Heterodyne Resonance Mechanism in a transient process in plasma. Experimental study and spectra

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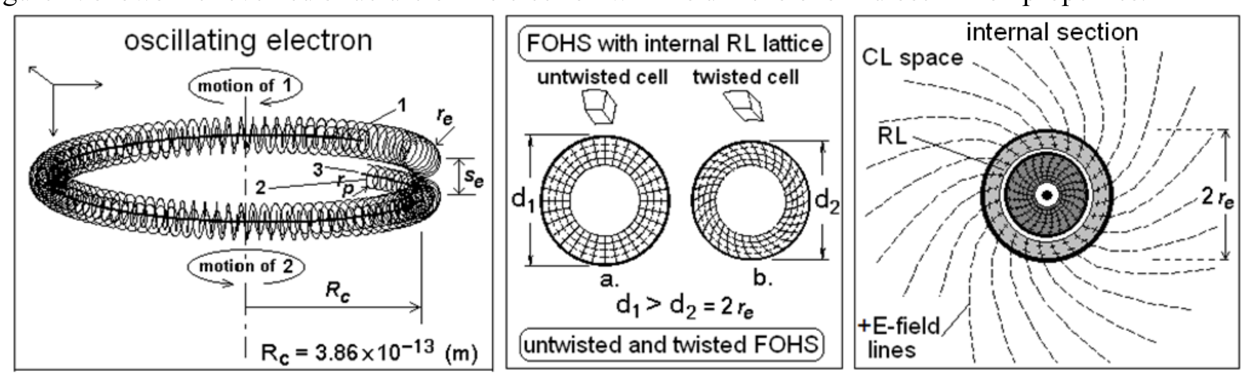
Abstract:
The Heterodyne Resonance Mechanism (HRM) is predicted in the Basic Structures of Matter – Supergravitation Unified Theory (BSM-SG). The HRM effect takes place in a transient process of plasma. Neutral plasma in self-oscillation mode with optical signature of glow discharge emits EM radiation in a broad spectral range. The spectrum is different from the atomic and molecular spectra. According to the BSM-SG models, the EM emission is caused by synchronised spin-flips of the electrons involved in ion-electron pairs. The ion-electron pairs are similar to some experimentally observed Rydberg matter, while possessing unknown so far features. The observed spectra are in the radiofrequency MHz range. The analysis leads to the conclusion that HRM takes please in the upper atmosphere of the earth and during the thunderstorms in lower atmosphere. This provides explanation for the strong EM waves emitted from lightning that cause disturbance in the sensitive electronic devices and radio communications. Further study on this issue by using the BSM-SG models may lead to technological recommendations for protection of sensitive electronics.

Keywords: *neutral plasma, glow discharge spectrum, Rydberg matter, electron spin flip, EM emissions during lightning*

1. Introduction

The structure of electron according to the Basic Structures of Matter – Supergravitational Unified Theory (BSM-SG) [1,2,3] was published in a peer reviewed article in Physics Essays in 2003 [4].
Figure 1. shows the revealed structure of the electron with its dimensions and oscillation properties.



a. b. c.

Fig. 1. Structure of the electron: 1 – external helical structure (FOHS), 2 – internal RL structures, 3 – FOHS section

The dimensional values estimated in Chapter 3 of BSM-SG are follows:

$R_C = 3.86159\times10^{-13}$ (m) - the known Compton radius

$r_e = 8.842\times10^{-15}\ (m)$ - thickness radius of helical structure 1

$r_p = 5.8952\times10^{-15}\ (m)$ - thickness radius of helical structure 2

$s_e = 1.77061\times10^{-14}\ (m)$ - helical step

$s_e/r_e = g$, where g is known as a g-factor

$g = 2.00231930436182$ (NIST CODATA)

The physical structure of electron is fundamentally important for understanding its quantum mechanical properties. It is revealed that the free electron possesses preferable quantum velocity corresponding to the principle quantum numbers in hydrogen atom. The parameters of electron quantum motion are given in Table 1.

Table 1. Quantum motion parameters of the electron

n	E (eV)	V_{ax} (c)	V_t (c)	V (m/s)	r_{mb}	quantum interaction
1	13.6	αc	c	2.187×10^6	$\approx R_c$	optimal
2	3.4	$\alpha c/2$	$c/2$	1.094×10^6	$2R_c$	suboptimal
3	1.51	$\alpha c/3$	$c/3$	7.288×10^5	$3R_c$	suboptimal
4	0.85	$\alpha c/4$	$c/4$	5.468×10^5	$4R_c$	suboptimal
5	0.544	$\alpha c/5$	$c/5$	4.374×10^5	$5R_c$	suboptimal

Notation: n – first harmonic or subharmonic number
E – electron energy in (Ev)
V_{ax} – axial velocity (expressed by speed of light)
V_t – tangential velocity
V – axial velocity in (m/s)
r_{mb} – magnetic radius (expressed by Compton radius)

The Heterodyne Resonance Mechanism (HRM) is predicted in the (BSM-SG). The HRM involves interaction between the electron, oscillating with Compton frequency, and the Cosmic Lattice (ether-like structure of the physical vacuum). The meaning heterodyne is known in radioelectronics as a nonlinear interaction between different frequencies. In our case it is somewhat different, because the Compton frequency is a property of the SPM (Spatial Precession Momentum) – a CL space feature involved in the constancy of velocity of light, but the purpose is similar: accessing the super-high Compton frequency of the CL structure (physical vacuum) by using a frequency in KHz range. The HRM effect takes place in neutral plasma where it invokes oscillating ion-electron pairs. Fig. 1. illustrates the oscillation traces of electron and a positive ion of a single ion-electron pair. The electron circling around much heavier proton (or atomic ion) outside of the Bohr surface (§7.2.2, Chapter 7 of BSM-SG) [3] creates a magnetic field. This corresponds to the Rydberg state of the atom. It is experimentally found that the so called Rydberg matter in plasma exhibits a magnetic field. The BSM-SG atomic models have a distinguished boundary between the normal and Rydberg state. At normal state the electron changes rotational direction and does not provide an external magnetic field. The term ion-electron pair is more descriptive than a Rydberg atom because the positive ion may be not only an atom but also a molecule. The magnetic lines from rotating electron envelop the ion-electron pair as shown in Fig. 2.

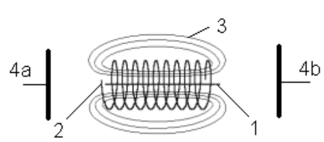


Fig. 2.. Helical trace and magnetic field of electron bound to a positive ion forming an ion-electron pair. 1- positive ion trace, 2 – electron trace, 3 - magnetic field from the electron, 4a and 4b – electrodes providing electrical field that triggers the HRM.

The study of the HRM effect is easier when a properly selected gas at partial vacuum is enclosed in a cell containing electrodes with a suitable geometry. The ionization and the motion of the ion-electron pair is triggered by an AC high voltage or strong DC pulse with a repetition rate in the kHz range. In fact, the applied electrical field must trigger the ionization and the initial acceleration of the ion-electron pair, which then performs its own magnetic field. Due to the magnetic interactions between the individual ion-electron pairs, they form a cluster, in which they move synchronously. The spatial arrangement of ion-electron pairs in such a cluster is illustrated in Fig. 3. for the case of atomic hydrogen.

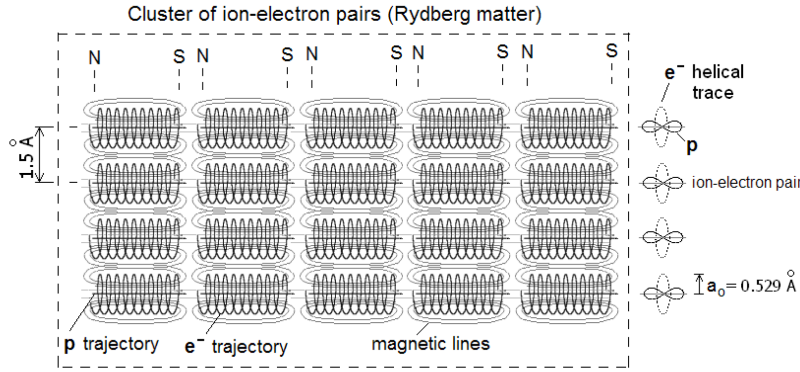


Fig. 3. Ion-electron pairs arranged in a cluster. The magnetic fields of the individual pairs are synchronized.

The distance of 150 pm corresponds to the experimentally obtained distance by L. Holmlid for n = 1, who did extensive research on Rydberg matter and found existence of clusters. […]. Our consideration for ion-electron pair, however, is logically different from his and other interpretations of the Rydberg state of matter.

A large number of clusters form a supercluster with a configuration similar to a rope of twisted threads as illustrated in Fig. 4.

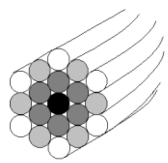


Fig. 4. Clusters form a twisted supercluster. The superclusters excite the surrounding gas molecules or ions and they emit light in the optical spectral range.

The electrons in the twisted supercluster tend to move with one and a same confined velocity. The HRM effect is most effective for optimal confined velocity corresponding to electron energies of 13.6 eV, 3.41 ev and 1.51 eV. At the same time, the magnetic fields of individual clusters tend to confine. This means that the radii of helical traces of clusters will vary from the centre to the periphery of the supercluster.

While in a neutral atom the electron changes the rotational direction during the orbital cycle, in Rydberg state (ion-electron pair) its rotational direction is one and a same. This not only creates a detectable magnetic field. In this state the magnetic moment of the electron (658 times greater than of the proton) is behind one effect, not predicted by the modern physics.

Table 1 shows the preferred quantum velocities of the electron due to quantum interaction with the CL space at Compton frequency.

The HRM effect is involved in the nuclear reactions known as LENR or cold fusion, presented in my book "Structural Physics of Nuclear Fusion with the BSM-SG atomic models" [4].

I experimentally observed the signature of HRM effect by detecting an uknown so far spectrum in RF range of activated neutral plasma of hydrogen and other gases in partial vacuum in 2005. I did not have adequate explanation at that time, so the spectra given in this article are published for the first time. They are discussed in my next book.

2. Vacuum cells

I made a few vacuum cells and a vacuum system for air evacuation and filling of these cells with a chosen gas. Most of the cells have two internal electrodes. Cells with a 3rd and a 4th internal grid electrodes were also used. Some cells were designed with one internal and a second external electrode. Fig. 5, 6 and 7 show three of the vacuum cells.

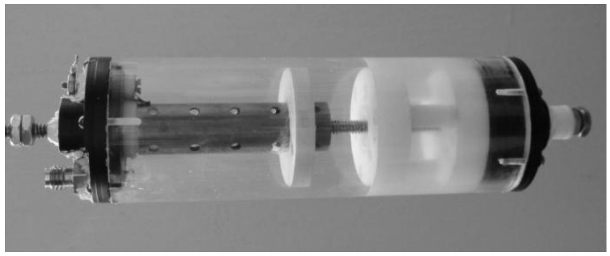


Fig. 5. Vacuum cell as a Grey tube with a vacuum fitting, according to patent application of Edvin Grey

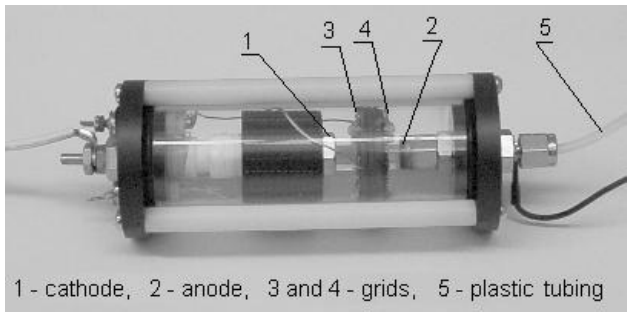


Fig 6. Vacuum cell with grid electrodes for study of glow discharge.

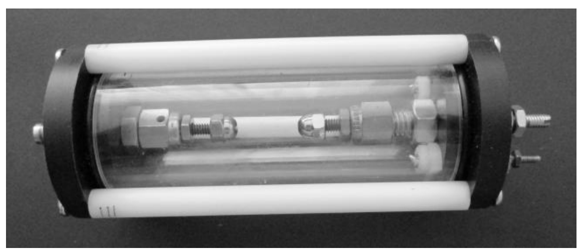


Fig 7. Vacuum cell with two glow discharge electrodes

The shown vacuum cells were filled and tested with various gases: air, H_2, He, Ar, N, CO_2 etc. The CO_2 gas appears to be not suitable. Many gas molecules are not suitable for HRM because of their shape. The most suitable is H_2 gas, since the conditions for ion-electron pair was easy achieved for molecular and atomic hydrogen. The noble gases are also suitable because they are atomic and their BSM-SG atomic model has a compact shape.

The vacuum cells have a fitting connected by a flexible tubing to a vacuum pump with a pressure gage and a stopping valve. I provided a variety of experiments at reduced pressure (partial vacuum) and at normal air pressure. The expected signatures of HRM effect are easier identifiable when working at partial vacuum in the range of 8 to 15 mbars. This permits also to use a moderate high voltage between 1.5 kV and 2.5 kV. Different cells were designed with the possibility to be filled with different gases and to operate at different vacuum levels

3. Electrical circuit setup for study of the HRM effect

From my previous research on gravity effect I found that the HRM effect takes place in a transition process for a very short time. How to study the HRM in a short transition process? I noticed one unusual effect. Without activated plasma the capacitance between both electrodes of the actuator (thruster) is only a few pikofarads. When the plasma is activated, however, the driving circuit (AC HV generator at about 25 kV AC) must deliver a power like driving a capacitive load of a few nanofarads. This problem has been noticed in a prior research experiments with glow discharge and the increased required AC power was considered as a reactive power. My analysis using the BSM-SG model of predicted ion-electron pairs led me to the conclusion that the increased apparent capacitance of the plasma is a result of the tendency of the electrons to move with preferred quantum velocities shown in Table. 1.

Therefore, the feature of the apparent capacitance of activated plasma could be used to make a resonant circuit (known also as a tank circuit) for study of this phenomenon.

Oscillation in needed resonant circuit can be easily triggered by electrical pulse or by using the specific feature of the V-A characteristic of the spark that has a negative region. This is valid also for a spark condition in a low gas pressure. I used the latter option for invoking a HRM effect in my gas cells at gas pressure between 9 and 15 mbars.

The circuit diagram for invoking a HRM effect is shown in Fig. 8. The resonant circuit is comprised of a vacuum cell VA, an external capacitor C and inductance L connected in a way shown in Fig. 8. The other components serve to invoke and measure the features of the observed oscillations. The optimal values of C and L depend mostly on parameters: the gas pressure, the applied DC voltage, the electrode distance etc. (*C* is in order of a few *nF*; *L* – tens of μH).

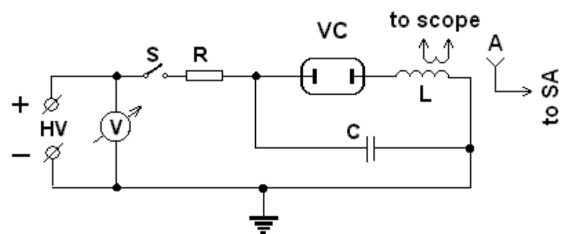


Fig. 8. Basic circuit for HRM study VC – a vacuum cell with gas, HV –high voltage, SA – spectrum analyzer

It was found that the glow discharge in vacuum cell VC in a configuration with external capacitance C and inductance L operates in a self-oscillating mode in which the signature of the HRM effect is observed. In case of hydrogen at vacuum pressure of 7- 10 mbars, HV 1.5 kV to 2.5 kV, the initial values of R, L and C, for example, were R = 2.2 Mohm, L =60 μH, C = 2 nF. There was a possibility for their adjustment in order of +/- 40% (or more). The complete test circuit in which the vacuum cell with the resonant circuit are embedded is shown in Fig. 9.

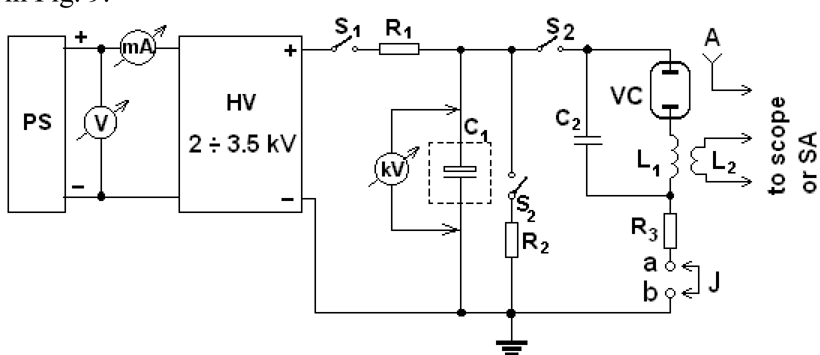


Fig. 9. Electrical circuit for study of HRM in the glow discharge in vacuum. PS – low voltage power supply, HV - high voltage power supply, VC – vacuum cell, R_2 – safety discharge resistor

The circuit in Fig. 9 with a capacitor bank C_1 = 12 μF / 4.5 kV and R_3 = 2.2 Mohm permits operation of the glow discharge after C_1 is charged and HV supply is disconnected by switch S_1 . Normally the jumper J is closed. The HV charge of C_1could be kept constant or slowly changing. In the latter case after C_1 is charged to 2.5 kV, the switch S_1 is turned off and S_2 is turned on, the glow discharge operates for about 1 min, while the voltage slowly drops to the minimal value for the glow discharge operation - about 1.3 kV (depending on the gas pressure).

The observed glow discharge has a specific optical and EM signature.

The optical signature is well-known from the prior art. The glow surrounding around the cathode, however, was not correctly understood. This is visible in the color pictures shown in Figures 10 and 11.

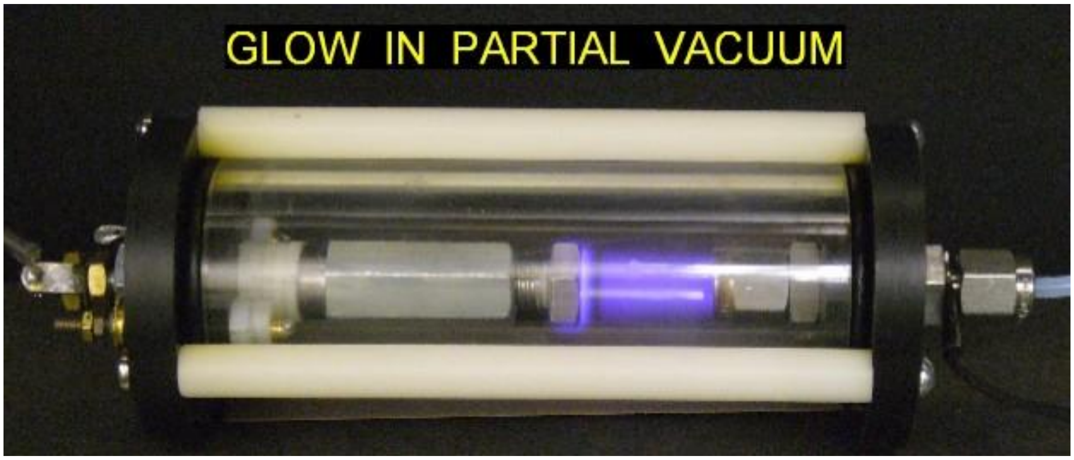


Fig. 10. Glow discharge of hydrogen in partial vacuum at 7 mbars

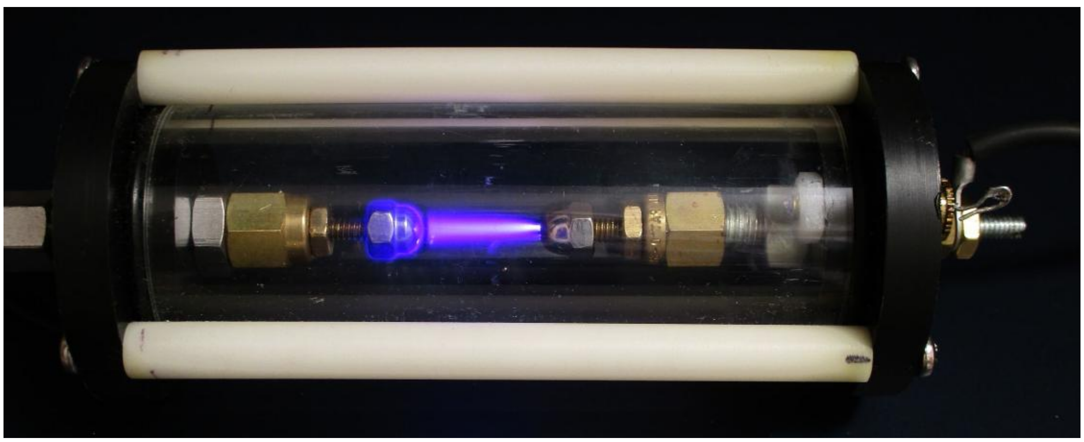


Fig. 11. Glow discharge of air in partial vacuum at 12 mbars. The glowing plasma enveloping the cathode is clearly visible. The two colors blue and pink corresponds respectively to oxygen and nitrogen gases.

According to the prior art explanation this is a result of positive ions bombarding the cathode. However, the question is why this could happen also at the back side of the cathode, where the electrical field gradient is zero. Our explanation is that this blue glow is a result of scalar (longitudal) waves, discovered by Nikola Tesla who named them “radiant energy”. These are “compress-like” waves in the CL structure of the physical vacuum. They are much stronger than the EM waves but attenuate faster. The same waves invoke the visible threads in the plasma globe when they are activated by external Tesla coil at distance without any wire connection. This is illustrated in Fig. 4.5. where a glow discharge in a Tesla globe is activated by external Tesla coil at distance a few cm from the globe. This is one demonstration of the effect from the scalar (longitudinal) waves. The same waves cause the glow discharge envelope of the cathode.

4. Experimental results.

When C_1 is charged to the operating voltage range and switch S_2 is closed a self-oscillation takes place in the circuit of the VC, C_2 and L_1 and the glow discharge is visible. It is characterized with a burst rate that depends on the VC geometric parameters, the (vacuum) pressure, the HV and the values of C_2 and L_1. At the same time the vacuum cell emits EM radiation in RF (MHz) range.

Fig 12. shows the waveform of a single burst recorded by oscilloscope Rigol DS1102E (the scope lacks of high display resolution). The waveforms are measured by using the vacuum cell shown in Fig. 10. with air at pressure of 11.5 mbars. The burst frequency is in the range of 400 to 800 KHz (depending on high voltage). The burst is followed by oscillations in MHz range that are signature of the HRM effect.

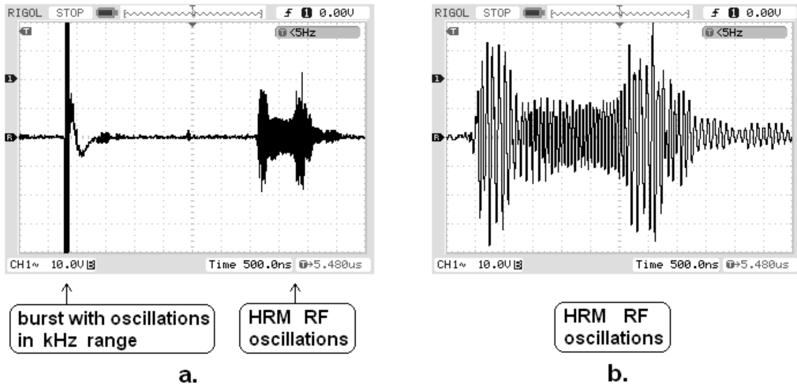


Fig. 12. Waveforms of glow discharge of air at 11.5 mbars partial vacuum, a. – busrt rate with the HRM oscillations, b. expanded view of the HRM oscillations

Fig. 13 shows the measured burst rate dependence on the external inductance for two HV values.

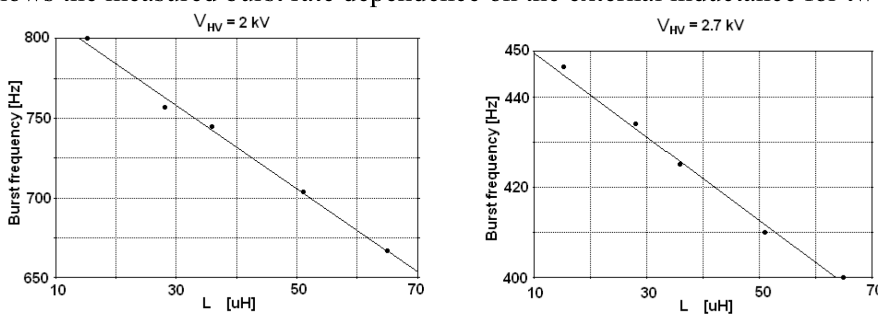
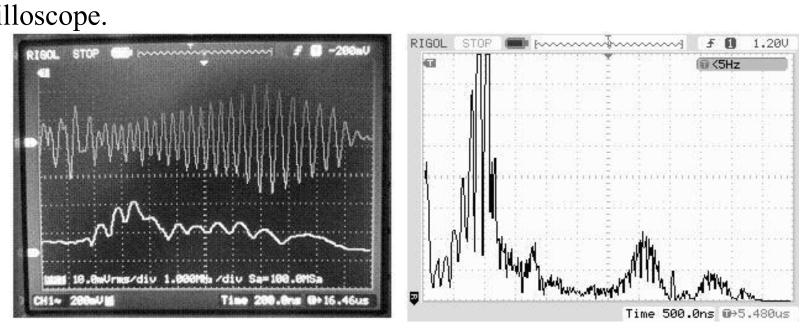


Fig. 13. Burst rate dependence on external inductance L_1 for 2 kV and 2.7kV. Vaccum cell with air at 11 mbars.

Fig. 14 shows a part of the HRM oscillations and FFT spectrum of air at 12 mbars, measured by Rigol DS1102E oscilloscope.



a. b.

Fig. 14. a - waveform of HRM (upper curve) and FFT spectrum (lower curve), **b -** FFT showing 3 spectral bands of HRM

The HRM spectrum in Fig. 14.b. obtained by FFT does not show sharp spectral lines (frequencies) for two reasons: The HRM frequencies are jittering (this will be explained in the next book) and the FFT is affected by the triggering accuracy (the triggering synchronization is in the kHz range). If using a fast spectrum analyzer like the Hewlett Packard HP 8590L with selectable spectral range the HRM spectrum will appear quite sharp. Another feature of the HRM oscillations is that they appear after some delay from the burst signal. With air at partial vacuum of 11 mbars, HV = 2 to 2.8 kV and electrode distance of 14 mm the delay is about 18 to 20 uS and the duration of HRM oscillations is about 2.5 - 4 uS. It is also observed that some RF oscillations with exponentially falling amplitude appear immediately at the burst, but they do not have the rich spectrum as the HRM oscillations. The delay between the burst oscillations and the HRM oscillations may vary with the pressure, but this was not studied yet.

The HRM signature is also apparent at atmospheric pressure, but at much higher voltage. The test with air is not the best option in comparison with hydrogen or noble gases but it shows some important features of HRM effect.

Conclusions:

a. **In a self-oscillating glow discharge mode the burst frequency is in the kHz range.**
b. **The RF frequency patch that is usually separated from the burst frequency by tens of microseconds is a signature of the HRM effect.**

The next high resolution spectra of hydrogen I measured in 2005. In my extensive search I did not find similar reported spectra and since I did not have reasonable explanation at that time I delayed their publication.

Fig 15. shows HRM spectrum of hydrogen in the frequency range from 1.255 to 13.75 MHz obtained by HP spectrum analyzer, model HP 8590L. A dry vacuum pump from Varian was used in order to avoid a contamination. The VC was initially purged at low vacuum below 3 mbars and then filled with a chosen gas. For test with hydrogen the gas pressure was in the range of 9 to 13 mbars and the applied voltage was in the range of 1.6 kV to 2 kV. The signal is taken by a small 10 cm antenna at distance of 15 cm from the cell.

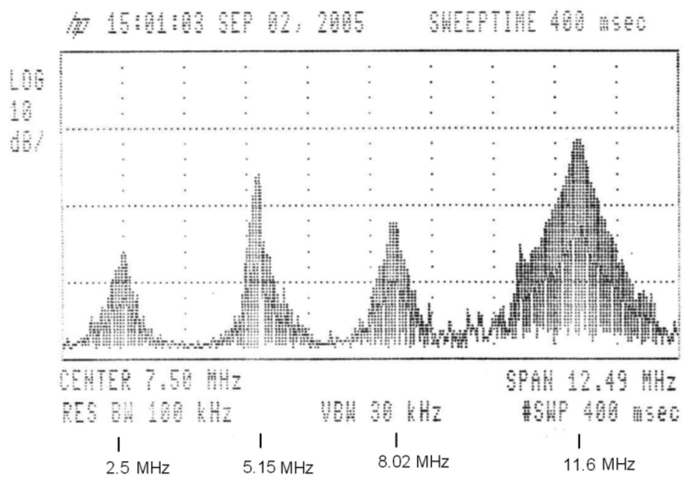


Fig. 15. Four bands of HRM spectrum of hydrogen with identified central frequencies

Fig. 16. shows the HRM spectrum of the strongest band at 11.6 MHz by enhanced spectral resolution.

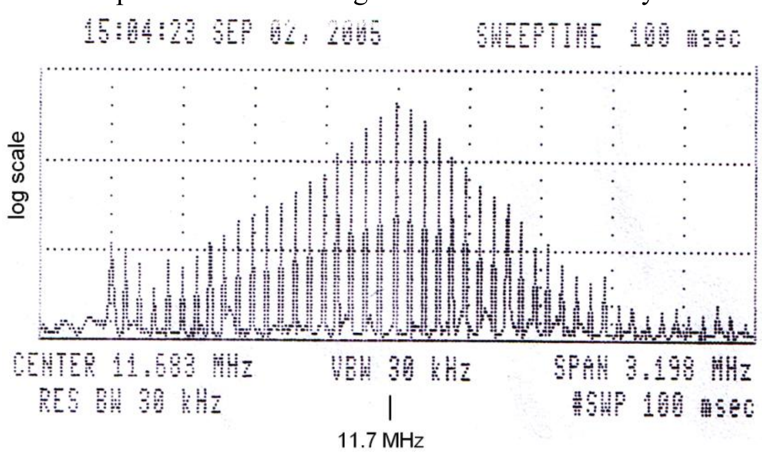


Fig. 16. RF spectral signature of a supercluster from HRM effect in EM activated plasma of hydrogen at 12 mbars.

Figures 17, 18, 19 and 20 show consecutively measured spectra of three bands with different sweep time. They show features that will be discussed in my next book.

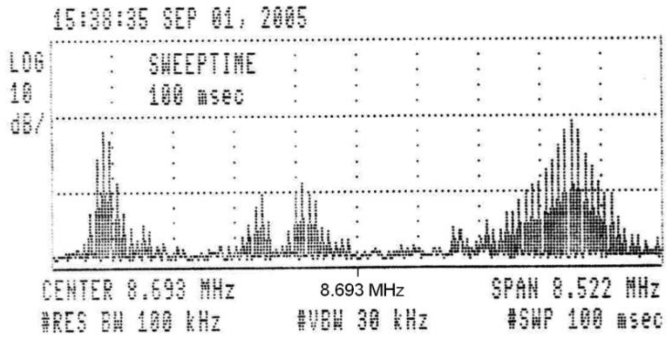


Fig. 17. Hydrogen spectrum, 100 ms sweep time

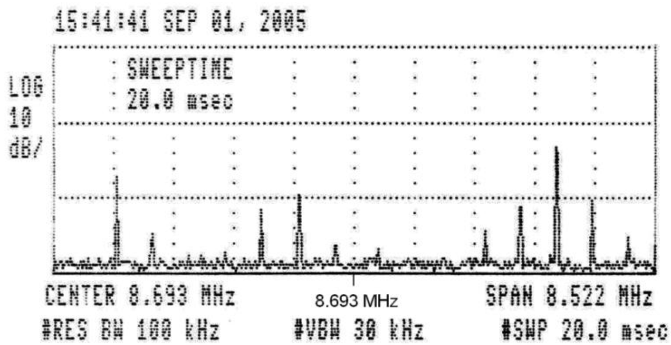


Fig. 18. Hydrogen spectrum, 20 ms sweep time

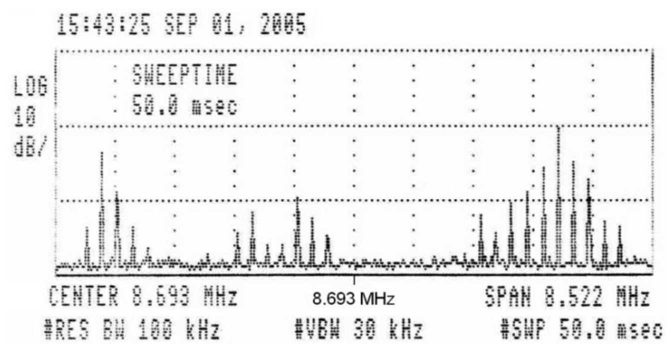


Fig. 19. Hydrogen spectrum, 50 ms sweep time

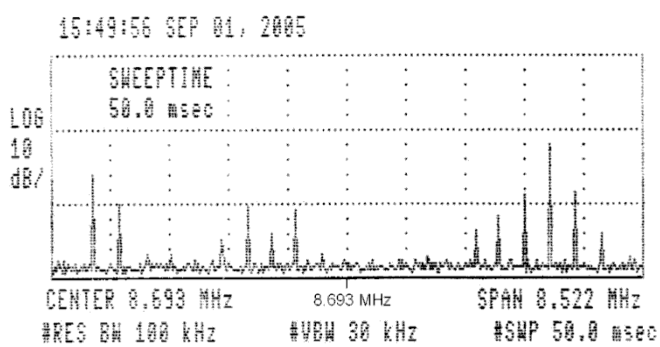


Fig. 20. Hydrogen spectrum, 50 ms sweep time

Fig. 21 shows the experimental setup for measuring the spectra of HRM effect. The Spectrum analyser and vacuum pump means are not shown.

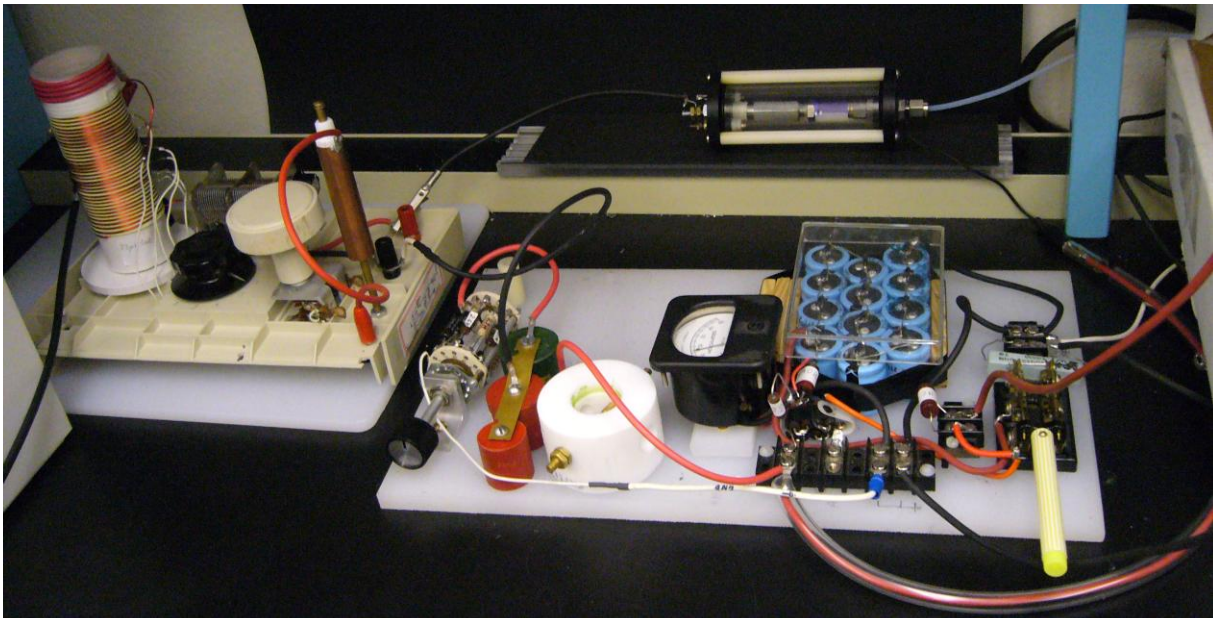


Fig. 21. Test setup for measuring the HRM spectra (2005)

Tens of hydrogen spectrums have been measured in 2005 in one of York University laboratories, Toronto, Canada. The applied HV could be kept constant or permitted to change slowly from 2.5 kV to 1.5 kV for 1.5 min by discharging of the capacitor bank C_1 . The discharge current was about 1 mA. The pressure level is stable for a single run of the spectrum analyser. It slightly changes from 9 mbars to 12 mbars for about 4 hours. Spectrums at normal air pressure from glow and spark discharge are also measured. In my next book the analysis of measured spectra is compared with other observations and experiments. The HRM effect emits EM waves in quite broad spectral range. It helps also to understand some transient events in the upper and lower atmosphere. The EM emission from lightning is of particular interest [7,8], and the HRM effect provides a key for understanding the physics behind this transition process. Additionally some experiments and observations indicate that HRM effect could exist even at higher pressure.

All measured spectra are given in my another article "Atlas of HRM spectra (volume 1)", (vixra.org).

5. Conclusions:

The HRM effect predicted in BSM-SG theory takes place in a transition process of neutral plasma. The detailed analysis of the HRM spectra will be given in my next book. My preliminary conclusion is that the observed spectra are signature of synchronized spin flipping of the electrons involved in the ion-electron pairs. Another conclusion is that the HRM effect takes place in the plasmoids observed in the upper atmosphere and in the lightning in the lower atmosphere that is a transition process. The most intensive emission takes place during the lightning between the cloud and ground. It is known that the lightning is not a single discharge. The lightning that hits the ground has two phases. The first one is its propagation to the ground that takes a finite time. The second one is after hitting the ground. During the first phase the release optical and EM radiation is not so strong. In the second phase, however, multiple thick flashes take place and the released energy is thousand times stronger. A strong HRM effect takes place during the second phase. The analysis of HRM effect by using the BSM-SG models permits to reveal the physical process behind the enormous released energy during the second phase of the lightning. The details of the revealed physical process will be presented in my next book.

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