium gas (see table 7),has been done to have a resonance frequency (n=3) near the measured frequency.

Gas kind	P_0 (mm)	f (KHz)	*L* (cm)
Helium	50	1.178	18
Helium	50	O.804	15
Helium	50	0.670	18
Helium	50	0.536	18
Helium	20	1.178	32
Argon	50	1.178	34

Table 7 : Measured discharge length

During the experiments only a sine-wave is used [6].

The efficiency in the destruction of the *paramecium caudatum* is the best for helium gas at high pressure(50 mm),with an exposure duration of 373 seconds at f=1178 Hz after searching at f = 1178,1177,1176,1175 each for 5 minutes. For lowest frequency such as: 268, 402, 536, 670, 804, 938 Hz no explosion but morphological modifications appear: at f=536 Hz (242 seconds exposure) and at f=804 Hz (199 seconds exposure) after a total plasma exposure of 35 minutes. For argon gas (50 mm) and a total plasma exposure of 25 minutes at 1175 Hz, it appears some morphological transformations but no explosion.

The efficiency is the worst for argon gas at low pressure (20 mm) which caused no clear effects on organisms. For that pure modulation frequency (sine-wave) of the Rife-Bare device with a 100 watts amplifier, the mean time necessary to destroy the micro-organism is higher than the usual time when a pulsed modulation is used. Indeed, the probability to destroy organisms , with a spectrum full of rays around a pure frequency obtained with a pulsed square wave with harmonics possibly, is the best compared with a sine-wave one's. The reason is due to the dispersion of the size of the organism of a given kind.

That experimental trend is conform to our theoretical results, expressed in our table, which shows that the easier destruction is obtained when one of the numerous acoustic resonance frequency is concerned. The plasma did not light along the entire tube length. It is true for a visible wavelength comprised between 0.4 and 0.7 micrometers, but uncertainly for an acoustic wavelength equal to 0.2 meters ! However we have calculated the acoustic resonance frequencies for the four tubes with the measured plasma light discharge length. In that case the *paramecium caudatum* resonance frequency is near or equal to the cell resonance one's for a smallest index n.

SUMMARY

1°) We have given a cell physical model, which is the opened acoustic resonator, called "Helmholtz resonator", to explain the experimental results obtained by Ackermann [4]. In effect the cell breakdown rate was not due directly to the sound-wave but to a resonance of the cellular architecture unknown at that time.

2°) We have shown, studying the behavior of the plasma produced inside the antenna cavity of the Rife-Bare device, the noticeable alternative pressure applied against its wall, especially for low modulation frequencies (see table 1).

3°) The cavity (spherical or cylindrical) which contains the gas (helium or argon) has numerous acoustic resonances. When the modulation frequency is equal or near to a resonance frequency, the variation of the pressure amplitude inside the "closed" resonator can be more 30 or 40 times the pressure of the excitation wave. The tube acoustic resonances are much more high-pitched than the cell's one.

4°) The experiments done with the phanotron closed resonator [5], show that the mortal modulation frequency used to destroy the *paramecium caudatum* is the fundamental resonance frequency $\left(f_r\right)_1$ in spite of the ignorance of the initial pressure P_0. It is important to note that the resonance selectivity in frequency is much more high for the cavity than for the micro-organism one's.

5°) The experiments realized with 4 cylindrical closed resonator [6] show that the more efficiency, related to the total destruction of the *paramecium caudatum*, is obtained with the helium gas at high pressure.

6°) We can conclude that the explosion of micro-organisms of kind *blepharisma* and *paramecium*, is due to low frequency acoustic resonances of the Rife-Bare plasma device antenna. The electric and induction magnetic fields effects are excluded, may be except to explain some morphological transformations ?

7°) The future research will be to express the influence of the mechanical frequency vibrations of the cylindrical glass tube upon the attenuation of the acoustic effect through its thickness.

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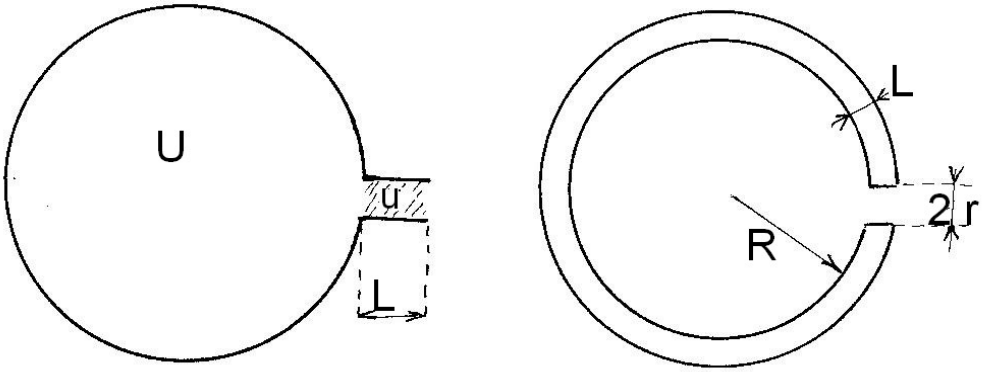
Cell fragility due to acoustic resonance



Model photo 1 Cell

$U=(4/3)\pi R^3$: Cell volume.

$u= L.\pi.r^2 =L.s$: ajutage volume.

L:cell membrane and ajutage thicknesses

Photo 2