Analysis of the HRM spectra in plasma glow discharge

Dr. Stoyan Sarg Sargoytchev

World Institute for Scientific Exploration

Abstract:

The HRM effect (Heterodyne Resonance Mechanism) is predicted in the Basic Structures of Matter – Supergravitation Unified Theory (BSM-SG). In properly activated neutral plasma a discrete frequency spectrum in radiofrequency range is observed. The term heterodyne means that the process is activated in the kHz range, while the observed spectrum is in the MHz range. The spectrum is different from the vibrational rotational spectra of molecules. It has spatial and time duration limits and could be observed only in a small volume at fast sweep time. The spectrum characteristics depend on the type of gas and conditions of the transient process. Hydrogen and inert gases are the most suitable for the HRM effect. According to analysis, the HRM spectrum is a signature of synchronized spin-flips of the electrons involved in ion-electron pairs. HRM effect involves quantum mechanical interactions in which the electrons access the zeropoint energy of the physical vacuum. It is predicted that the HRM effect takes place in the transient process of lightning. The signature of HRM effect in the lightning is a subject of another article.

Keywords: *neutral plasma, glow discharge spectrum, Rydberg matter, electron spin flip, zeropoint energy*

1. Analysis of prior art research on Rydberg matter showing a signature of HRM effect.

Extensive research on Rydberg matter was made by Leif Holmlid. In his article [9] he says Excitation levels n, nB with shorter interatomic distances exists for hydrogen clusters and distances down to 140 pm are now measured with this light-scattering method. The clusters studied have maximum dimensions from 0.3 nm up to tens of nm, often being planar. In another article Leif Holmlid detects energetic ions [10].

In another article by F. Olofson, P. Andersson and L. Holmlid, about Rydberg matter clusters in polar mesospheric clouds it is found: Such experiments show that RM clusters interact strongly with radar frequencies: this explains the radio frequency heating and reflection studies of PMSE layers. [11]. In the same article it was also found that the time between collisions with other RM clusters is about 6 h. In other article S. Badiei and L. Lolmlid, presents s study of hydrogen Rydberg matter (RM) by pulsed-lase-time-of-flight. It was found that between four and six photons with a total energy of 8.8 – 13 eV take part in the RM fragments.

In his manuscript of “A problem in Plasma Science” Dr. Harold Apsden put emphasise on anomalous acceleration forces exerted by electrons on ions. He discussed this issue in his article in IEEE Transaction on Plasma Science [12].

In the article “Anomalous Electron-Ion energy Transfer in a relativistic-Electron-Beam-Heated Plasma”, J. Sethian e al., describe an experiment to study the previous observations that the beam-to-plasma energy transfer is far faster than can be explained by classical processes. [13]. In a plasma column they inject an electron beam, with parameters v = 350 kV, I = 22 kA, t = 60 ns. They claim: experimental evidence is presented for an observed anomalous electron-ion energy transfer in a magnetized beam-heated plasma that is approximately 103 times faster than classical. They claim a rapid decrease in plasma density during the first 2 usec after beam injection. In fact this is anomalous process of plasma expansion not explainable by the rules of classical thermodynamics.

Yu Astrov et al. observed quite interesting formations of clusters [14]. They make a gas discharge device formed of two parallel perfectly flat silicon disks with diameter 20 mm doped with gold or zinc to behave as a spatially distributed resistive load. A photo resistive layer is deposited for changing the resistance by illumination. Transparent metal electrodes are deposited to which a DC voltage in order of a few kilovolts is applied. The gap between disks with size of 1 mm is filled by nitrogen at pressure of 120 hPa. The device is transparent permitted observing the discharge pattern while the resistivity can be controlled by illumination. The device is cooled to liquid nitrogen temperature of 90K. Applying a high voltage causes a discharge pattern of spatially separated clusters that are optically recorded. The most stable pattern is hexagonal. In Fig. 2 of the article they show two of the observed patters with the following description: The hexagon (initial pattern evolves from the homogeneous state by increasing the supply voltage, a further increase of the voltage is accompanied by the transformation of the hexagon into the stripe pattern. In another article of Astrov et al., with better optical resolution they observe a zigzag pattern instead of clear stripe [14]. The observations matches the specific features of the superclusters from ion-electron pairs.

Conclusions:

a. The observed pattern in [14] is a signature of superclusters formations
b. The superclusters are aligned along the sight of observation and evenly separated. The most stable pattern is a hexagonal. Evidently the complex individual magnetic field of the superclusters keeps them separated.
c. The appearance of zigzag pattern indicates that the magnetic field configuration of the superclusters is complex, but it is the same for all superclusters during their time of existence.
d. The experiments with injected high current short pulse show an anomalous effect of plasma expansion [13].

2. Why the HRM spectrum has not been identified and studied in the past.

It is curious that plasma glow discharge is known for about 130 years but one very important problem has not been solved. Oscillations in ionised gases are firstly reported by F. M. Penning in 1926 for different gases included the inert gases [15]. At that time the quantum mechanics was flourished and many publications were focused mostly on theoretical interpretation. With the advance of technology in radiofrequency (RF) range a large number of papers appeared after 1950, but the theoretical interpretation was tightly bound to the quantum mechanical model of the atoms based on Bohr atom of hydrogen. It is reasonable to use the hydrogen since the hydrogen molecule is easier for analysis. Some of the observed frequencies in RF range were suspected to be from the vibrational-rotational spectra of H_2^+ ion. Jeffers was the first who succeeded to assign 30 observed frequencies in the range of 3.99 MHz to 1276 MHz [16]. Evidently, the search for these frequencies has been guided by theoretical predictions. Jeffers assigned them to the energy levels of the para H_2^+ ion related to the electron spin change according to the Hamiltonian $H_{eff} = d\vec{S}.\vec{K}$. Table 1 shows some of the frequencies assigned by Jefferes to the spectral bands of the observed HRM spectra.

Table 1. Transition frequencies and Hamiltonian coefficients, for vibrational states v = 4 to v = 8, rotational states K = 1 and K = 2 [16].

V	3/2,3/2 – 3/2,5/2	1/2,3/2 – 1/2,1/2
4	5.721 MHZ	15.371 MHz
5	5.258 MHz	14.381 MHz
6	4.817 MHz	13.413 MHz
7	4.395 MHz	12.461 MHz
8	3.989 MHz	11.517 MHz

In is known that the neighbouring frequencies of the spectral bands of vibrationa-rotational spectra are not equally spaced. This is apparent also in the frequencies of the two bands in Table 1. The differences between the neighboring frequencies from v = 4 to v = 8 decreases. If fitting to a robust line the decrease in the band (3/2,3/2 – 3/2,5/2) is with a coefficient -0.4327 and in the band (1/2,3/2 – 1/2,1/2) it is with a coefficient -0.9628.

In contrast, the observed frequencies of the HRM spectra are equally spaced. This striking difference is amongst the strong arguments that the HRM spectra are not vibrational-rotational spectra of the molecules. The explanation is again in the difference between the quantum mechanical mathematical models of the atoms and the BSM-SG physical models. The HRM spectra cannot be theoretically predicted by the QM models. This in fact left one unsolved problem for many decades.

3. Analysis of the experimental data from the study of the Heterodyne Resonance Mechanism published in [6,7]

Fig 1. 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 with air at pressure of 11.5 mbars. (Fig. 10 of [7]).

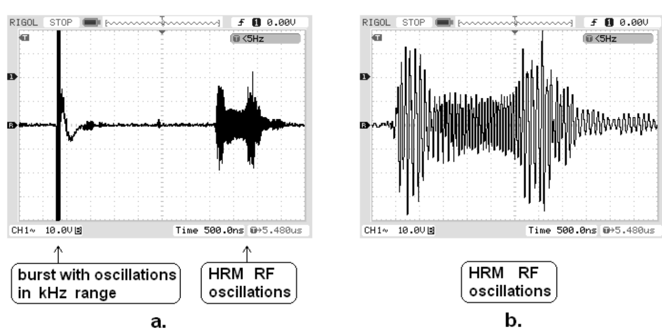


Fig. 1. Waveforms of glow discharge of air at 11.5 mbars, a. – waveform of burst rate with the HRM oscillations, b. expanded view of the HRM oscillations

The burst frequency is in the range of 400 kHz to 800 KHz (depending on high voltage). The burst is followed by oscillations in MHz range that are signature of the HRM effect.

Fig. 2 shows the measured burst rate dependence on the external inductance for two HV values.

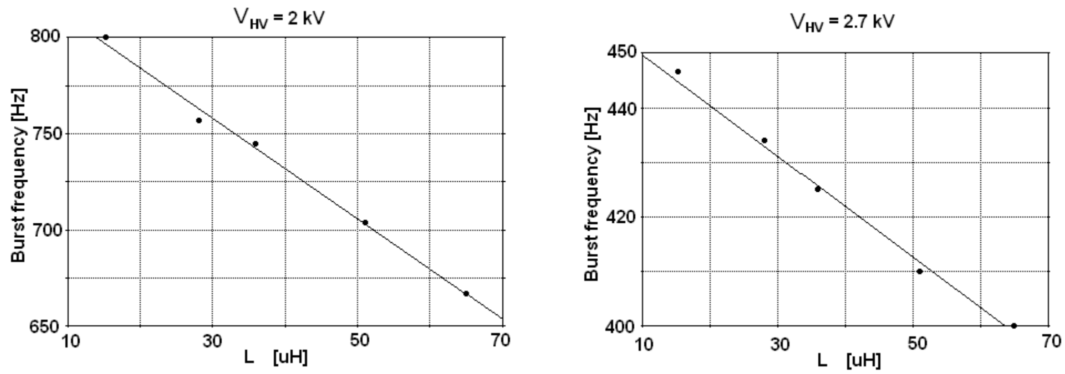


Fig. 2. Burst rate dependence on external inductance L_1 for 2 kV and 2.7kV. Vaccum cell with air at 11 mbars.

The waveform in Fig. 1.a shows the burst rate (frequency) in KHz range and the RF frequency of HRM in MHz range. Fig. 4.b shows the HRM in MHz range with higher resolution. The gas was air at 12 mbars. It was observed that there is always a delay between the burst pulse in KHz range and the HRM. The operating HV was between 2 and 3 kV. For many runs the delay is between 20 and 24 uS and the HRM duration between 2 and 4 uS. The burst frequency depends on the external inductance L1 and the HV as shown in Fig. 2. but the delay and the duration of HRM are not much dependent on L1 and HV. The delay exists also for external activation by electrical pulse as shown in Fig. 3 [7].

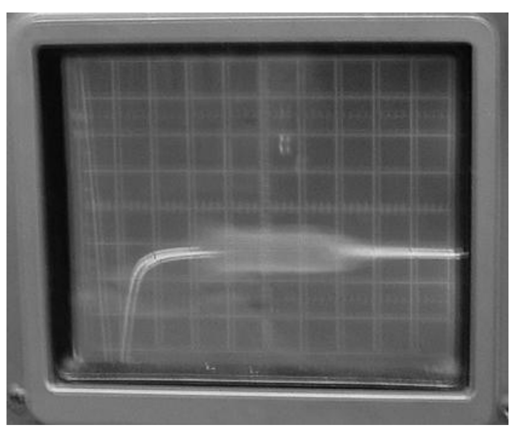


Fig. 3. HRM patch appears after some delay from the switching pulse

Let us analyze the hydrogen spectrum shown in Fig. 4 [6,7]. The four bands of HRM spectrum probably correspond to ion-electron pair clusters with electron velocities corresponding to 0.85 eV, 1.51 eV, 3.4 eV and 13.6 eV. The higher intensity band at 11.6 MHz is probably for pairs with electron energy of 13.6 eV (the optimal confined velocity of the electron [4]).

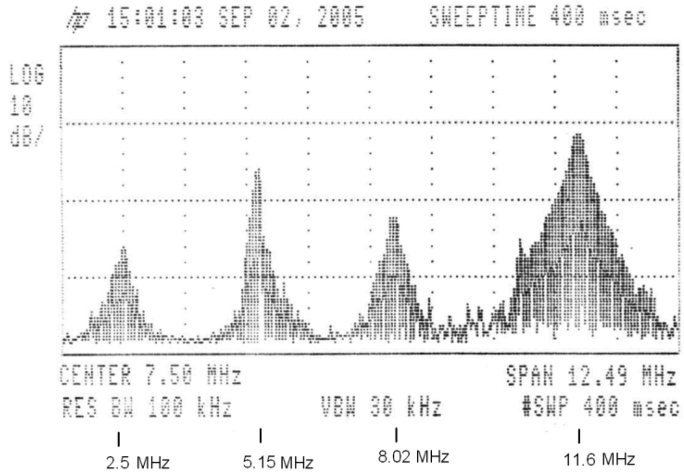


Fig. 4. Four bands of HRM spectrum of hydrogen with identified central frequencies

Fig. 5. shows the HRM spectrum of the strongest band at 11.6 MHz by enhanced spectral resolution.

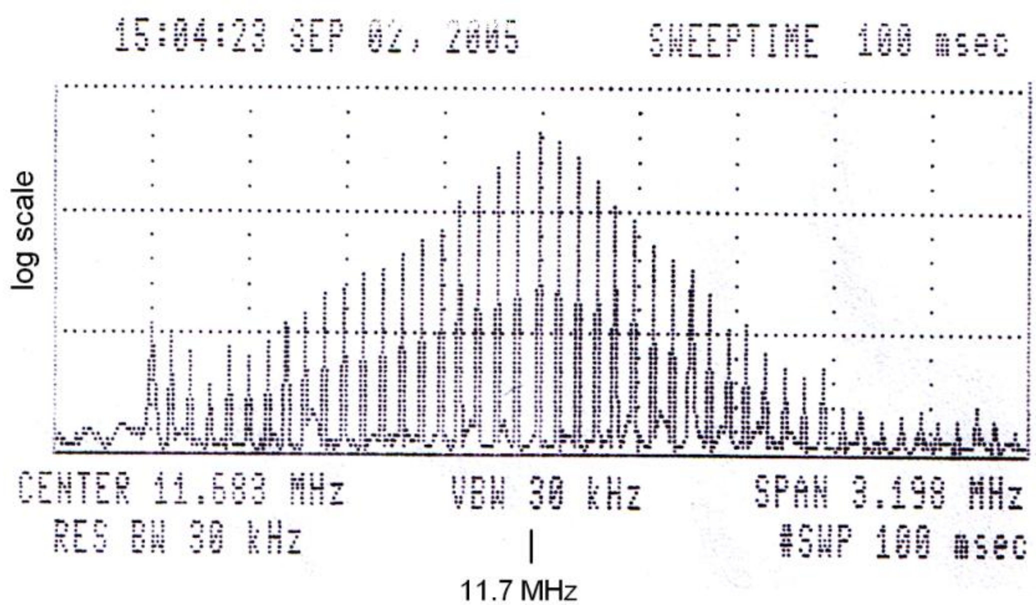


Fig. 5. RF spectral signature of a supercluster from HRM effect in EM activated plasma of hydrogen at 12 mbars.

Fig. 6. shows oscillations with one and a same frequency of 5.17 MHz obtained by using a tunable resonant circuit [7]. The shape of waveform is like signal with amplitude modulation. It is clearly visible that at the nodes the oscillations change the phase by 180 deg. This could be from electron spin change. The signal intensity is so high over the noise that we may conclude that electron spin change occurs simultaneously in a huge number of ion-electron pairs.

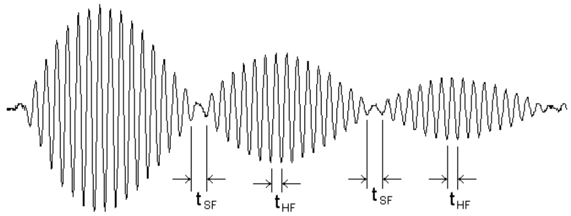
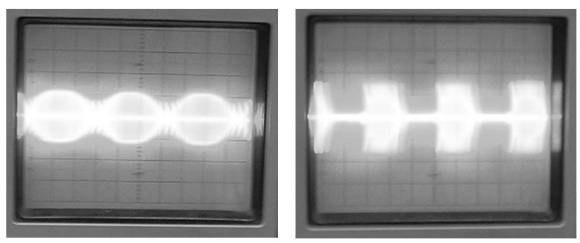


Fig. 6. Expanded section of HRM oscillations of hydrogen gas measured by a digital scope.

The amplitude modulation of the waveform in Fig. 7. indicates that the intrinsic electron energy is not constant. It changes periodically that causes a periodical spin flip of the electrons. This conclusion comes from the waveforms shown in Fig. 6 where the oscillations are externally manipulated by a positive feedback. We see that at strong feedback a gap between patches occurs without oscillations. This means that the electrons exhaust their internal energy due to external manipulation, so they need some in order to restore it to the optimal level. The needed energy they obtain from the ZPE-D energy of CL space.



a. **b.**

Fig. 7. Envelope waveforms for different strength of the positive feedback; a. – weak, b. strong

Now let us imagine the spatial arrangement of one supercluster. Its configuration is illustrated in Fig. 8. It is formed by one central cluster and three layers of clusters. Each layers contains six clusters. Clusters of any layer are at the same radius in respect to the central axis. At the same time they are twisted like the threads of a rope. The ion-electron of the whole supercluster moves with one and a same velocity, corresponding to one of the electron quantum energies of 13,6 eV, 3.41 eV, 1.51 eV, 0.85 eV etc.

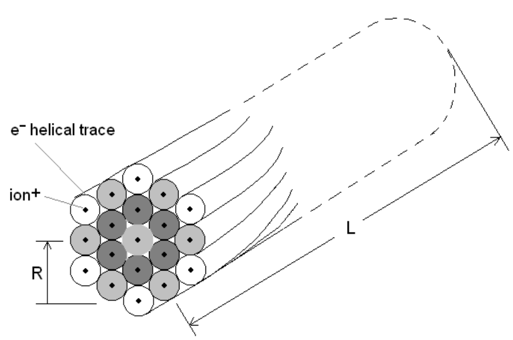


Fig. 8. Spatial arrangement of clusters in the supercluster. The clusters of same order are at one and a same radius in respect to the central axis.

The analogy of this configuration is like a solenoid with multiple layers of windings. The magnetic field of such solenoid is illustrated in Fig. 9. The field strength decreases with the radius in respect to the central axis.

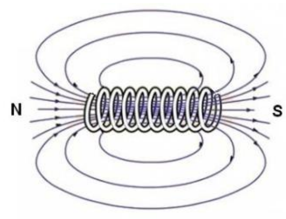


Fig. 9. Magnetic field of the single layer solenoid.

The magnetic fields created by ion-electron pairs in the configuration shown in Fig. 8 could be regarded as a multi-layer solenoid shown in Fig. 9 but with some particular differences. The external magnetic field decreases with the radius, but we must consider one additional option: The electrons in the clusters of one and a same layer (see Fig. 8) may not have one and a same rotational direction. In three of the clusters, for example, the rotation could be clockwise, while in another three – a counter clockwise.

Assuming that the observed spectra are result of spin flip of the electrons we will use the expression (1) and (2) of the spin magnetic moments of the electron, μ_{es}

$$\mu_{es} = \pm \frac{eh}{4\pi m_e} \qquad (1)$$

$$W = \mu_{es} B = \Delta E \qquad (2)$$

where: B is the magnetic field in which the electron moves, W – is the work between two spin energies equal to the energy difference ΔE between the up and down electron spin. From well-known expression $E = hf$ we have the frequency shift proportional to ΔE

$$\Delta f \sim \Delta E \qquad (3)$$

The graphical illustration shown in Fig. 10 helps understanding the observed spectra.

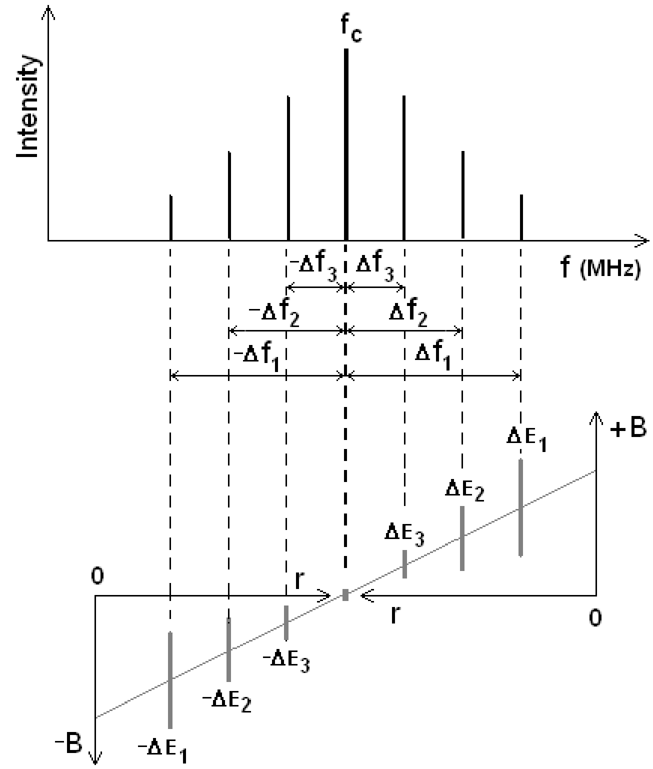


Fig. 10. Graphical illustration of the physical parameters behind the observed frequency spectrum due to electron spin flip. The upper coordinates are in the frequency domain, while bottom coordinates *+B* and *–B* are shown as a function of *r*, but r for +B and –B are shown in opposite direction in order to match the spectrum domain.

The upper part in Fig. 9 is the spectrum of one supercluster, while the bottom part shows the dependence of the frequencies on the radius of the clusters with one and a same radius referenced to the central axis of the supercluster. The magnetic field shown by gray lines decreases with the cluster radius (in analogy with the magnetic field of solenoid shown in Fig. 8). According to (2) and (3) the frequency shift is proportional to the strength B of the common magnetic field. For this reason B decreases with the radius r of the cluster. (). When referenced to the central frequency Fc, the positive frequency shifts corresponds to a magnetic field with a direction +B, while the negative shifts - to the magnetic field with an opposite direction –B. These means that in one and a same cluster half of the electrons may have, for example, a clock-wise rotation, while the other half - a counter-clockwise rotation. The central frequency should be due to at largest radius of the cluster where B is small. To verify this, a serial resonance frequency was included in a serial connection with the circuit shown in [7, Fig 9]. By tuning the resonant circuit the central peak was separated with higher resolution, while other frequencies are suppressed. The observed high resolution spectrum of the central frequency is shown in Fig. 11.

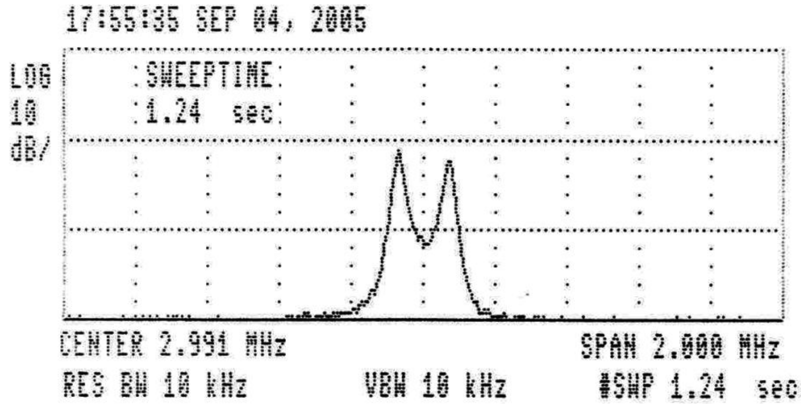


Fig. 11. Central frequency with high spectral resolution showing two close frequencies

One additional question should be answered: Why all frequency shifts are referenced to the central line? The reasonable answer is: The central frequency is stable because the magnetic field creating by the rotating electron is much stronger than the magnetic field from the electron spin, so it serves as a base for the frequency shifts. The difference between frequency intensities in the supercluster could be explained by the following consideration. The central fc frequency emitted from the central cluster must pass through the external clusters and it is known that EM waves are attenuated when passing through a plasma. The EM waves from external cluster will not exhibit such attenuation and therefore they will appear with stronger intensity. Note that the stronger magnetic field provides a larger frequency shift, not a stronger intensity of the frequencies.

All above mentioned considerations explain the symmetry of the observed spectra shown in Figures 4 and 5. However there are some additional features of the ion-electron superclusters that are apparent from the spectra shown in Figures 12,13 and 14. These spectra of hydrogen are made at one and a same, HV and pressure values and the same sweep time. However, we see that the position of the central frequency is the same but some frequencies are missing or shifted at the consecutive spectra runs. If ignoring the missing frequencies the positions in the frequency domain are still symmetrical. The possible explanation is follows: The missing spectral lines could be a result of the way the magnetic fields of clusters at one and a same radius are interconnected. They could be paired either to the opposite clusters or to the nearby cluster (lying at one and a same radius in respect to the superculster axis). Their interconnections will influence the common magnetic field configuration that will become more complex than the simple analogy with the multilayer solenoid.

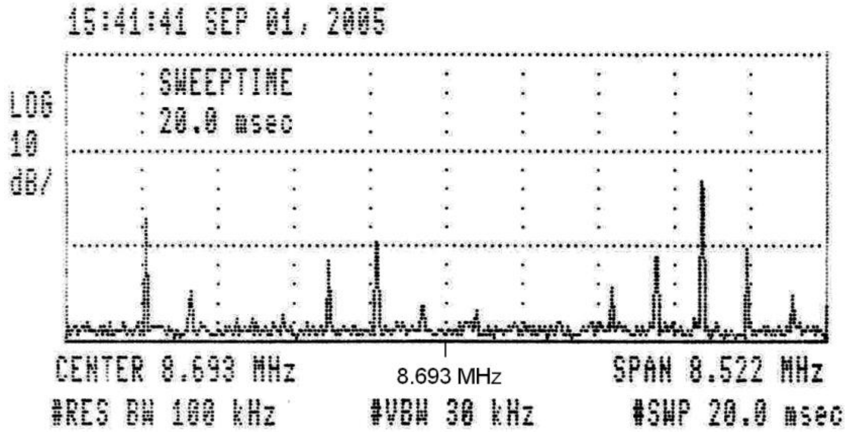


Fig. 12. Hydrogen spectrum, 20 ms sweep time [6]

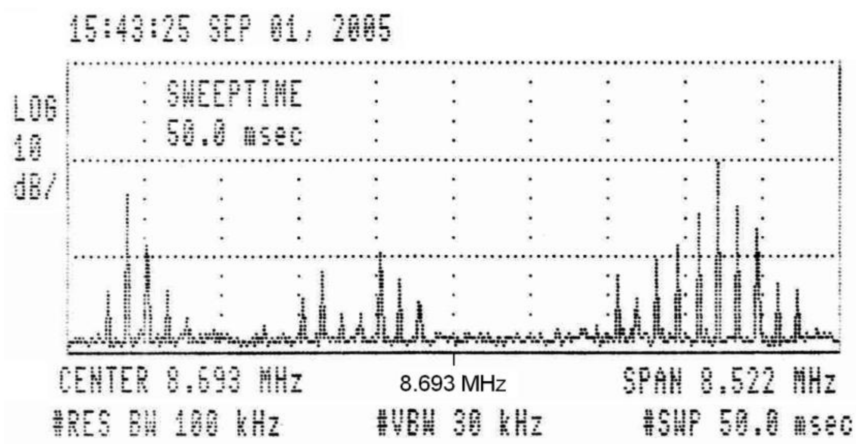


Fig. 13..Hydrogen spectrum, 50 ms sweep time [6]

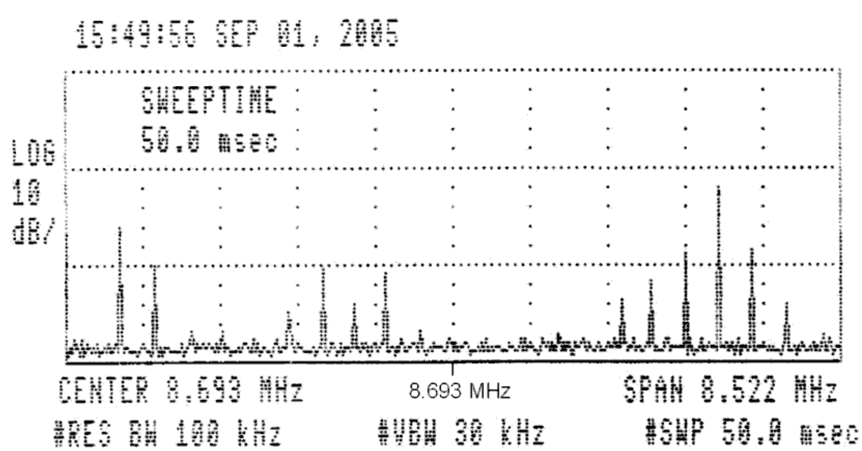


Fig. 14. Hydrogen spectrum, 50 ms sweep time [6]

4. Conclusions from the experimental analysis of the HRM effect invoked in a plasma glow discharge

a. The HRM effect takes place after some delay from activation electrical pulse (in order of 20 uS for air at 13 mbars). This time is necessary for ionization and formation of ion-electron pair.
b. The duration of the HRM oscillations is about 2 to 4.5 uS (for air at 13 mbars).
c. During HRM mechanism electron tends to move with one of optimal quantum velocity, while the common magnetic field forces a synchronization that affects the internal energies of the electron, so they could replenish their energy by spin flipping.
d. The spin flipping of a huge number of electrons in oscillating ion-electron pairs is synchronized due to the common magnetic field.
e. In spin flipping the electron interacts with the super-high Compton frequency taking that is a quantum mechanical feature of the electron
f. The synchronized spin flip of enormous number of electrons takes a fraction of the zeropoint energy of physical vacuum denoted as ZEP-D in BSM-SG theory (Dyamic type of Zero Point energy) [8].

The main questions are: where is the fraction of the accessed ZPE-D energy and how it could be obtain by external means?

The ZPE-D accessed by electrons is in the oscillating ion electron pairs. In order to obtain this energy by external means the ion-electron pairs must be destroyed. The released energy will be taken from the free ions, so they will have larger momentums in comparison to their momentums at the time of ionization. Their integral momentum containing the accessed ZPE-D energy could be used either for obtaining of electrical potential or used directly for expansion of the gas. For the second option the possibility for directing the axis of the superclusters with external magnetic field could be used. Obviously it will lead to a push force different from the explosion force caused by the chemical reaction. Consequently:

g. The oscillating ion-electron pair after a specific time of their creation must be destroyed in order to release the accessed zeropoint energy.
h. The expansion of the gas due to a forced destruction of the ion-electron pairs is not a thermodynamical process.

The conclusions from sections §1 and §4 serve as a physical base for definition of the technical considerations for using of the HRM effect for accessing the zeropoint energy of the physical vacuum.

It is evident that further research on the HRM effect will be quite useful. It could provide more information about the HRM effect dependence of type of gas, HV activation, and gas pressure I expect that if the vacuum cell is longer and the glow discharge appear separated into light and dark zone the spectrum could appear different. If these zones correspond to not synchronized superclusters the spectrum will not be of well separated discrete frequencies with equal space intervals. Therefore, it will be useful to study the spectral and spatial charactersitics simultaneously. This will lead to deeper understanding the physics of lightning phenomena. In lightning between clouds and ground and enormous energy is released that many think does not come entirely from the accumulated electrical potential in clouds. This is a subject of another article.

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