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DETECTION OF SOLAR BURSTS BY USING LPDA

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Abstract

The Log Periodic Dipole Array (LPDA), a broadband, multi-element narrow-beam antenna, is used conveniently for the reception of solar bursts over Kalyani (22°58´N, 88°46´E), W.B., India. Detection capability and use of Fast Fourier Transform (FFT) indicate the method as a decent alternative for categorizing solar bursts from a separation of radio frequency interferences. The dynamic pattern of solar corona is formed by condensed tubes of solar plasma and it is extremely structured. There are various kinds of transient phenomena happening on numerous time scales from hours to few milliseconds accompanying with the development of these condensed tubes of solar plasma. Observed from ~20 MHz up to near 10 GHz these bursts with characteristic time less than one second contain spikes, spike like, very small period regular or irregular pulsations, dips in radio emission, eruptions, zebra – pattern structures, etc. and this can be associated with some kind of procedure of energy release fragmentation. Specially solar flares are one of the classic active phenomena where magnetic energy deposited in these structures is converted into kinetic energy of highly accelerated charged particles through magnetic reconnection. Unique characteristic parameters of solar flares are its duration. Solar flares detected at radio frequencies (called bursts) within period less than one second can be a key to comprehend the elementary energy release procedure in flares.

Keywords:

Fast Fourier Transform;
solar bursts;
LPDA;
Rradio frequency interferences.

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1. Radio bursts at the dynamic spectrum

There are generally five distinctive types solar radio bursts at the dynamical spectrum [8] and the noise storms in the meter wave range evidenced to be the most extensive appearance of solar activity, when against the background of the prolonged increased continuous emission several narrow-band short-term bursts of type-I seem at different frequencies. Rarely occurred slow-drift type-II bursts are outstanding events associated with big spaces. From the solar corona Type-III bursts are too fairly frequent bursts received and is categorized by their momentary period and rapid drift from high to low frequencies in decimeter and meter wave range (velocity order of 10^2 Km/sec). It is assumed, that the radio emission is generated by beams of fast electrons at levels of the local plasma frequency or its second harmonic. Type IV bursts is continuum radiation succeeding type II bursts. The type V burst is a broad-band continuum radiation following a type III burst generally below 150 MHz. It is anticipated, that this is emission of a part of the electrons, producing the type III burst, trapped in a magnetic loop.

Table 1. Classification of solar flares (Measured as the Peak, 1-8 Angstrom (0.1-0.8 nm band))

Different classes of Solar Flare	Intensity: Watts per square meter
A	$10^{-8} <= I < 10^{-7}$
B	$10^{-7} <= I < 10^{-6}$
C	$10^{-6} <= I < 10^{-5}$
M	$10^{-5} <= I < 10^{-4}$
X	$I >= 10^{-4}$

The solar flares are classified by intensity, from lower to higher as A, B, C, M and X. Each category has nine divisions extending from 1-9, e.g. C1 to C9, M1 to M9, X1 to X9. A multiplier is used to indicate the level within each class. For example: M6 = 6×10^{-5} W/m^2.

2. Recording Techniques

The LPDA, a broadband, multi element narrow beam antenna, is used suitably for the recepti-on of solar bursts. It can provide accommodations an extensive range of frequencies from 50 MHz to 300 MHz with modest gain and directionality. Here receiving systems connected to two LPDAs effectively receive solar signals. Here two low noise amplifiers (LNA) used to diminish the local noises significantly and then the signal is fed to HFA (high frequency amplifier (VHF)) to amplify. A schematic diagram of the entire arrangement is shown in Figure 1. The received data from LPDA through DSO (digital storage oscilloscope) are subsequently transferred over a LAN for computer simulation. We have initiated to retrieve the files from the solar data archive, analyze the data, and sketch our burst identification strategy. This method is executed during October, 2010 to December, 2010 to examine the solar burst activity.

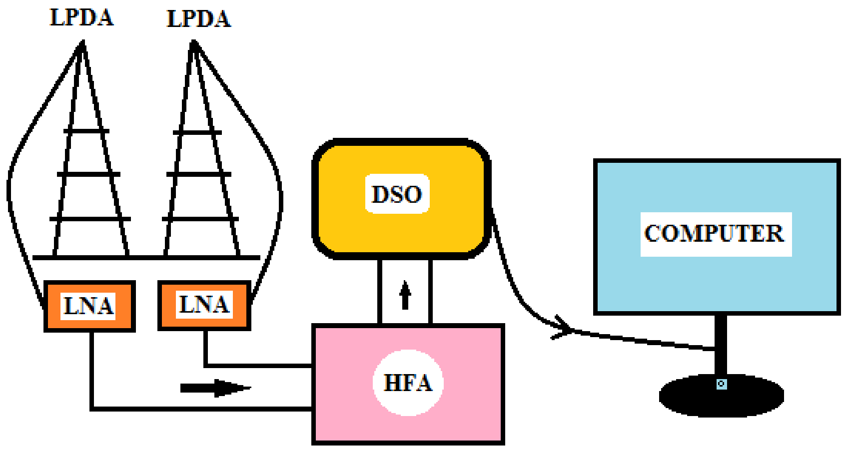


Figure 1. *Schematic diagram of the Experimental set up.*

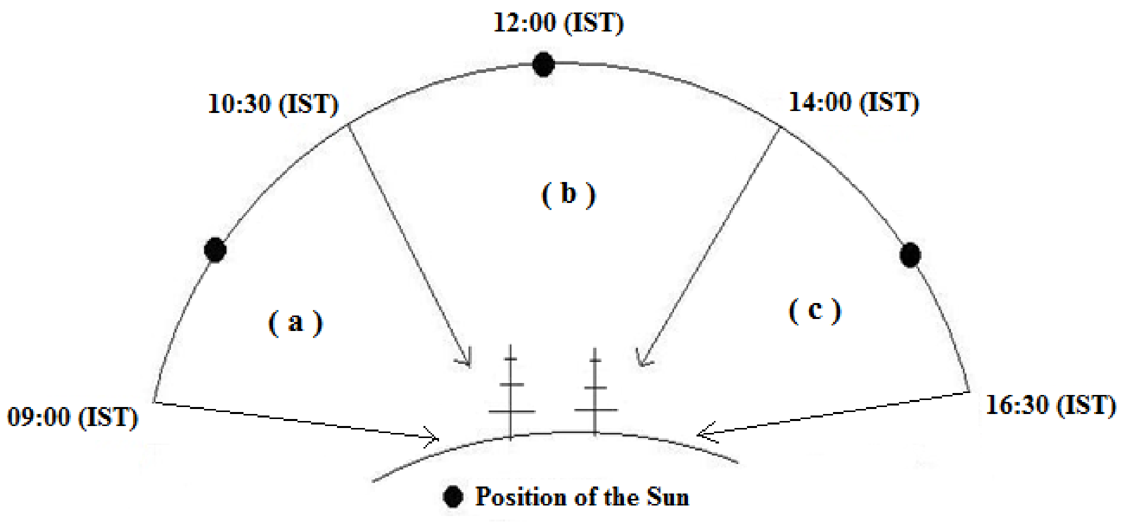
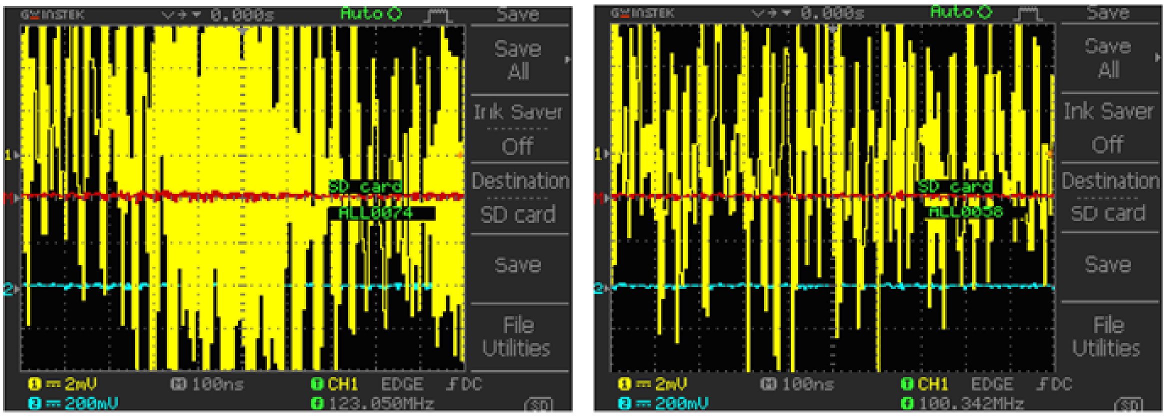


Figure 2. *Reveals how the two LPDAs are used as anti-sunward detector during (a) 09:00 hrs to 10:30 hrs of IST and (c) 14:00 hrs to 16:30 hrs of IST whereas sun-ward detector during (b) 10:30 hrs to 14:00 hrs of IST.*

Some typical records of solar signals with and without solar bursts are presented in Figure 3 and Figure 4 respectively. The display of the digital storage oscilloscope can be converted from analog to digital form if required.

(a) (b)

Figure 3. *Typical records showing solar signal without solar bursts.*



(a) (b)

Figure 4. *Typical records showing solar signal with solar bursts.*

3. Identification of solar bursts

Identifications of solar bursts divided into following steps:

(i) Through MATLAB programming we denote the data which contain solar bursts as 'SL01', 'SL02', etc. and rest of the data is denoted as 'A01', 'A02', etc.

(ii) Then convert all the recorded voltage-time scale data to power-frequency scale by FFT (using MATLAB)

(iii) Next to reduce the background noise we calculate the average of summed anti-sunward data denoted as 'AV' (Figure 5 & Figure 8). For this data for duration of three months have been taken into consideration.

(iv) Then we subtract 'AV' from data which contain expected solar bursts and then the subtracted data are denoted 'S01', 'S02' etc. (Figure 10). For evaluation we also choose some data which are just before and after expected solar bursts and subtract 'AV' from them. The subtracted data denoted as for example 'SA23', 'SA24', etc. (Figure 9).

We have then plotted frequency (in MHz) vs. power (watt) data by using MATLAB programming as shown below. The subtracted data so obtained analyzed elaborately and then compared with other reported data for verification.

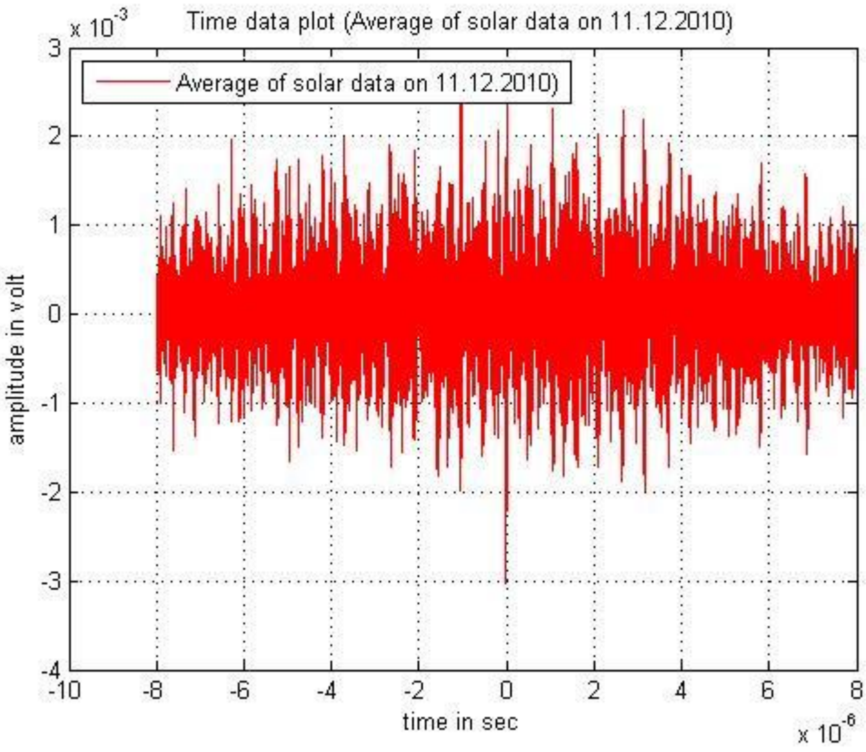


Figure 5. *Time-voltage plot of average of all the recorded solar data on 11.12.2010 which do not contain expected solar burst.*

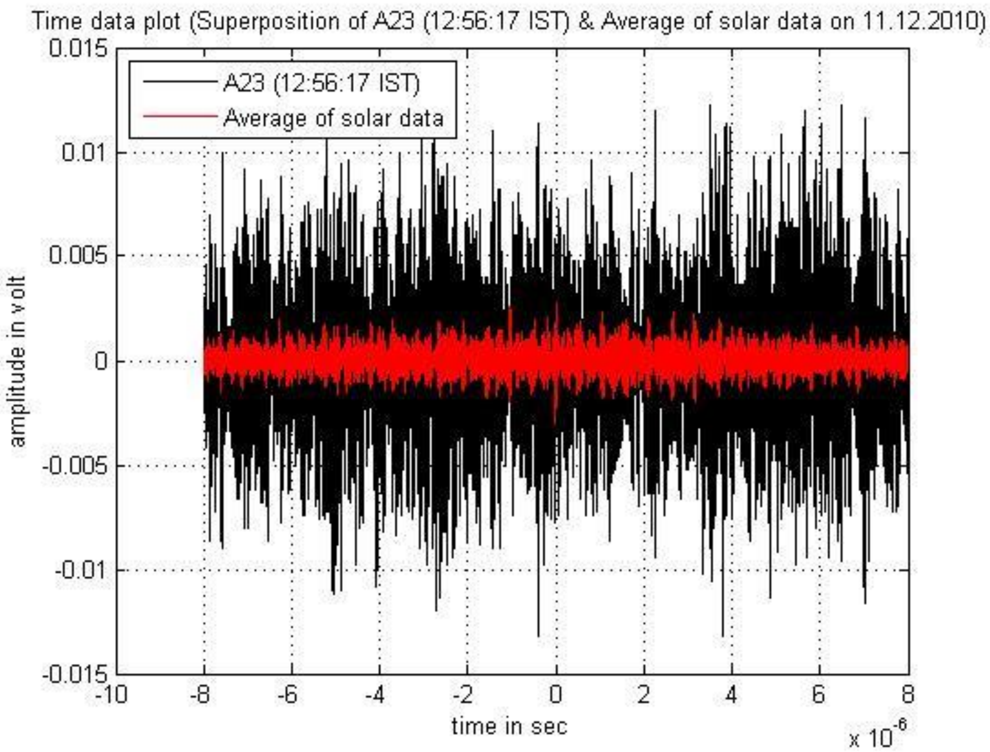


Figure 6. *Superposed time-voltage plot of average solar data and solar data of just before and after expected solar bursts.*

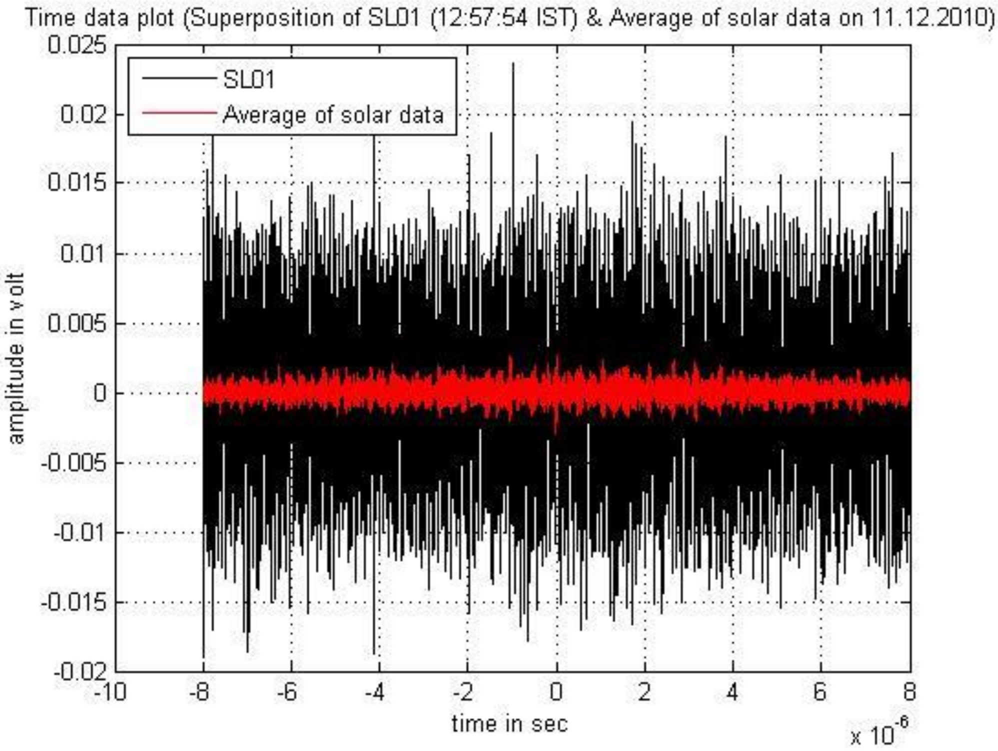


Figure 7. *Superposition of time-voltage plot of average solar data and solar data which contain expected solar bursts.*

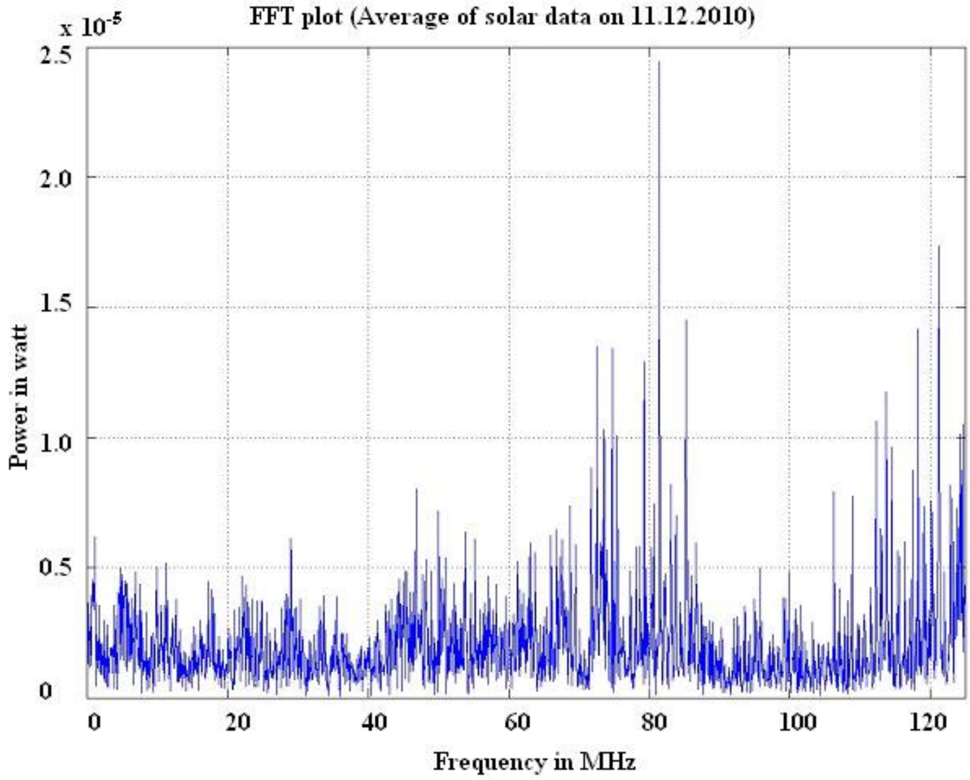


Figure 8. *FFT plot of average of all the recorded solar data on 11.12.2010 which do not contain expected solar burst.*

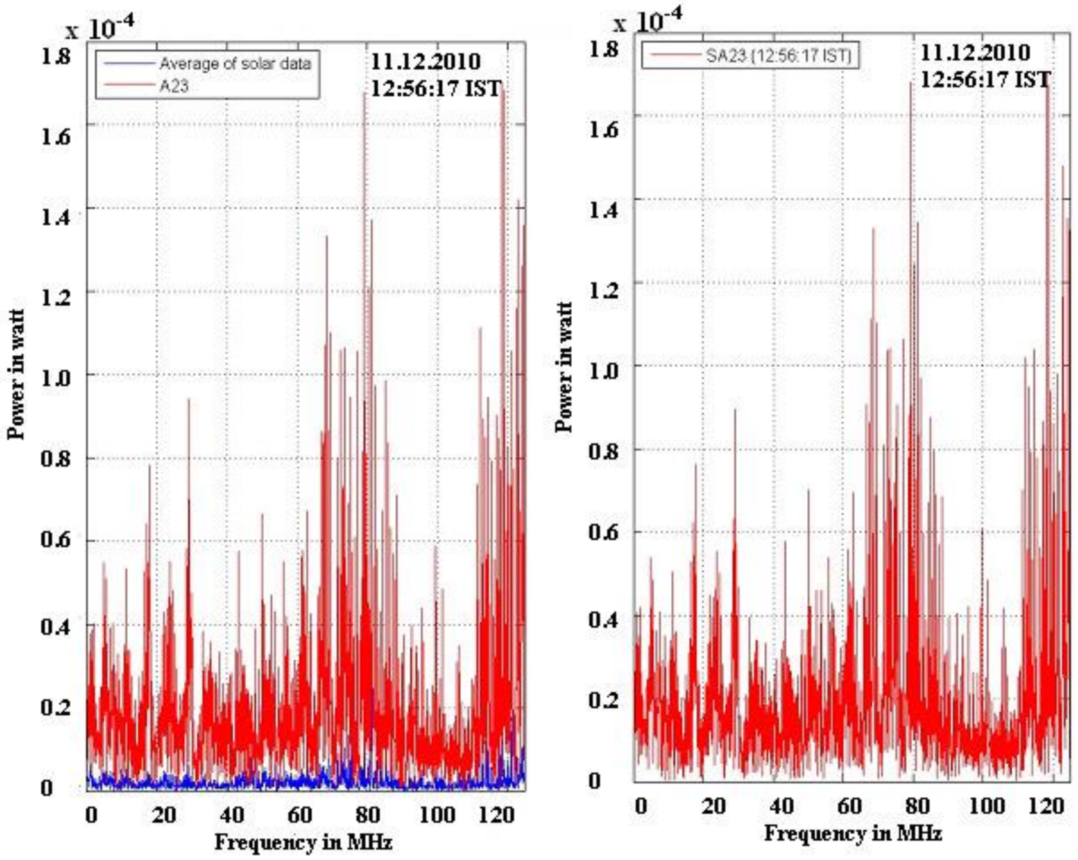


Figure 9. *FFT plot of superposed and subtracted average solar data (as shown in Figure 7) and solar data of just before and after expected solar bursts.*

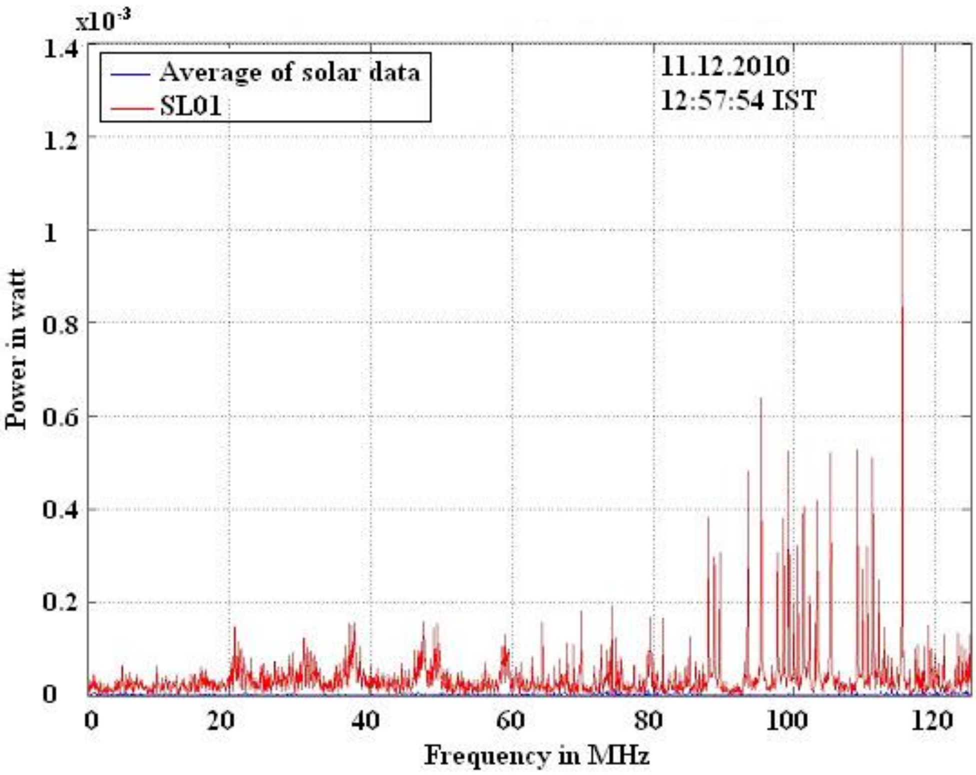


Figure 10. *FFT plot of superposition average solar data and solar data which contain expected solar bursts.*

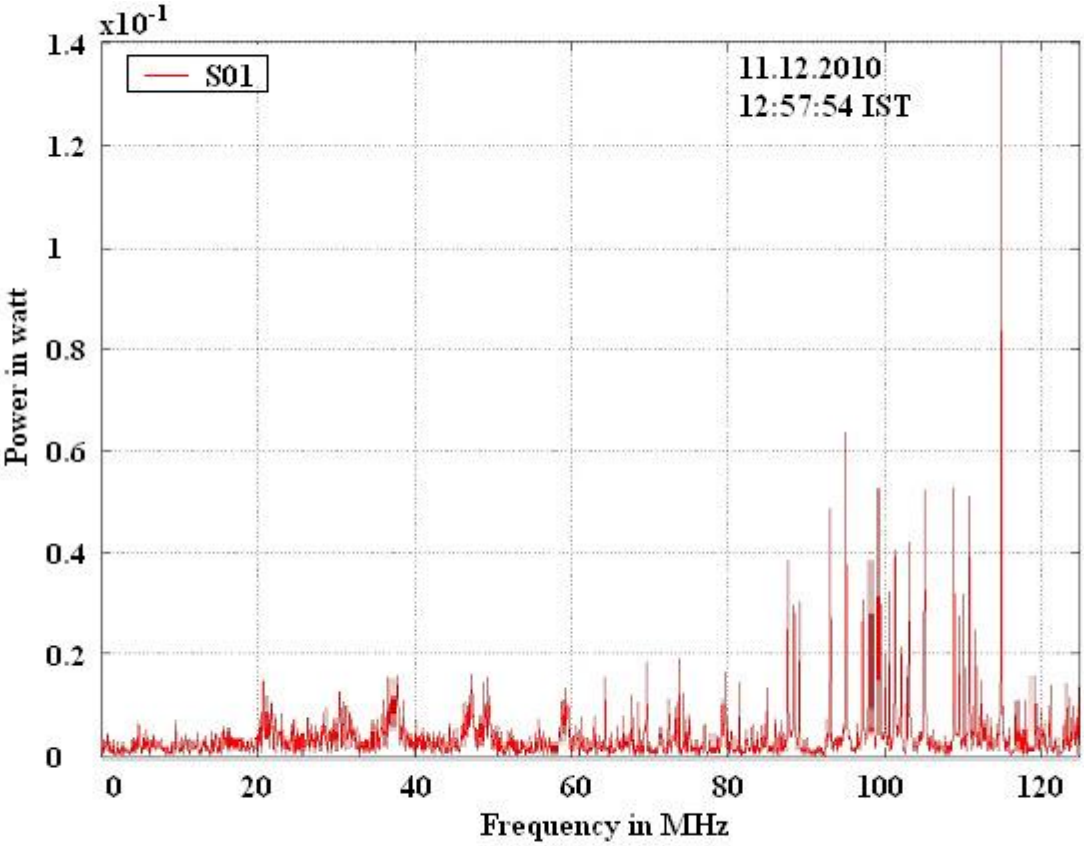


Figure 11. *FFT plot of solar data which contain expected solar bursts after subtraction from average solar data (AV).*

4. Discussion

The rigorous study of the fine structure of the solar radio radiation is a significant understanding of plasma processes in the solar corona [9-11]. It remains a reliable means for both analyzing the solar corona and authenticating the results of laboratory plasma experiments. High time and frequency resolution data have improved our studies of similar fine structures in star areas. So, the continuum radio emission of the type IV was accompanying for long time with the synchrotron radiation of electrons confined into a magnetic cloud [9, 12-14], but the analysis of fine structure recommended that the plasma mechanism is predominant in the meter and decimeter waveband. A more suitable solar burst documentation policy may be highly gainful at this time when the when the solar activity is picking up.

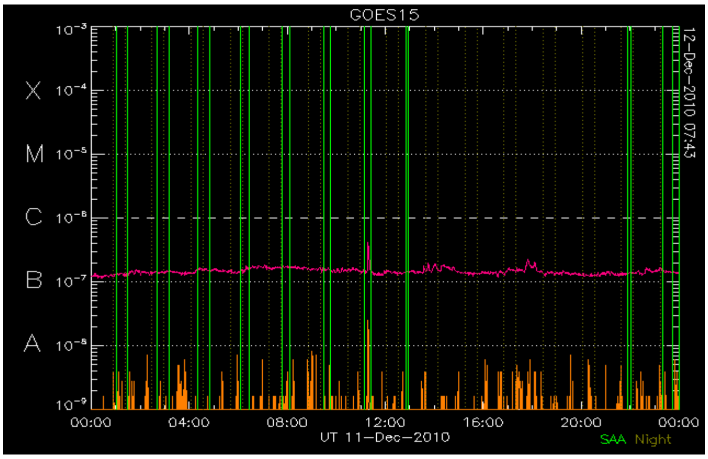


Figure 11. *RHESSI quick look browser page, recognizing the solar activity of 11th December, 2010*

Figure 11 represents the RHESSI quick look browser page representing the records of A, B.C, M and X type of solar activity of 11th December, 2010. It is the same date we have exemplified elaborately with our own data as a typical case and so can be used as a decisive comparison. A solar burst is a huge explosion in the Sun's atmosphere which affects different layers of the sun, e.g. photosphere, chromospheres, and corona. It is accountable for heating plasma to very high temperature (~107 K) and accelerating nucleons and heavier ions to near the speed of light [12]. As a matter of fact, they produce radiation across the electromagnetic spectrum from radio waves to gamma rays. Most of the bursts happen in active regions around sunspots, where strong magnetic fields enter the photosphere to link the corona to the solar interior. Solar flares are powered by the abrupt release of magnetic energy stored in the corona. A strong flare can cause coronal mass ejections (CME). X-rays and UV radiation discharged by solar flares can affect Earth's ionosphere when long-range radio communications may be disrupted [15-16]. The happening of solar flares becomes more when the Sun is active and less when the Sun is quiet.

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References

[1] Belov, A. V. et al. (2005) "The relation of global magnetic solar field indices and solar wind characteristics with long term variations of galactic cosmic rays", *29th International Cosmic Ray Conference*, Pune (2005) Vol. 2, 235-238.

[2] Culhane, J. L.,et al. (1970) "The cooling of flare produced plasmas in the solar corona," *Solar Phys*., Vol. 15, 394.

[3] Donnelly, R. F. and Puga, L. C. (1990) "Thirteen-day periodicity and the center-to-limb dependence of UV, EUV and X-ray emission of Solar activity", *Solar Phys*., Vol. 130, 369-390.

[4] Jansky, K. G. (1933) "Radio waves from outside the solar system", *Nature*, Vol. 132, 66.

[5] Méndez Berhondo A. L. and Rodríguez Taboada R. E. (2006) "Radio bursts of very short duration: Fine structure of solar flare emissions", *Geofísica International*, Vol. 45, No. 4, 271-276.

[6] Méndez Berhondo, A. L. (2009) "Solar bursts with fine temporal structure" *A. Rev. Cub.Física*, Vol. 26 No. 2A, 112-115.

[7] Hanslmeier, A. (2007) The Sun and Space Weather, 2nd Edition, *Springer Publication*, 71-75.

[8] Liu, J. Y., Chiu, C. S. and Lin, C. H., "The solar flare radiation responsible for sudden frequency deviation and geomagnetic fluctuations, *J. Geophys.* Res., 101, 10,855-10,862, 1996.

[9] Afraimovich, E. L., Kosogorov", E. A., and Leonovich, L. A., The use of international GPS network as a global detector (GLOBDET) simultaneously observing sudden ionospheric disturbances, Earth, Planets, and Space, 52, 1077-1082, 2000.

[10] Donnelly, R. F., Extreme ultraviolet flashes of solar flares observed via sudden frequency deviations: *Experimental results*, *Sol. Phys*., 20, 188-203, 1971.

[11] Donnelly, R. F., Empirical models of solar flare X-ray and EUV emissions for use in studying their E and F region effects, *J. Geophys.* Res., 81, 4745-4753, 1976.

[12] Donnelly, R. F., and Puga, L. C., Thirteen-day periodicity and the center-to-limb dependence of UV, EUV and X-ray emission of Solar activity, *Sol. Phys*., 130, 369-390, 1990.

[13] http://igscb.jpl.nasa.gov

[14] Afraimovich, E. L., Altynsev, A. T., Grechnev, V. V., and Leonovich A. L., The response of the ionosphere to faint and bright solar flares as deduced from global GPS network data, *Annals of Geophys*., 45, 31-40, 2002.

[15] Belov, A. V., Gushchina, R. T., Obridko, V. L., Shelting, B. D., and Yanke, V. G., The relation of global magnetic solar field indices and solar wind characteristics with long term variations of galactic cosmic rays, *29th International Cosmic Ray Conference Pune* (2005) 2, 235-238, 2005.

[16] A. L. Méndez Berhondo, A.L. and Rodríguez Taboada, R. E. Radio bursts of very short duration: Fine structure of solar flare emissions, *Geofísica Internacional*, 45, 271-276, 2006.