An Analysis of A Single Solar Radio Burst Type III and Type II Coronal Mass Ejections Associated to Solar Flare Event

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ABSTRACT Solar radio burst type III and II is the subject matter that we are focusing on because type II and III burst are seem to have relation to each other. The most common of type III burst is called isolated type III burst which is produced by energetic electron from small scale energy release site on the sun and it is ranging from small bright point to large active region. This stage can be considered as a pre-flare stage that could be a signature of electron acceleration. Nevertheless, the most important is that the nonlinear wave-wave interaction which involving interaction of electrostatic electron plasma that called as Langmuir waves active region radio emissions is believed to be a main subject that relevant with a type III burst. In this study, solar radio bursts are observed by using the CALLISTO spectrometer. The log Periodic Dipole Antenna (LPDA) involved in this search over a broad region centered on the Sun and it covered the range of frequency from 45 MHz- 870 MHz and it is connected to the CALLISTO spectrometer. At certain period of time, when the Sun launches billons tones of electrically conducting gas plasma into the space at millions of miles per hours it is assigned that CMEs begin to launches. At this time, the appearance of SRBT III was observed and followed by SRBT II within the time interval of 15 minutes. During flares, large scale of magnetic field structures can be destabilized and be repelled into the interplanetary medium; along with the large mass it contains to form so-called CMEs. Based on the result obtained, the SRBT III is followed by SRBT II which only in short period. During the SRBT II, the solar flare was also appearing and same goes to the CMEs.

1. INTRODUCTION

Basically the appearance of solar storm such Coronal Mass Ejection (CMEs) and solar flare, solar radio burst can be observed over a broad frequency range. Coronal Mass Ejections (CMEs) are enormous eruptions of plasma and magnetic fields ejected from the sun into interplanetary space, seen by coronagraphs as they move out of their field of view over the course of minutes to hours. CMEs can only be observed by blocking the intense glare of photosphere because their brightness is of order of magnitude of the solar corona. In this study, solar radio burst type III and II is the subject matter that we are focusing on because type II and III burst are seem to have relation to each other. During a flare, large quantities of energy are transferred between the corona and the chromosphere through thermal conduction, non-thermal particle beams, radiation transport and the mass motion. Solar Radio Burst Type III in the IP medium can be grouped into three broad classes representing three different situations of electron beam production and propagation: (i) isolated type III bursts from flares and small-scale energy releases, (ii) complex type III bursts during CMEs, and (iii) type III storms. We discuss them in turn in the next three subsections.

The most common of type III burst is called isolated type III burst which is produced by energetic electron from small scale energy release site on the sun and it is ranging from small bright point to large active region [1,2,3]. It reveals a wave-particle and wave-wave interactions in

magnetic traps in the solar corona [4]. This burst is still one of the interest burst in order to understand the flare plasma diagnostics in the low corona [5]. Interestingly, the motion follows the predominant magnetic field direction, the apparent speed is a significant fraction of the speed of light. CME interactions were first identified as long – wavelength radio enhancements in the wind in the Wind/WAVES dynamic spectra [6,7,8].

Type II burst are confined to frequency ~ 150 MHz, although occasionally they are observed at higher frequencies. The type II burst are produced by plasma emission mechanism and observed slowly drifting features in the radio dynamic spectrum. Payne-Scott is the one who first discover the slow drifting radio burst (1947) from the records at 200, 100 and 60 MHz. It is well known that frequency drift rate of a type II burst is related to the speed of the shock that produces the burst and density gradient in the ambient medium.

The solar radio burst type III solar burst is the most dominant with the solar flare phenomenon was first introduced by Wild in 1963 [9] in the frequency range 500 – 10 MHz [10,11,12]. There are three sub-types of Type III burst that originate in the interplanetary (IP) medium which are (i) isolated Type III bursts from energy system and small-scale energy releases, (ii) a complex Type III bursts during CMEs, and (iii) Type III storms. This stage can be considered as a pre-flare stage that could be a signature of electron acceleration [13]. It is found that 60 % of fast drifts (type III) solar radio bursts are synchronized in time with solar flares [14]. Some evidence showed that type III are generated in a weak-field region comes from the absence or low degree of circular polarization of the bursts [15]. Nevertheless, the most important is that the nonlinear wave-wave interaction which involving interaction of electrostatic electron plasma that called as Langmuir waves active region radio emissions is believed to be a main subject that relevant with a type III burst [16,17,18,19,20]. It is believed that a beam-plasma system is unstable to the generation of Langmuir waves, which are high frequency plasma waves at the local plasma frequency [21,22]. Type III bursts early in the rise of impulsive solar flares may indicate that open field lines are an essential part of models for energy release by magnetic fields in such flares [23,24]. Nevertheless, it is important to analyze in radio and x-ray region to understand the distribution of high and low energy [25,26,27,28]. To explain the unique features of what happen during CME, one has to recall the ability of a CME to drive a shock depends not only on its speed, but also on the properties of the medium through which the CME propagates. Further exploration of the relationship between solar burst type II and III with the solar storm such solar flare and CMEs is done to get more information of the evolution of all those phenomenon interactions.

2. SOLAR FLARE OBSERVATION AND e-CALLISTO SOLAR SPECTROMETER NETWORK

Solar flare produce copious amount of coherent radio waves, which have been classified for more than 40 years into different classes. Energy during solar flares is used to accelerate particle to high energy. Whereby, electrons will propagate in the solar atmosphere and emitting radio waves when passing the magnetic field. Next, it will collide in the dense lower atmosphere and emit high energy [29,30,31].

Most of the CALLISTO sites focused the frequency 45 MHz to 900 MHz region seems this is the best range with a very minimum of Radio Frequency Interference (RFI). In this study, the data were observed on 27th January 2011 at 12:14 UT till 13:00 UT. The coronagraphs were taken from Solar and Heliospheric Observatory data (SOHO).

In this study, solar radio bursts are observed by using the CALLISTO spectrometer. The log Periodic Dipole Antenna (LPDA) involved in this search over a broad region centered on the Sun and it covered the range of frequency from 45 MHz- 870 MHz and it is connected to the CALLISTO spectrometer [32,33]. Signal from the feed will be fed into the receivers. After that, the signal will be converted to a first intermediate frequency of 37.7 MHz by two local oscillators [31,34,35,36,37]. This antenna covered from 45 - 870 MHz [38,39,40,41].

The CALLISTO spectrometer is a low-cost radio spectrometer used to monitor metric and decametric radio bursts, and which has and the named CALLISTO which is inspired from the name of one of the Jupiter's larger moons [42,43,44,45,46]. In this case, we focused the range of 150 MHz till 900 MHz [47,48,49]. CALLISTO consist three main components which are the receiver, a linear polarized antenna and control/logging software [50,51]. We have selected the data from the 150 MHz till 900 MHz region seems this is the best range with a very minimum of Radio Frequency Interference (RFI) [51,52,53,54,55]. In this paper, we have focused the study area of solar flares in an X-ray and radio region to evaluate the distribution of high and low energy [38].

3. RESULTS AND ANALYSIS

At certain period of time, when the Sun launches billions tones of electrically conducting gas plasma into the space at millions of miles per hours it is assigned that CMEs begin to launches. It is critical when CMEs and the magnetic field which laced together with CMEs' cloud smashed into Earth magnetic field. This is because; they will dump energy into earth magnetic field that can cause magnetic storms. Widespread blackouts by overloading power line equipment will happen due to the storms.

Figure 1: e-Callisto Spectrometer at 12:14 UT – 12:30 UT and LASCO C2 images (Credited to e-Callisto and SOHO)

At this time, the appearance of SRBT III was observed and followed by SRBT II within the time interval of 15 minutes. It was appear at range of 30MHz to M90Hz for about 4 minutes. During the existence of SRBT II, the solar flare also observed. Solar flares are classified according to their x-ray brightness in the wavelength 1-8 Angstrom. Basically, there are three categories of flares, which are X-class flares, M-class flares and C-class flares. X-class flares are the brightest, followed by M-class flare and C-class flare.

Figure 2: Departing sunspot complex 1147-1149 poses a slight threat for C-class solar flares.
Credit: SDO/HMI

Based on the information provided by space weather .com, it was detected that during this time there is x-ray solar flare. It was happen due to an explosion on the sun that happen when the energy stored in twisted magnetic field which is usually occur above sunspot. X-rays and gamma rays are the sources of flare to produce a burst of radiation across the electromagnetic spectrum. Solar flare is considered as a high energetic and complicated phenomenon in which mass eruption occur. During flares, large scale of magnetic field structures can be destabilized and be repelled into the interplanetary medium; along with the large mass it contains to form so-called CMEs. Table 1 shows the condition of the Sun during 27th January 2011.

Table 1: Space weather condition at 27th January 2011

Solar Wind	X-ray Solar Flares
speed: 317.2 km/sec density: 3.9 protons/cm ³	6-hr max: C1 2003 UT Jan27 24-hr: C1 2003 UT Jan27

Figure 3: e-CALLISTO at 12:29 UT – 12: 45 UT and LASCO C2 images and e-Callisto at 12:44 UT – 13:00 UT and LASCO 2 images (Credited to e- Callisto and SOHO)

The observation was made till 13:00 UT. The results show that, a small loop was observed. This loop indicates that, a small CME was appearing in this time. Whereby, CMEs associated with metric type II burst and CMEs associated with IP type II burst and it is clear evidence that the energy of CME is an important factor in deciding whether it will associated with a type II burst.

4. CONCLUDING REMARKS

Based on the result obtained, the SRBT III is followed by SRBT II which only in short period. During the SRBT II, the solar flare was also appearing and same goes to the CMEs. During the last two decades it become clear that solar conditions greatly affect the earth and environment. Thus, it is important to observe the activities on the sun continuously to understand the unique behavior of the sun from time to time.

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Biography

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