Eur. J. Oncol. - Library Vol. 5

NON-THERMAL EFFECTS AND MECHANISMS OF INTERACTION BETWEEN ELECTROMAGNETIC FIELDS AND LIVING MATTER

An ICEMS Monograph

RAMAZZINI INSTITUTE

Edited by
Livio Giuliani and Morando Soffritti

European Journal of Oncology Eur. J. Oncol. - Library Vol. 5

National Institute for the Study and Control of Cancer and
Environmental Diseases "Bernardino Ramazzini"
Bologna, Italy
2010

RAMAZZINI INSTITUTE

SPONSORS

International Commission for Electromagnetic Safety

National Institute for the Study and Control of Cancer and Environmental Diseases “Bernardino Ramazzini”

isbn
978-88-6261-166-4

pubblicazione
Fidenza 2010

CONTENTS

Polarizability of normal and cancerous tissues, a radiofrequency nonlinear resonance interaction non invasive diagnostic Bioscanner Trimprob detector

Clarbruno Vedruccio
COMSUBIN, Ufficio Studi, Italian Navy, La Spezia, Italy.

Abstract

The spectrum analysis of low level E.M.F. Non-Linear Resonance Interactions (NLRI) between biological tissues and the signals emitted on three sharp frequency windows by a 'bioscanner' Trimprob, as available in literature, could be used to investigate suspected cases of disease and cancer. The paper is focused to review the scientific literature that spreads the possibility of the cancer detection by means of low level radio frequency oscillations and to explain the experimental approach necessary to deeply understand the Trimprob technology. The system is based on a non-linear radiofrequency oscillator working on 462 MHz plus the harmonics. The diseased biologic tissues, suspected of cancer, are irradiated in the oscillator " near-field" while a spectrum analyzer placed outside of the near field detects the oscillator interaction frequency lines with the tissues. The technology is provided whith a very high dynamic range, that is evidenced by means of a deep depression, at the resonance, of the interested frequency line in order of 20 or more decibel (dB). When a resonance approaches, the resultant effect is quite similar to the Grid-dip meter technology, well known by radio communications and radar engineers, and that is still used to investigate the resonance of passive L/C radiofrequency oscillators as well as the new RFID (Radio Frequency Identification) widely used in the industry. The NLRI provides a selective structural characterisation, like a sort of 'electronic biopsy' response of biologic tissues in support of modern diagnostic imaging techniques. Further to existing literature describing methods for cancer detection by means of electromagnetic fields, the paper shows this innovative "in vivo" medical diagnostic equipment applications.

Key words: **Bioscanner, Trimprob, N.L.R.I. (Non Linear Resonance Interaction), cancer diagnosis, electromagnetism, electronic biopsy**

Address: Clarbruno Vedruccio, COMSUBIN, Ufficio Studi, Italian Navy, La Spezia, Italy
E-mail: clarbruno@tin.it

Review of scientific literature

In the past century, a great number of researchers have given their contribution to the study of the interactions between biological matter and electromagnetic fields. Many investigated the dielectric properties of living matter. Some others analyzed the differences between a cancerous agglomerate of cells and homogenous or 'normal' tissues. The period between the First and the Second World War spanned the early days of radio and electronics: vacuum tubes were the radio frequency oscillation generators, the spectrum ranged between a few kHz and 15 MHz. Measurements on biological materials were based on resistivity or impedance and instruments such as the Wheatstone bridge. After the second world conflict, investigations on biological materials were extended into the microwave bands[1].

Among the pioneers in this field, there were H. Fricke[2] and S. Morse[3]. In 1926, in their paper entitled "*The electric capacity of tumors of the breast*", they reported that "*malignant tumors have a greater polarizability than normal breast tissues or benign tumors*". They carried out their experiments at low frequencies around 20 kHz. Tissues were cut into small blocks and placed in a conductivity cell for measurement. They claimed that measurements performed on tissues from locations other than the breast convinced them that the method was of general applicability and that in some cases the "*measurements may be made directly on the patient*". Following the publication of these results, Fricke published a paper in which he declared that "*It seems probable that the measurement of the capacity may provide a very practical method for diagnosing the malignancy of a tumor.*" These experiences are of a great importance to explain and clarify some aspects that arises in the common use of the Bioscanner/Trimprob device, and it is extremely interesting to read this paper in which the authors wrote: "*While the resistance of biologic tissues has been studied by many investigators, little attention has been directed to their capacity".* The term "capacity" is to be associated to the well known property of the tissues which is usually called its "polarization". Theoretically we assume two type of electric capacity, the first is the "static capacity" that is independent to the frequency of the alternating current, the second is the "polarization" type that depends upon the interphases in the tissues and suggest that capacity might have a considerable biologic significance. The "polarization" capacity is related to the alternating current applied or irradiated to the tissue under test. In their paper, Fricke and Morse claim: It has been a constant surprise to find that *the capacity of malignant tumors of the breast is so consistently larger than that of normal tissues in the same location or of benign tumors as to make its estimation in any individual case clearly of diagnostic value.*

As above reported, these aspects are important to clarify the mechanism of the *non linear resonance interaction* applied to the diagnosis by means of this technology. It is known by the users, that the Trimprob works on three frequencies, and that the first is 462 MHz , while the others are the harmonics of the first ones.

Despite the frequency used for the analysis, but in accordance with the Fricke and Morse paper, the tissue capacity values have to be higher for the malignant tumors, lower for benign and much lower for healthy ones. The measured values are also greatly different in the order of four times greater for malignancy than for healthy tissues. In other words, we have to expect that a malignant cells agglomerate, that it is characterized by a high capacity, must have a non linear resonance interaction on the lower frequency of the harmonically related group emitted by the Bioscanner/Trimprob.

Differently, the benign pathologies, like benign prostate hypertrophy or breast fibromas, will not have the same capacity than a malignant tumor and of course, the non linear resonance interaction could be detected on a higher frequency.

Materials and Methods

The main feature of Trimprob apparatus is a cylindrical probe shown in fig. 1, within which a resonant cavity incorporates a transmission line tuned to the frequency of oscillation which is in the 65 cm wavelength band (462 MHz).

At the open end of this line there is a semiconductor with non-linear characteristics, which is activated by a nanosecond electromagnetic pulse. This transient provides an injection of electromagnetic energy into the tuned line, which performs a damped oscillation. This particular tunable amplifier-oscillator represents the core of the Trimprob diagnostic device. It possesses lock-in or synchronization characteristics and, because of its particular construction, it produces a harmonically related group of coherent electromagnetic waves. These oscillations are radiated as a beam through the "beam window" of the oscillator dome at the end of the probe, where it has been geometrically focused, and the beam is used to irradiate the diseased tissues.

The working principle can be explained by considering the equivalent circuit diagram of figure 2. The left part stands for the probe and the right part for the tested biological tissue, while the coupling is represented by (virtual) interrupted lines. Inside the probe, the transistor T activates an electric circuit, which has a natural frequency of oscillation f1 that is determined by self and capacity of this circuit. The current I passing through T is a *non-linear* function of the potential difference V. Actually, $I = -aV + bV^2 + gV^3$, where *a* defines a "negative resistance". It results from a positive feedback, mediated by magnetic coupling with the self of the first circuit. This non-linear system produces stationary oscillations of well-defined amplitude, but when the probe is brought close to the tested biological tissue, it becomes an "active oscillator" that interacts with a "passive oscillator".

Fig. 1. The Trimprob equipment is composed by the Bioscanner probe and a computer based spectrum analyzer

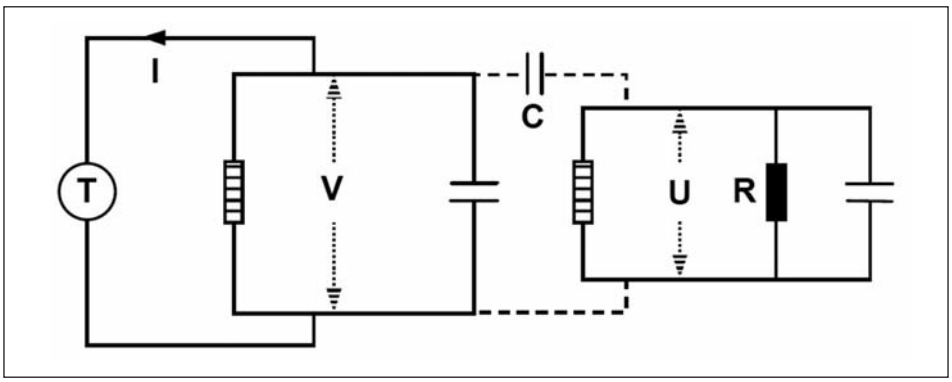

Fig. 2. Coupled active and passive oscillators equivalent electric circuit

Although the irradiated biological system contains various subsystems that could be set in forced oscillations, their mutual interactions are negligible. It is therefore sufficient to consider the effects of the active oscillator on one particular passive oscillator of given resonance frequency f_2. We can even imagine a circuit, where the self and capacity determine the frequency f_2, while the resistance R defines energy absorption. The probe acts there like an "open capacity" and the tested biological tissue is subjected to the resulting electric field. This type of coupling is unusual. It involves a capacity C that increases when the probe approaches the tested tissue. Since this capacity facilitates the passage of high frequency currents, we can call this a *dynamic coupling*. All these features are taken into account by *two coupled differential equations*, describing the possible variations of the potential differences V and U. The detailed mathematical treatment is available on internet[1], but the basic ideas can be expressed in simple terms. Let us consider the particular case where the active oscillator is unperturbed (C = 0). The equation for V reduces then to the well-known *Van der Pol* equation, initially introduced to account for the possible actions of a triode. Even when the amplification coefficient *a* is very small, the rest-state (V = 0) will be unstable. The slightest perturbation will be amplified and the capacity will accumulate charges, but when they increase, there will be also a greater tendency towards discharging. The system will end up with a stationary harmonic oscillation of frequency f1 and given amplitude for the potential difference V. For larger values of *a*, higher *harmonics* will appear, since the equation for V contains terms that vary like V^2 and V^3. This remains true when the active oscillator is coupled to a passive oscillator.

We can thus adopt a solution for V that accounts for the existence of oscillations at a fundamental frequency f and its harmonics, 2f and 3f. The value of f, as well as the amplitudes and phase factors of all these components can only be specified, when we take into account the fact that V produces forced oscillations for U and that this has an effects on V, because of C. The result can be summarized in the following way: the active oscillator is able to "feel" what happens inside the tested biological tissue, since *it has to transfer energy* to the passive oscillator to produce forced oscillations of the hidden entities. The active oscillator is also able to "tell" us how the passive oscillator is responding, since the amplitude of its own oscillations is strongly reduced when there is a large energy transfer. This is revealed, indeed, by a reduction of the amplitude of the emitted wave, displayed on the screen of the spectrum analyzer. The mathematical treat-

ment reveals that the active oscillator draws more energy from the batteries when resonance is achieved, but its own energy is reduced, as if it had to make a "big effort". This mechanism is the essence of the *non-linear resonance interaction*[1, 4, 5].

Although the values of f_1 and f_2 are fixed, it is possible to achieve, or at least to approach, *ideal resonance* where the "dip" of a given spectral line is strongest, by changing the value of C through a modification of the distance between the probe and the tested tissue. The first spectral line is very sensitive to the existence of a resonance, when the negative resistance *a* is small, but a higher value will allow for a simultaneous search of resonance phenomena at the fundamental frequency f and its harmonics 2f, 3f, etc.

The effect of this interaction is easily detectable by means of a spectrum analyzer feed by a small antenna. At the resonance, on one or more of the spectral lines, two effects are detectable: the first is related to the transfer of an amount of radiofrequency from the generator probe to the diseased tissue, that absorbs a part of the signal on the proper frequency line (dynamic resonance), while the second effect it is related to the deformation of the electromagnetic pattern emitted by the probe, due to the interaction with a resonating diseased tissue, that produces in the "near field" a sort of parasitic resonating element able to deflect the waves in other spatial directions, in the same way that beam antennas for radio communications works.

The subject under test must be further from the probe than the "near field", and the same applies to the spectrum analyzer, which is a part of the system. Using this arrangement, it is possible to observe an effect that appears as absorption of one or more of the spectral lines radiated by the scanner. This is observed on the spectrum analyzer display, that transforms the received signal into a Fast Fourier Transform (FFT). These lines are specifically tuned to the types of tissues to be investigated. At the moment, three spectral lines are used: the first, corresponding to the wavelength, responds specifically to highly anisotropic states like micro-agglomerates of cancer cells; the second line responds to parenchyma (soft tissues) diseases; the third line responds to anomalies of the lymph and vascular system.

The interaction between a non-linear active oscillator and an ordinary (linear) passive oscillator leads to the peculiar phenomenon of "non-linear resonance interaction". A similar behavior is known as a *grid-dip meter* (g.d.m.). Initially, it contained a triode[6] that was associated with an oscillating circuit in such a way that it delivered a stationary oscillation at *one* particular, easily tunable frequency. The tunable active oscillator could be coupled by *magnetic induction* with another oscillating circuit, containing a real coil. When such a grid-dip meter is tuned, so that its natural frequency is identical to the natural frequency of the passive oscillator, there will be a resonance. Since the active oscillator is transferring energy to the passive oscillator, the oscillating current passing through the coil of the active oscillator is reduced, and an ammeter, included in the grid circuit, will indicate this effect. At resonance, there appears a "grid-dip", but to avoid ambiguities, the active generator should produce no harmonics. When a spectrum analyzer is used to monitor the near field and primarily the far field emitted by the g.d.m. coil in the free space, while interacting with a tuned for resonance, passive L/C simple circuit, we can observe some interesting not commonly investigated effects.

Fig. 3A and 3B shown the necessary setup for this experiment: A Millen mod. 90651-A g.d.m. placed on a laboratory wooden table near a passive oscillator composed by an U shaped coil paralleled by a 30 pf variable air spaced capacitor. The circuit is tunable in frequency around the 140-170 MHz band, that was used to facilitate the passive circuit

Fig. 3. A) Experimental asset. The far-field spectrum analyzer is placed on the table about 50 cm. far from the g.d.m and the passive oscillator. A small antenna picks up the r.f. field. The author right hand is moving the L/C oscillator tuning to achieve a resonance with the grid dip meter: when the resonance is achieved, the spectral line on the display is immediately depressed (B)

realization as well as a proper coupling with the g.d.m. The passive oscillator U coil is placed in the near field of the g.d.m. test coil. At a distance of at least 50 cm, just outside the near field, another portable spectrum analyzer with a 1/8 wavelength rod antenna picks up the g.d.m. far field.

A slight tune of the g.d.m., to achieve the resonance with the passive circuit, is evidenced by a sharp dip of the ammeter current. This common and known effect represents the normal use of the instrument. At the same time, the far field received by the spectrum analyzer antenna shows a strong dip of the corresponding frequency line as evidenced in figs. 4-5;

The spectral line will drop the amplitude more than 20 decibel and could be in the order of 30 or more dB. In other words the frequency line will disappear from the display. Instead the near field detection will show a little attenuation of the spectral line in the order of few dB. This far field monitoring, to display the waves propagation of a passive oscillator interacting with an active one, was not previously reported in literature and represents the basis of the Trimprob operations.

The use of a g.d.m. not consent the cancer or other disease detection but it is used, scaled in frequency, for field modeling purposes and for other experiments and laboratory measurements, cause the magnetic coupling of the oscillators, although the propagation of the involved radiofrequency field is the same of the diagnostic device, that is not easily influenced by magnetic-coupled passive oscillators.

The EM cancer detector is different, since it allows for an *electric* and no magnetic coupling, by means of a quarter wavelength antenna, activating charged particles inside biological tissues or other polarizable materials. Moreover, there are *harmonics,* that the spectrum analyzer allows for a distinction of possible resonance effects for anyone of the frequency components and could be considered like a sort of *'electric field capacity coupled grid dip meter*' provided of a far field detection. Both g.d.m. and Trimprob, are provided of synchronization capabilities[1] that are evidenced by a loop locking of the

Fig. 4. The g.d.m. oscillator line out of resonance at 152.5 MHz

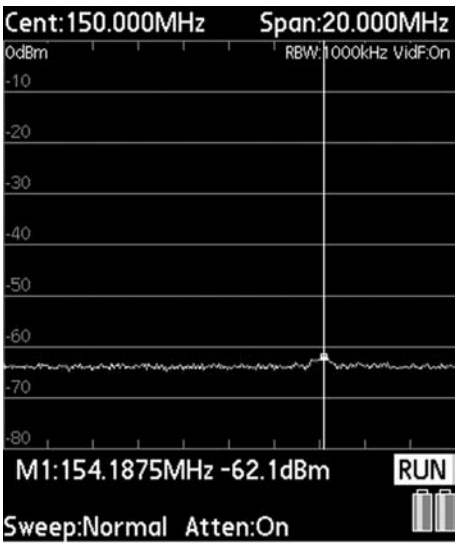

Fig. 5. Frequency resonance interaction, the far field spectral line is depressed

active oscillator frequency respect the passive ones. Effect evidenced by the spectrum analyzer tracking capabilities that measures not only the amplitude, but also the precise frequency at the interaction resonance. It is astonishing observe the damping force opposite to frequency variations when the two oscillators are in their respective 'capture range'. To have diagnostic capabilities the irradiated radiofrequency by the probe has to be of few about ten milliwatt; or the interaction with the tissues will be no more evidenced cause excessive oscillator coupling and other saturation effects. A similar behavior is common with not well designed g.d.m., when these instruments are used to analyze the resonance of passive L/C oscillators, especially when the g.d.m. power is excessive. Instead, in the case of the Bioscanner, very low in level signals, in the order of microwatts could still interact with near the skin anomalies on 462 MHz, but a more sensitive spectrum analyzer is required, to display the far field. An experimental tunnel diode[7] nonlinear oscillator probe was realized and laboratory tested by the author. This could represent a promising technology for a skin cancer like melanomas, detector, useful also for a low level e.m.f. interaction device with cells, in laboratory experiments. The lock-in characteristic is also evidenced by the immediate synchronization in frequency of a couple of 'Bioscanner' probes when such a non-linear oscillators are in their respective 'capture range', that is about one wavelength wide. Greatest distances are possible with the aids of corner reflectors to focusing both the probe fields. The spectral far field line amplitude, due to the phase synchronization of the oscillators, is greater than for a single oscillator.

Opinions and implications

The first experiments, carried out by the author in the early days of the Bioscanner invention and development, as well as several clinical trials during the last years, have

scientifically validated the efficacy of the described low level e.m.f. cancer detector in several body organs like breast[8], prostate[9-11], bladder[12, 13], stomach-duodenum[14, 15], thyroid[16, 17], colon-rectum[18]. The Trimprob clinical diagnostic accuracy as reported in Table 1, that resumes the above mentioned clinical studies[19], spans several applications in the field of characterization of benign vs. malignant pathologies, prevention, screening capabilities and some other not disclosed here, possible applications.

In the last years was only possible to realize a not invasive diagnostic tool based on this technology, commercially named Trimprob, that was based on these researches, 'medical CE' certified, and quite diffused in Italy and abroad. The above mentioned results, still requires an important consideration: the cancer detection is possible, with the described device, only on the cited sharp frequency window centered on 462 MHz, no more than 8 MHz wide. Outside this range, the nonlinear resonance generator doesn't interact with the diseased tissues.

Table 1 - Trial Results Sinthesis

Organ	Sens.	Specific.	V.P.P.	V.P.N.	Accuracy
Prostate					
1 - Trials by dr. Bellorofonte (Milano); *European Urology* (2005)	95	43	94	90	
2 - Trials by prof. Tubaro (Roma); *Urology* (2008)					
Solo Trimp.	86	63	60	88	72
Trimp+DRE	96	57	59	95	72
Bladder					
Trials by dr. Leucci (Lecce); *Electromagnetic Biology and Medicine* (2007)	87,5	90,5	83,3	91,1	89,5
Breast					
Trials by IEO-MI (dr. Paganelli-dr. De Cicco); Tumori (2006)	84	75		80	72
Tyroid					
Trials by Prof. Sacco; *Chirurgia Italiana* (2007)	100	100			100
Stomach-duodenum					
1 - Trials by dr. Mascia; *International Review of the Armed Forced Medical Service (IRAFMS)* (2005)	93	93	95	92	
2 - Trials by dr. Sacco; *Chirurgia Italiana* (2007)	100	100			
Rectum					
Trials by prof. Leo, Dr. Vannelli Istituto Nazionale dei Tumori (MI); *Disease of Colon & Rectum* (2009)	94	85	86	93	89

References

1. Meessen A. Working Principle of an EM Cancer Detector. Available on internet, http://www.meessnen.net/AMeessnen/EMcancerDet2.pdf; Institut de Physique, Université Catholique de Louvain, Louvain-la-Neuvre, Belgium 2000.
2. Fricke H. Phys Rev 21, 708 (1923); J Gen Physiol 9, 137-52 (1925); Phys Rev 1925; 26, 682-7.
3. Fricke H, Morse A. Phys Rev 25, 361-367 (1925); J Gen Physiol 9, 153-167 (1925); The electric capacity of tumors of the breast. J Cancer Res 1926; 10: 340-76.
4. Vedruccio C, Meessen A. EM cancer detection by means of non-linear resonance interaction. Proc. and Extended Papers book. PIERS 2004, Progress in Electromagnetics Research Simposium, Pisa, Italy, March 28-31, 2004; 909-12.
5. Vedruccio C, Meessen A. Nuove possibilità diagnostiche tramite onde elettromagnetiche. Fisica in Medicina, AIFM, 2004; 3: 225-30.
6. Hund, A. High frequency measurements. McGraw-Hill, 1951.
7. Manager, H.R.L. et al. Tunnel diode manual. General Electric, 1961.
8. De Cicco C, Mariani L, Vedruccio C, *et al.* Clinical Application of Spectral Electromagnetic Interaction in Diagnosis of Breast Lesions. Results of a Pilot Study. Tumori 2006; 92(3): 207-12.
9. Bellorofonte C, Vedruccio C, *et al.* Non-invasive detection of prostate cancer by electromagnetic interaction. Eur Urol 2005; 47: 29-37.
10. Da Pozzo L. *et al*. Tissue Resonance Interaction Method for non Invasive Diagnosis of Prostate Cancer: a Multicenter Clinical Evaluation. BJU Int 2007; 100(5): 1055-9.
11. Tubaro A, De Nunzio C, Trucchi A, *et al.* The Electromagnetic Detection of Prostatic Cancer: Evaluation of Diagnostic Accuracy. Urology 2008; 72(2): 340-4.
12. Leucci G, Vedruccio C, *et al.* Studio Pilota per la Diagnosi del Carcinoma Vescicale mediante l'utilizzo del TRIMprob, (preliminary results), proc. of XI Congresso Nazionale AURO, Department of Urology, Ospedale Vito Fazzi, Lecce, Italy, 6-9 Oct 2004.
13. Gervino G, *et al.* Diagnosis of Bladder Cancer at 465 MHz. Electromagn Biol Med 2007; 26(2): 119-34.
14. Vedruccio C, Mascia E, Martines V. Ultra High Frequency and Microwave Non-linear Interaction Device for Cancer Detection and Tissue Characterization, a Military Research approach to prevent Health Diseases. International Review of the Armed Forces Medical Services (IRAFMS) 2005**;** 78(2): 121-6.
15. Sacco R, Sammarco G, De Vinci R, *et al*. Relief of gastric cancer with an electromagnetic interaction system (TRIMprob) in outpatients. Chir Ital 2007; 59(6): 823-8.
16. Lucisano AM, Innaro N, Pata F, *et al.* Diagnosis of Carcinoma in Multinodular Goiter by Electromagnetic Interactions. Preliminary Results. European Surgical Research 2006; 38: 129-32.
17. Sacco R, Innaro N, Pata F, *et al.* Diagnosi Preoperatoria di Carcinoma Incidentale in Gozzo Multinodulare mediante Interazioni Elettromagnetiche. Chir Ital 2007; 59(2): 247-51.
18. Vannelli A, Leo E, Battaglia L, *et al.* New technique for diagnosis of rectal cancer. Dis Colon Rectum 2009; 52(1): 162-6
19. Vedruccio C, Ricci C. The Trimprob Non Linear Resonance Interaction for early cancer detection. In: Casciaro S, Samset E, Eds. Minimally Invasive Therapies and Novel Embedded Technologies. Lecce: Lupiensis Biomedical Publications, 2007.