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STUDY OF IONOSPHERIC IONIZATION USING EXTREMELY LOW FREQUENCY (ELF) MEASURES IN SÃO JOSÉ DOS CAMPOS, BRAZIL REGION

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Abstract

In a recent theoretical article, the author described a possible process of generating electromagnetic waves in the range of (1-12) Hz caused by diamagnetic currents originated by heat in ionosphere through high frequency waves (HF). The origin of the HF waves that reach the ionosphere can be sent from the Earth's surface or even directly solar phenomena. Through a SpectranNF-5035 detector, developed by German Aaronia with high sensitivity (1 nV) nanoVolt in a range of (1-12) Hz and low sampling time (5 ms), with specific external ELF antennae was possible to measure these waves and detect Schumann resonances peaks. During the months of July and August of 2016very dry and away from electrical discharges in the region of São José dos Campos, SP, Brazil were made several series of measurements to detect these waves and also Schumann resonance's in 1 to40 Hz.During January 2016to October 2018, with very wet and dryer period in the region, these measurements it was made. The positive results of these experimental observations as well as discussions and suggestions are presented in this paper.

Key words: *Ionosphere, ELF electromagnetic waves, SpectranNF-5035, Schumann resonances.*

I. INTRODUCTION

The non-ionizing radiation environment of a region has its intensity that can be measured in power (dB_m) in milliwatts, in Volt/meter (V/m) corresponding the electric field or Volt (V) in the case of electrical potential relative to earth ground level. These values always vary with the frequency band [1] to be measured. General spectrum analyzers can observe this radiation in a particular frequency range, with continuous monitoring or discrete values of predetermined frequency band. In general, analyzers covering the frequency range of 1 kHz to 26 GHz which are currently available on the international trade in addition to having high costs are used for measurements inside laboratories. They are not portable, and do not have sufficient sensitivity to observe radiation environmental intensities in power with less than -90 dB_m values which corresponds to 1×10^{-12} W of power [2]. These analyzers also require multiple sets of antennas to cover the entire frequency range to be used.

The non-ionizing radiations are those which do not produce direct ionization,that is, do not have sufficient energy to strip out electrons from atoms (<12eV), the meanshave enough powerto dissociate molecules, or, break chemical bonds.

Non-ionizing radiation are always present in the environment [3]. Electromagnetic radiation also consists of waves that propagate through space. These waves can be ionizing or non-ionizing radiation and are formed by composing an electric field (**E**) and magnetic field (**B**) which oscillates perpendicular to one another in the simplest case. The direction of propagation corresponds to the energy displacement (Poynting vector). These radiations include ultraviolet (near the visible), visible light, infrared, ELF (Extremely Low Frequency), LF (Low Frequency), VHF (Very High Frequency) and microwave. Some of this radiation is an electromagnetic spectrum band called Radiofrequency (RF) [4, 5]. The alternating electric current also produces electromagnetic fields around the various conductors and equipment in any place in Brazil. For example, the oscillation frequency of the alternating current in Brazil is 60 Hz and its harmonics are as 120Hz, 180Hz, 240Hz and more. Between 1 Hz and 40 Hz (ELF) are naturally Schumann waves determined by the resonances in 7.8 Hz, (14-16) Hz, 20.0 Hz and 33.0 Hz. Between (1-12) Hz, according to the recent theoretical work [6, 7], waves formed in the ionosphere through HF wave and local

ions interactions that can exist.These waves are extremely difficult to be measured given the low electric field values (E) and magnetic fields (B) by which they are transported [8, 9].This experimental work shows measurements of these parameters performed in the region of São José dos Campos, Brazil.

II. MATERIAL AND METHODS

To collect the measures of non-ionizing radiation from 1 Hz to 1kHz, it was used, one good commercial equipment purchased from Aaronia Company AG, Germany. A SpectranNF-5035 sensor works between the frequency (1 Hz to 1 kHz, and 1 kHz to 1 MHz) with a compact and omni directional antenna with precision of (1nV) nanoVolt. The sampling time in the measurements may be chosen from 5ms to 3000ms. The resolution band width (RBW-Resolution Band Width) may range from 0.3 Hz to 1MHz. The sensor is fully portable with its own batteries for 8 hours of continuous operation. Specific software provided by Aaronia AG writes the data on files (.ldt) and simultaneously generates graphics on screen display of computer that can save images. All details of the parameter settings and operation of the frequency spectrum analyzer can be found in the above-mentioned manufacturer's website [10]. A laptop PC (Dell Vostro i5) it was used for the acquisition and determination of the frequency spectra with the measured data files. Because the system is compact and portable, it is possible to carry out surveys of non-ionizing radiation field at any remote location. Figure 1 shows the lifting of the electric field (V/m) environment at ITA campus in São José dos Campos, SP, Brazil. It was observed in this graph that the electric local transmission line on site (ITA campus) induces the electric field at 60 Hz and 120 Hz, showing the proper functioning of SpectranNF-5035 sensor.

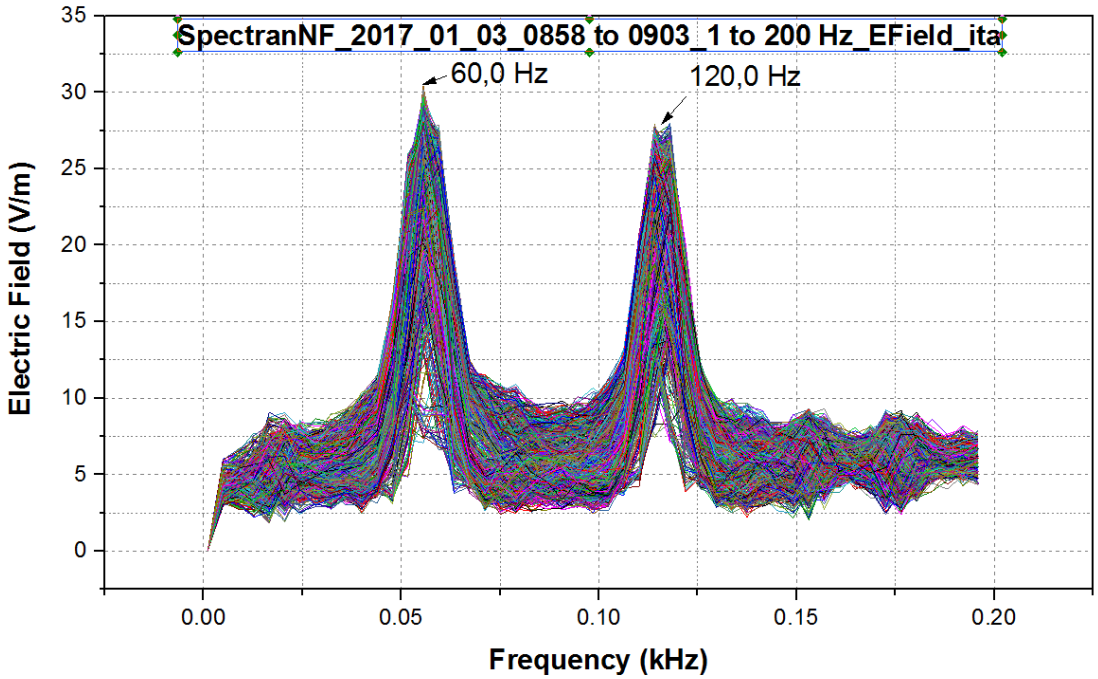

Fig. 1 – Calibration of SpectranNF-5035 measuring electric field underlocal electric power line of 220V and 110V

The 60 Hz are the first frequencyof transmissions line in Brazil giving maximum value of 30 Volt/m.Different colored lines corresponds to the number of samples taken.

III. RESULTS AND DISCUSSION

The measures in São José dos Campos were made on the campus of the Department of Physics of theITA (Technological Institute of Aeronautics) with possible low interference from the local power grid. As a first result, it was found that the electric field spectrum (V/m) between 1 Hz and 1kHz was repetitive and constant in region with

amaximal intensity of< 50V/m. In the Figure 2 it is plotted this variation and the peaks produced in 60Hz, 120Hz, 180Hz.., produced of local power transmission line. In reference the local earth ground level and the ionosphere it is plotted the electric potential in Volts shown in Figure 3. The background value due to all local received emissions in same measurements site stay near value 0, 5volts. The highest electric potential in 2.2 Hz, 4.3 Hz, 6.1 Hz and 7.6 Hz located peaks, was wavering between 0.04 and 0.05 microvolts and background noise with a lower value of 0.01 microvolts is as shown in Figure 4 below. To this extent, the electric potential of the local site to that referring is already included local power network that contributes a maximum to 5 microvolts in August and September of 2016 and January of 2017 to October2018intheregion.Figure 5 shows measurements obtained in the region in the frequency range between 1 Hz and 40 Hz. These measures allowed observing the peaks of this natural radiation called Schumann resonances at 7.8 Hz, (14-16) Hz, 20 Hz and 33 Hz, well defined. In the period of lower ionization of the ionosphere in the region, at night, this value in intensity is minimal and corresponds between 5 and 10 microvolt of electric potential, called background noise ELF. During the local day and with enough of electric discharges activities in the low earth atmosphere this value measured here can reach up to 70 microvolts.

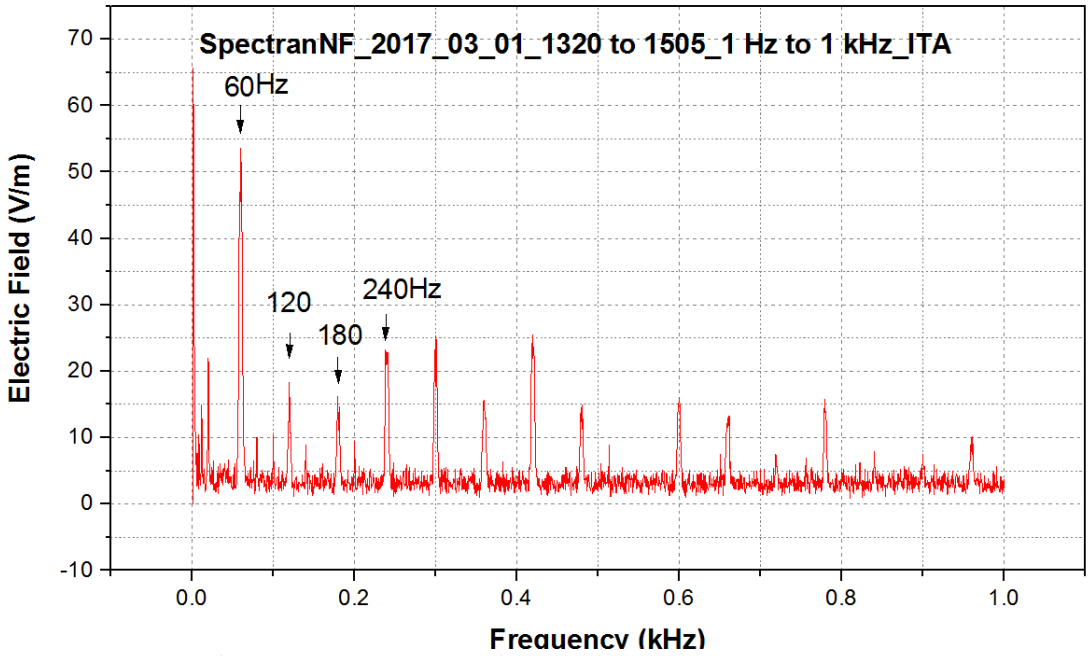

Fig. 2 The local electric field background and peaks from local electric power line in Hz, giving near 50 Volt/m in 60 Hz. First point in this graph is electronic noise.

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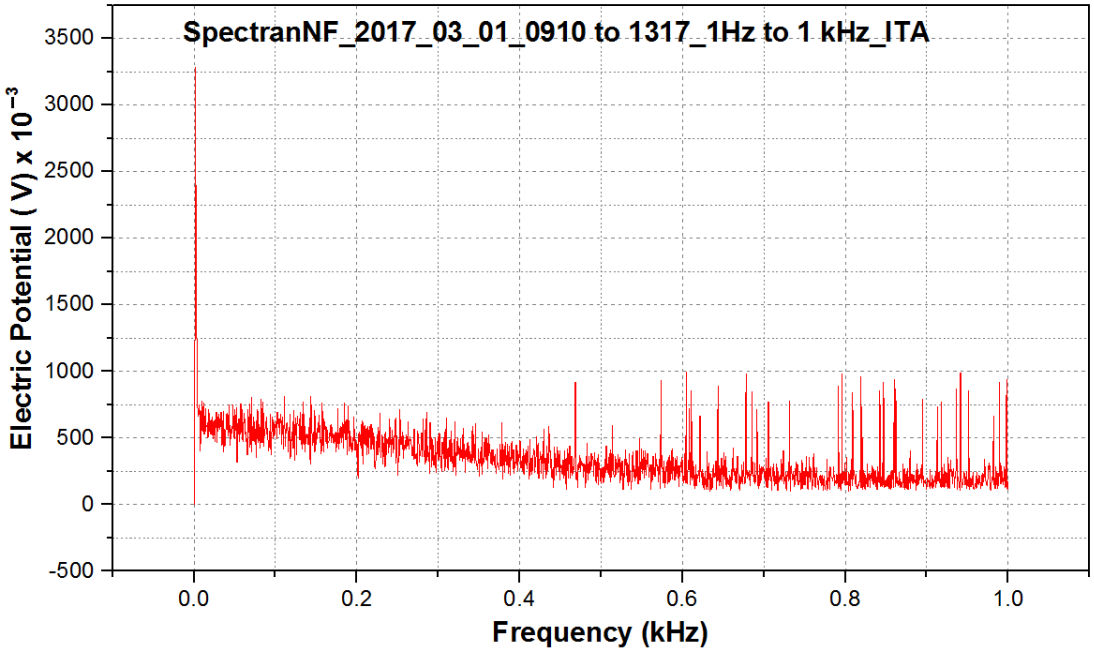

Fig. 3 – Electric Potential (V) variation with frequency in the region.First value and spikes variation above 0.4 kHz in the graph was electronic noise

The Figure 3 gives the electric potential variation from 1Hz to 1000 Hz. The intensity stay near 0.5 V constant in the frequency range 1-40 Hz. Between 0.4 to 1.0 kHz the signal stay under 0.5 V and a kind of noise appeared also in the begin the initial pulse and after above 0,4 kHz that is due to electronic noise.

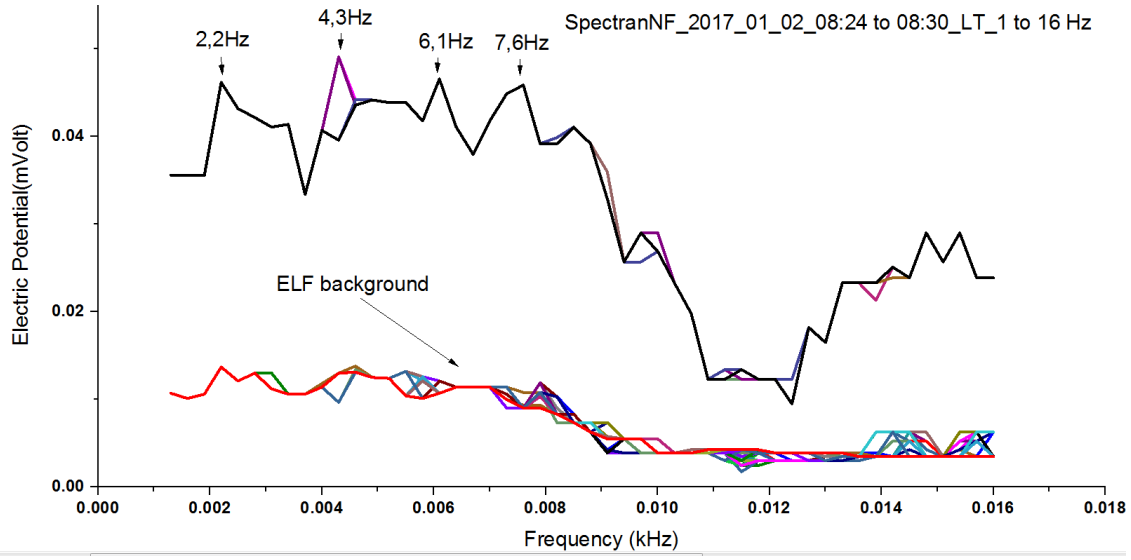

Fig. 4 – Measurement of ELF potential electric field mV (microvolt) background and ionosphere peaks production due to diamagnetic currents.Different colored lines corresponds to the number of samples taken

Measures in Figure 4 made with monitoring obtained on 2017/02/01 from 08:24 to 08:30 local time show that the values are already the maximum of the region. Generally nocturnal measures and periods are until 07:00 local time, the intensity of this wave of (1-12) Hz is minimum value of 10 microvolts order that it is call the ELF background.

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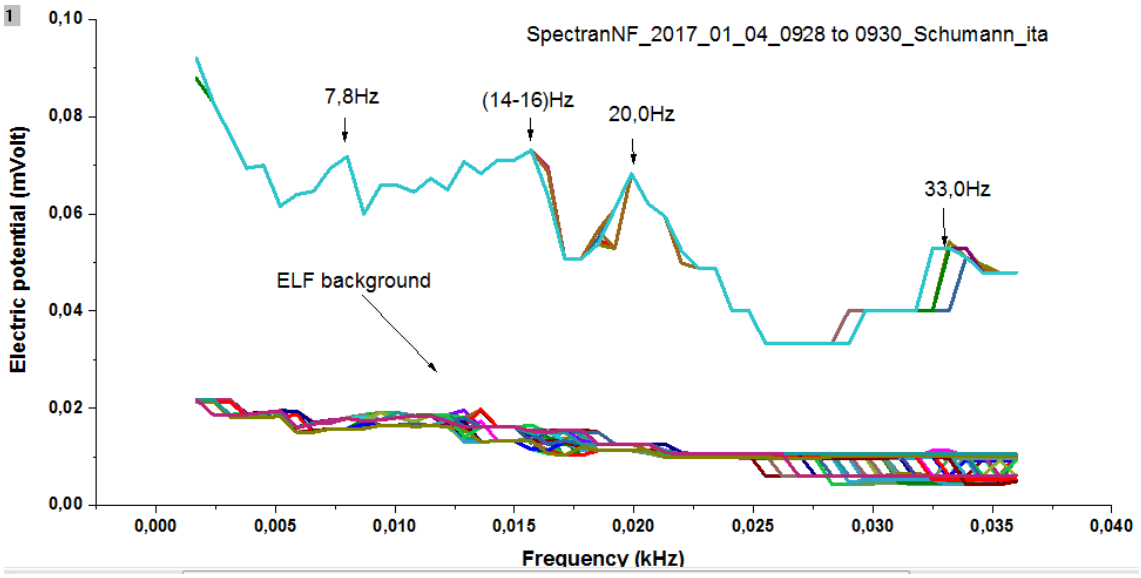

Fig. 5 – Measurements of Schumann's resonances peaks (mV) microVoltand local ELF background. Different colored lines corresponds to the number of samples taken

IV. CONCLUSION

In the period of 2016, 2017 and 2018the spectrum in frequency from 1 Hz to 16 Hz was measured through a Spectran NF-5035 sensor developed by a German company, Aaronia Ag. These spectrum showed electric potential peaks (V) at 2.2 Hz, 4.3 Hz, 6.1 Hz and 7.6 Hz ranging from 40 to 50 microvolts maximum in the period from 10:00 to 20:00local time. At night until 07:00 morning in the local time, this reached near 10 microvolts in the same frequency range. Between 07:00 and 10:00 local time, values are minimum passing unstable (~ 10μV) microVolt to the maximum (~ 70μV) as shown in Figure 4, in the text. It was found that in the morning hours before 10:00 local time, the electric potential of the signal becomes maximum when there is an increase of X-rays flux in wavelength from 0.5 to 4.0 Å and in wavelength from 1 to 8 Å; shown by satellite Goes series 13 and 15, measurements. It was concluded that through diamagnetic currents in the ionosphere, it is more or less ionized creating electromagnetic waves between 1 Hz and 12 Hz, and visible peaks with intensities and frequencies described above. In the same way it was measured for the period the Schumann resonance showing peaks of 7,8Hz; (15-16) Hz, 20,0Hz and 33,0Hz. Maximum value in intensity of peaks ranging in 70μV(microvolt), and minimum calling the ELF local background of less than 10μV. So it is measured the ionospheric diamagnetic currents and also the Schumann resonance's using the SpectranNF-5035 and one external antenna. From 1 Hz to 1000 Hz the local electric field (V/m) and electric potential in (V) was measured. These measurements in Figures 2 and 3 clearly show the influence of the local electric power transmission line.

V. ACKNOWLEDGMENT

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