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Variations of Signal Strength during Solar Bursts: A Probable Coronal and Surface Effects of the Sun

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Abstract

Variations of signal strengths during solar bursts recorded at Kalyani corresponding to two different frequencies, 406.7 MHz and 100 MHz are reported. The amplitude of the signals received at 406.7 MHz is found larger and that the flares analyzed are mostly of M-type. The signal strengths of the coronal effect at such times were very high compared to the surface effect of the Sun. The signal level of surface effect of the Sun at the peak activity varies in amplitude from 0.06 volts to 0.1 volt while those related to solar corona vary in between 7.0 to 7.2 volts. Both the solar wind velocity and proton density are found to increase in the dates of severe bursts and there are sudden disturbances in the arrival direction of solar wind particles. Also the geomagnetic indices are enhanced at the time of solar bursts when the DST index reduces rapidly.

Keywords: Solar Flare; Disturbance Storm time index; Solar wind parameters; Radio Signal

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1. Introduction

A coronal mass ejection is basically a massive burst of solar wind and magnetic field rising above the solar corona and is associated with the solar flares. The dynamic pattern of highly structured solar corona is produced owing to dense tube of solar plasma. Solar flare is one of the active phenomena in solar system wherein the magnetic energy is transformed into kinetic energy of the accelerated charged particle through magnetic reconnection [1-3]. The observation of white light corona is a complicated task due to appearance of aberrations and hence demanding an ideal instrument. On the other hand, if we collect monochromatic emission of the corona by using monochromatic filters, it becomes much simpler [4-6]. We have simultaneously received radio signals originated from solar corona by using 406.7 MHz radio telescope and the solar flare emitted from the surface of the Sun by using log periodic dipole antenna (LPDA) in the frequency range 50 to 300 MHz, besides alternative search strategy for interstellar communication as well as propagation of radio signals during solar eclipse [7, 8] in our laboratory at Kalyani (22.98°N, 88.46°E), West Bengal, India. It is the purpose of this paper to examine the variation of signal strength at the two systems of observations during the solar bursts as well as to determine the effect of various geomagnetic parameters at such times.

2. Typical records

Figure 1 shows some typical variations of solar bursts recorded by the two systems of observations corresponding to different frequencies, 406.7 MHz and 100 MHz. In the typical record we have chosen to reproduce the LPDA connected receiver data of solar bursts at a fixed frequency of 100 MHz due to its prominent nature in the record. For the same date of August and September prominent bursts as recorded by the two receivers have shown. The X-axis in the records represents the same time scale while the Y-axis indicates the amplitudes. It is interesting to note that the amplitude of the signals received at 406.7 MHz is much larger than that received at 100 MHz.

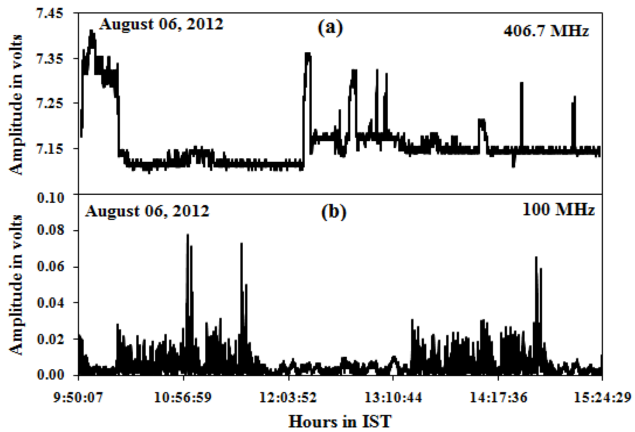


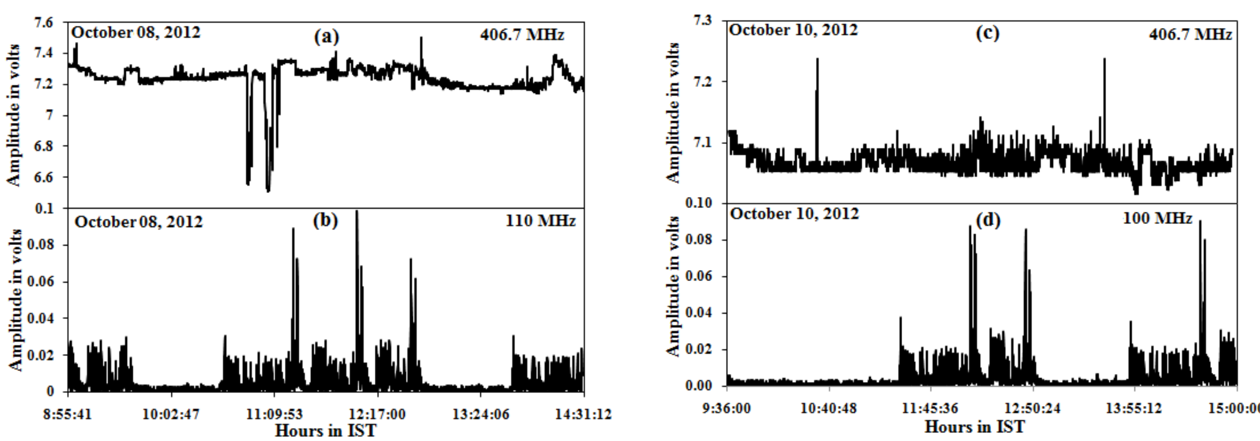
Figure 1. Some typical variations of solar bursts recorded at (a) 406.7 MHz, and (b) 100 MHz on August 06, 2012; the other two samples corresponding to the said two different frequencies for September 06, 2012 are marked by (c) and (d) respectively

3. Results and Discussion

3.1 Signal strength variations due to solar bursts

Some interesting records related to signal strength variations due to solar bursts have shown in Figure 2, which support the identical behavior of the characteristic variation as pointed out in the typical variations of Figure 1. However, it is seen that for 406.7 MHz radio signals there is a significant variation in the level. These varying characteristics are not uncommon as the solar coronas are well classified into different types of shapes with changing strengths depending on its point of origin.

In our one type of observation, the solar coronal radiation we have received at a particular frequency (406.7 MHz) through solar radio telescope while in the second type solar bursts have been recorded through LPDA with varying frequency. During the four months period of data recording from August 2012 to November 2012, we noted that for majority of the cases the response of maximum amplitude in this part of data lies in the frequency range from 100 MHz to 110 MHz as indicated in some others records exhibited in Figure 2.



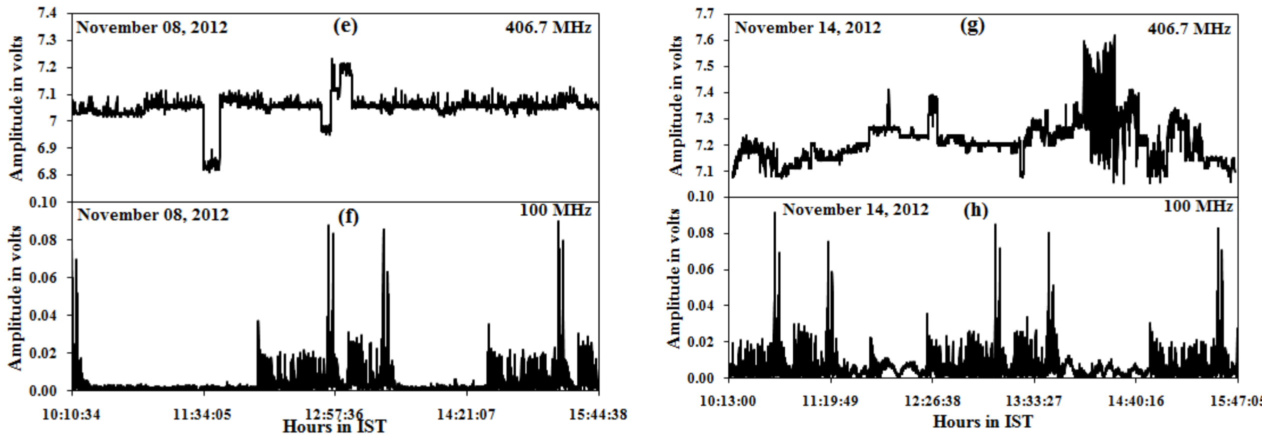


Figure 2. Some other records of solar bursts recorded at the two frequencies at different dates: (a) and (b) for October 08, 2012, (c) and (d) for October 10, 2012, (e) and (f) for November 08, 2012, (g) and (h) for November 14, 2012

The solar flares we have received when compared with the NASA reported time exhibit a good time coincidence. It may be noted that the flares we have analyzed are mostly of M-type solar category. The signal strengths of the coronal effect at such times were very high compared to the surface effect of the Sun due to the tremendous temperature of coronal area belonged to the outer most layer of the solar atmosphere. Actually, the temperature is the vital part of solar radiation and it controlled the radiation strength. According to Wien's law the temperature increases with the decrease of wavelength of the radiation *i.e.* the temperature is increased with the increase of frequency of the radiation. So the energy of the radiation becomes high with the higher value of the frequency. This explains why the amplitude of these signals emitted from the corona is much higher compared to other recorded burst data. The signal level of surface effect of the sun lies on the 'zero' line while the peak activity varies in the amplitude range of 0.06 volts to 0.1 volt. On the other hand, in the case of first category related to solar corona, the signal level lies in between 7.0 to 7.2 volts. It is also noted that there are some time differences occasionally between these two types of emissions.

A list of solar flares related to Figure 1 and Figure 2 is presented in Table 1. The corresponding time (in IST) and the sunspot numbers have also shown.

Table 1. The list of prominent solar flare observed during August to November in 2012

Date (Year 2012)	Time (IST)	Flare Type	Sunspot Number
August 06	10:08	M1.6	1542
September 06	9:43	M1.6	1560
October 08	16:47	M2.3	Un-numbered eastern limb
October 10	10:34	M1.0	Un-numbered eastern limb
November 08	7:53	M1.7	1611
November 14	9:34	M1.1	1613

3.2 Solar wind parameters

The solar wind is constituted by highly energetic charged particles. This is mainly composed of electron and proton, released from the upper atmosphere of the Sun. The temperature and the speed of these particles are changed from time to time. These particles with huge amount of kinetic energy enable them to escape from the solar surface. Corona is the determining factor for the source of solar wind. The temperature of the corona being extremely high, the solar gravitational force cannot hold these particles. With a view to examine the contribution of the solar wind parameters, we have collected the solar wind data for the concerned period. In Figure 3 we have plotted the solar wind velocity (proton velocity), proton density, most probable velocity and their arrival direction for the four months. It is highly interesting to see from Figure 3 that both the solar wind velocity and proton density are increased in the dates of solar activity producing severe bursts. We have also noted that there are sudden disturbances in the arrival direction of solar wind particles. These increments are assumed to happen due to emitted solar flare from the outer surface of the sun.

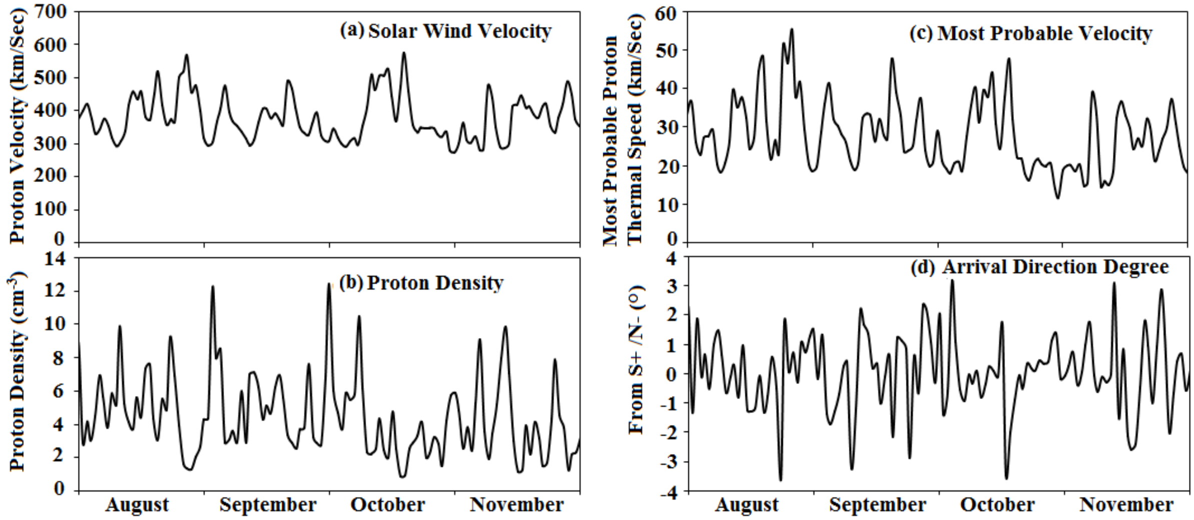


Figure 3. The solar wind parameter in the month of August to November 2012: (a) corresponds to solar wind velocity, (b) proton density, (c) most probable velocity and (d) arrival direction of solar wind particles

3.3. Disturbance storm time index

The disturbance storm time index (DST) is basically a geomagnetic index, which checks worldwide magnetic storm levels. Actually, this DST index is a measure of geomagnetic activity used to find the severity of magnetic storms. It is based on the average value of the horizontal component of the Earth's magnetic field measured hourly at four near-equatorial geomagnetic observatories [9]. In the case of a classic magnetic storm, the DST exhibits a sudden rise, corresponding to the sudden commencement of the storm and then decreases sharply as the ring current intensifies. In our analysis, we have plotted the DST index in the month of August, September, October and November 2012. It should be noted that there has some sudden fall in the DST strength in August 06, September 06, October 08, October 10, November 08 and November 14, 2012. This happens due to the interaction of solar radiation with the magnetic field of the Earth. It appears from Figure 4 that the amplitude is dropped from the negative value of 32 nT on August 06, 2012 to the negative value of 110 nT on November 14, 2012.

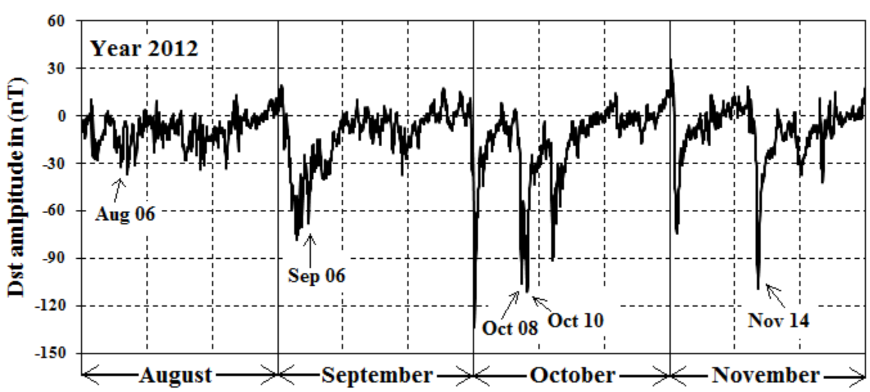


Figure 4. Disturbance time storm index in the month of August to November 2012

3.3.1 Other geomagnetic indices

The K-index quantifies disturbances in the horizontal component of earth's magnetic field with an integer in the range 0-9 with 1 being calm and 5 or more indicating a geomagnetic storm. It is derived from the maximum fluctuations of horizontal components observed on a magnetometer during a three-hour interval. The label '*K*' comes from the German word 'Kennziffer' meaning 'characteristic digit.' The A_p index is a measure of the general level of geomagnetic activity over the globe for a given day and is derived from measurements made at a number of stations world-wide of the variation of the geomagnetic field due to currents flowing in the earth's ionosphere and magnetosphere. *C* index is a subjective daily character figure of geomagnetic activity for a single observatory for Earth and considered 0

– for very quite magnetic condition, 1 – for moderately disturb condition and 2 – for severely disturb condition. C_p index is observed from sum of eight daily values of c_p index range from 0 to 2.5 wherein 2.5 is taken as most disturbed. The *aa*-index is a simple global geomagnetic activity index and is derived from the *K* indices and has units of nT.

It is seen from Figure 5 that the magnitudes of K_p, C_p, A_p and *aa* are increased between September 01, 2012 to September 09, 2012 showing peak value around September 06, 2012. Again a second peak is noticed during October 06, 2012 to October 12, 2012 when the received solar bursts become very prominent.

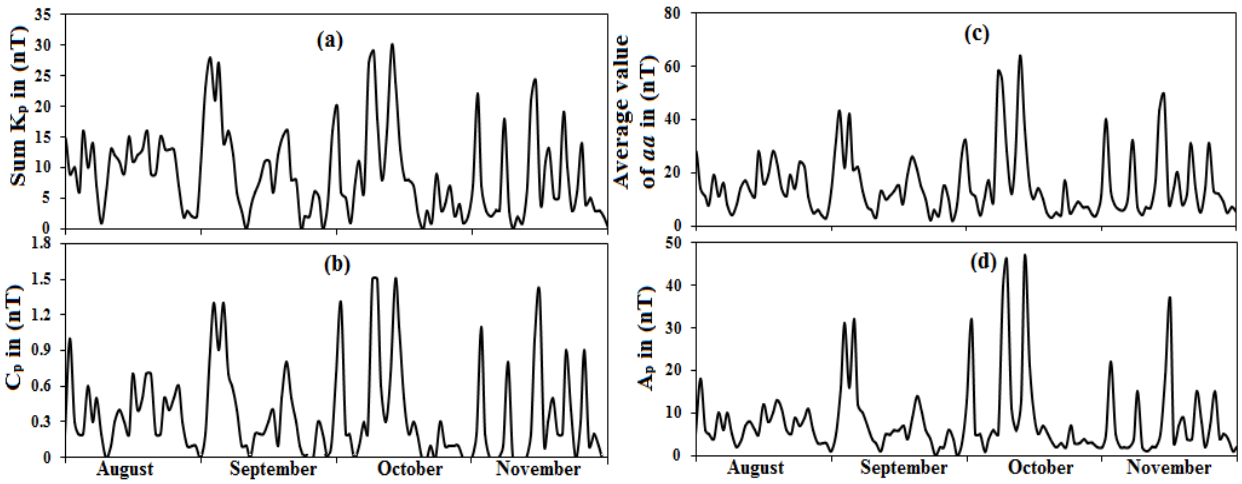


Figure 5. The Solar Geomagnetic indices (Sum K_p, C_p, *aa* and A_p) for the corresponding months

4. Conclusions

The corona is basically a part of the solar flare whose temperature is so high that it may throw some charged particles as solar wind. These may build up the electric field that again accelerates the charged particles [10]. The relation of solar wind and coronal feature can be established by observing the solar corona in front of solar disk. Coronal holes closely communicate with high-speed component of solar wind and these solar wind particles can interact with upper atmosphere and may influence the global electric circuit at high latitude [11]. The signal strengths of the coronal effect in our observed data were very high compared to the surface effect of the Sun. In fact, the signal level of surface effect of the Sun at the peak activity appears to vary in amplitude from 0.06 volts to 0.1 volt while those related to solar corona exhibit a change in between 7.0 to 7.2 volts. The solar wind also couples with magnetosphere and hence derives the ionosphere so that it again interacts with neutral atmosphere [12-13]. These solar wind particles, i. e. the so-called charged particles interact with Earth's magnetic field and influence the geomagnetic indices. Due to the active role of the charged particles, the geomagnetic indices are enhanced at the time of solar bursts when the DST index reduces rapidly.

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