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Electron Density And Drift Rate Of Solar Burst Type II During 1st June 2015

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ABSTRACT. This event allows us to investigate the electron density and drift rate of solar burst type II During 1st June 2015. It is believed that the plasma–magnetic field interactions in the solar corona can produce suprathermal electron populations over periods from tens of minutes to several hours, and the interactions of wave-particle and wave-wave lead to characteristic fine structures of the emission. An intense and broad solar radio burst type II was recorded by CALLISTO spectrometer from 25-80 MHz. Using data from a the Blein observatory, the complex structure of solar burst type III can also be found in the early stage of the formation of type II solar burst type event due to active region AR2358. The drift rate of solar burst type II exceeds 0.03 MHz/s with a density of electron in the solar corona. There are 18 CMEs occurring that day and the distributions of CME speed are between 200 ms^{-1} to 1100 ms^{-1} so that the average velocity of the CMEs that occur that day is 1025 m/s. This is one of the largest number of sunspots that have recorded in this year. However, all of these sunspots are quiet and stable and the solar activity remains low. Therefore, it can be observed that only B class of flare from the X-Ray Flux Data.

1. INTRODUCTION

The Sun produces a very high energy deep within its core. The temperature in this region is approximately 15 000 000 C and a pressure (340 billion times Earth's air pressure at sea level) is so intense that nuclear reactions take place. Because of this reaction, one alpha particle or helium nucleus which consists of four protons to fuse together. Alpha particle is 7 %, massive than the four protons because the difference in mass is expelled as energy. The energy is carried to the surface of the Sun in the form of light and heat, through a process known as convection. Its mass is 1.989×10^{30} kg and its luminosity is 3.85×10^{26} W [1].

It is well known that the solar activity is due to large and changing magnetic fields threading the outer regions from Convective zone to Corona and produce the sunspots, solar flare and Coronal Mass Ejections phenomena [2]. It refers to the phenomena that naturally occur within the outer atmosphere of the sun when it magnetically heated [3]. Solar activity generated due to the strong magnetic field and a chaotic dynamo near the surface of the sun which caused a smaller magnetic fluctuation [4]. During solar activity the energy particle of the Sun released due to solar flares, coronal mass ejection (CME), coronal heating as well as sunspot. This sunspots occur by high concentrations of the magnetic field which inhibit the flow of heat to the surface from the convection zone below. One still unresolved puzzle about the chromospheres is why at some frequencies (at least 10 −100) GHz the polar coronal holes appear brighter than the rest of the quiet Sun due to corresponds to an elevated temperature in the upper chromosphere in coronal holes relative to the normal quiet Sun [5].

The Coronal Mass Ejections (CMEs) ejected from the sun are one of the main solar phenomena and the Earth-directed CMEs were very important, since they can produce geomagnetic storms. There is a crucial link between activities in the sun to the earth. Geomagnetic storms can excite if a CME collides with the earth. The higher speed of solar wind enhances magnetic field and generate geomagnetic storm that involves reconnection with the Earth's magnetosphere [6]. Geomagnetic storms can cause electrical power outages and damaged communications satellite. Besides, it also will produce energetic particles that give damages to the electrical equipment and astronauts. Meanwhile, ionosphere and the radio communications at the earth can be directly affected by solar flares. Also, solar flare release energetic and non-thermal particles into the space [7]. An understanding of both CMEs and flares are required to understand and predict the space weather and its effects to the climate of the earth [8,9,10,11,12,13,14,15,16,17].. It is necessary to study the initial stage of CME of their kinematics and the other features. For many CMEs, with the use of data from various instruments, time profiles of velocity, acceleration and geometric characteristics of CMEs immediately after their initiation were obtained in any wavelength [18,19].

Type II burst is confined to frequencies ≤ 150 MHz, although occasionally that are observed at higher frequencies [20]. Type II bursts typically occur at around the time of the soft X–ray peak in a solar flare and are identified by a slow drift to lower frequencies with time in dynamic spectra, the frequent presence of both fundamental and second–harmonic bands (with a frequency ratio of 2), and splitting of each of these bands into two traces [21,22,23]. Basically there are seven types of SRBT II, which are Narrow Bandwidth, Band Splitting, Multiple Band, Compound Type III-II Burst, Herring Bond Structure and Other Fine Structure [24].

2. SOLAR BURST OBSERVATION

CALLISTO spectrometer designed and built to detect the intensity of electromagnetic radiation at radio frequencies between 45-870 MHz. It consists three main components which are the receiver, a linear polarized antenna and control/logging software [25,26]. Due to the development of the technology, more advanced system was implemented to the system includes a tower-mounted preamplifier or low noise amplifier, additional antennas and a focal plane unit (FPU) with antenna polarization switching and noise calibration capabilities [27,28].

3. RESULTS AND ANALYSIS

Important parameters that have been taken into account are such burst duration, drift rate, energy of the photon, and harmonic structure of the burst. The current conditions of space weather were taken from the space weather website provided by NASA and the images of the structure of sunspot on the Sun, data and other images revealed by SOHO Observatory, Solar Monitor, SWPC and CACTUS which also have a collaboration with NASA.

Here, we considered event is the event is on the 1st of Jun 2014. The occurrence of the event is interesting in many aspects which is also in Blein. From the dynamic spectra of the CALLISTO, it can be observed that there are two types of Solar Radio Burst emitted from the Sun which are SRBT III and followed by SRBT II. Type III that appears is single SRBT III for approximately 4 minutes at 13.32UT till 13.36UT. This burst duration is longer compared to the other events.

Eight minutes after the SRBT III, SRBT II began to appear at 13.42 UT. This SRBT II duration time is longer compared to SRBT III that appear before its appearance for about 20 minutes. Whereby, this SRBT II ends at 00.00 UT. Similarly with the previous event both SRB were drifting from 80MHz to 20 MHz and 27 MHz for SRBT III and II respectively.

Parameter	Value
Solar Wind Speed	342.4 km/Sec
Proton Density	4.1 protons/cm^3
Interplanetary Magnetic Field	5.0 nT

Figure 1 . The current condition of the Sun (Credit to spaceweather.com)

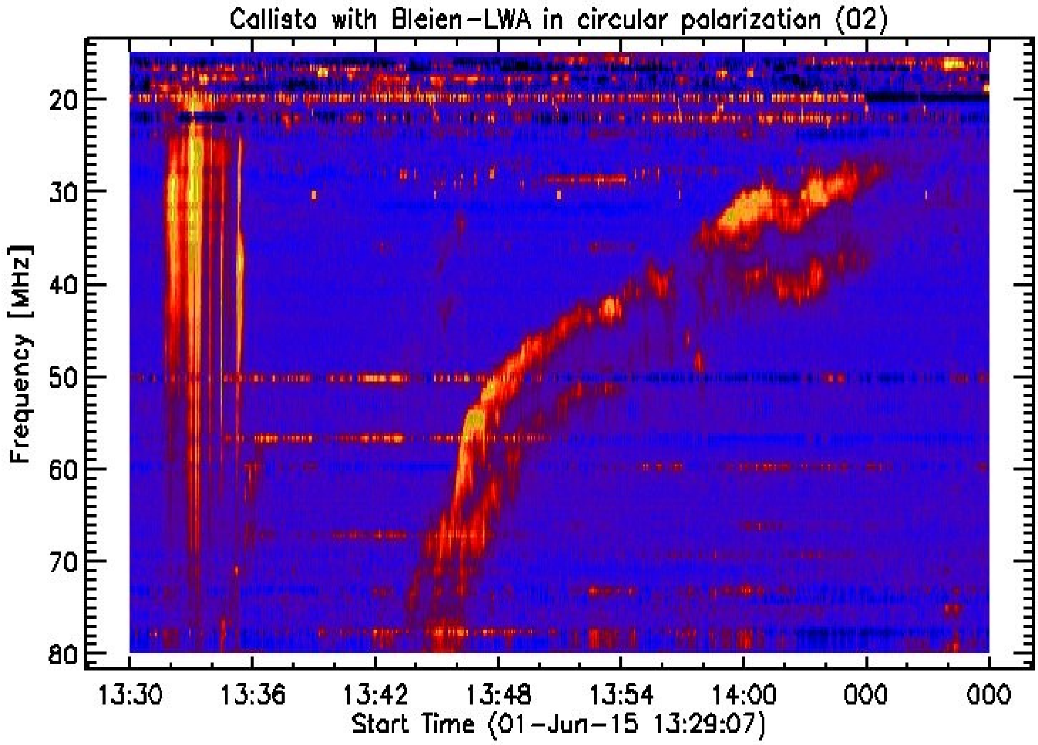

Figure 2. SBRT III and II on 1st of Jun 2015 (Credit to e-CALLISTO)

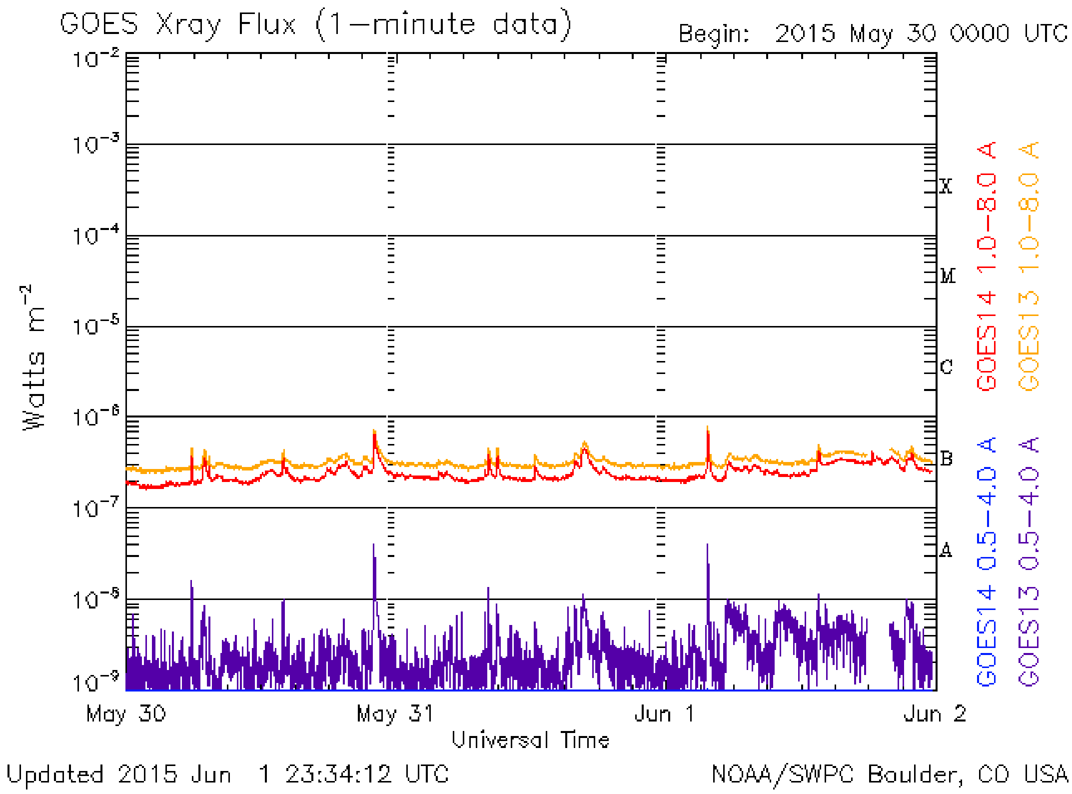

Figure 3. GOES X-ray Flux Data starts on 30th to 2nd of May (Credit to Solar Monitor)

From our analysis, no active regions were observed on the 1st of June 2015. However , from the X-Ray Flux Data it can be observed that only B class of flare happen on that day. This class of flare low class of flare and do not cause harm to our environment.

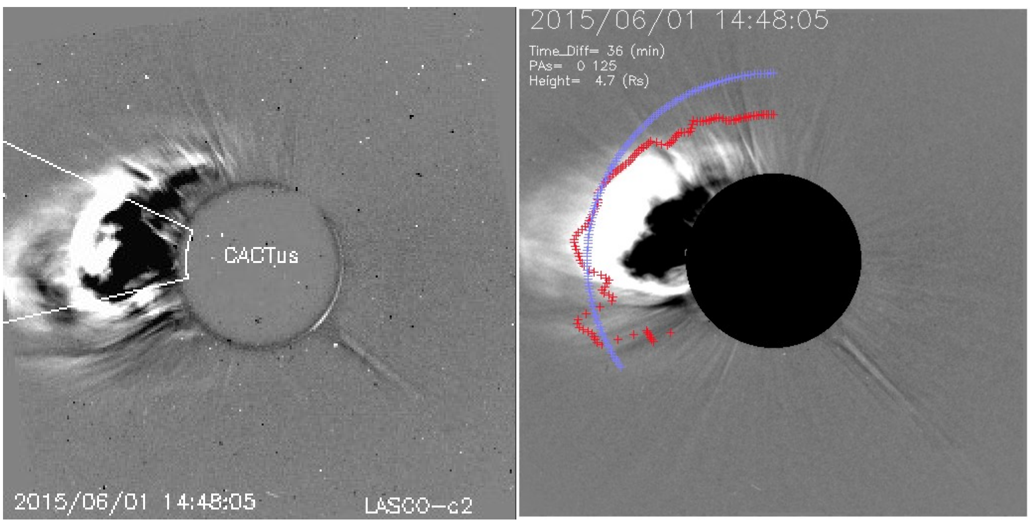

Figure 4. Image of CME on 1st of June 2015

It is widely known that the radio emission it occurs as a final step in a series of physical process: initiation of shock, particle acceleration, generation of plasma waves and finally conversion of plasma into electromagnetic waves. From the observation of CACTUS, during the day, there is a CME detected with the height of 4.7 Rs. It is also a medium height, of CME.

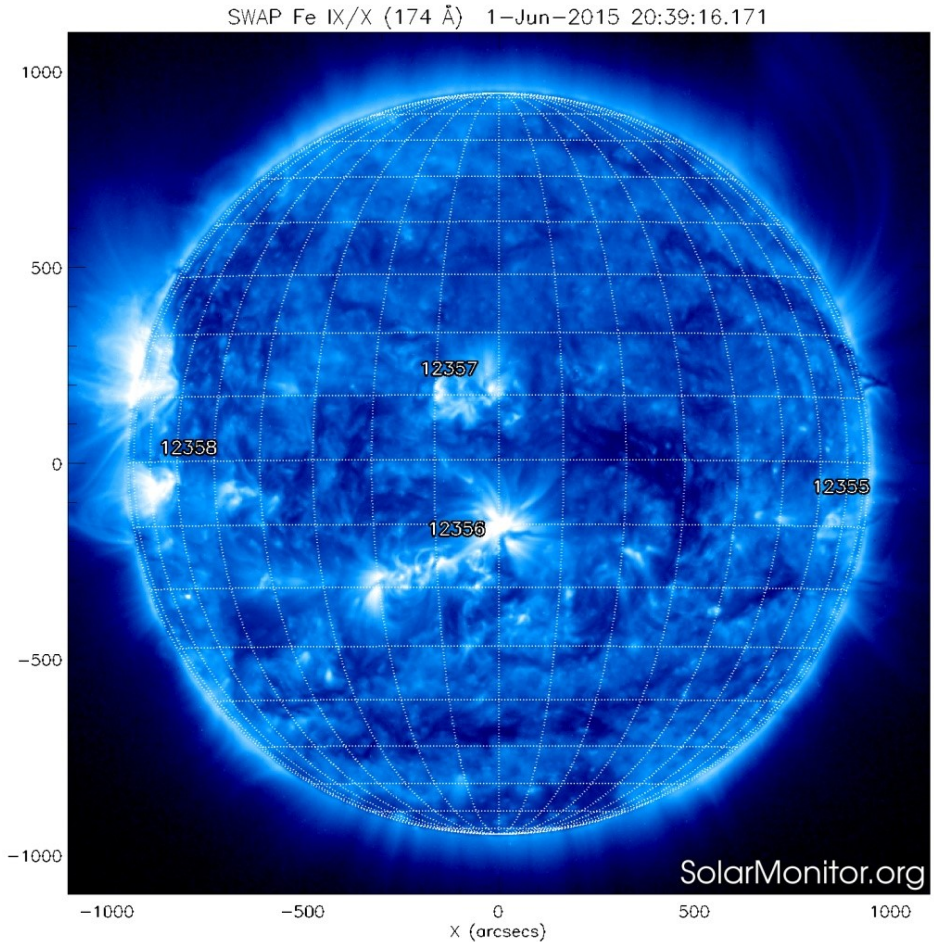

Figure 5. Solar Active Region on 1st of Jun 2015 (Credit to SolarMonitor)

All of these sunspots are quiet and stable and the solar activity remains low. There are no flares detected during that day. The relationship of SRBT II and CME had been a long controversy whereby sometimes type II associated with CME and sometimes not.

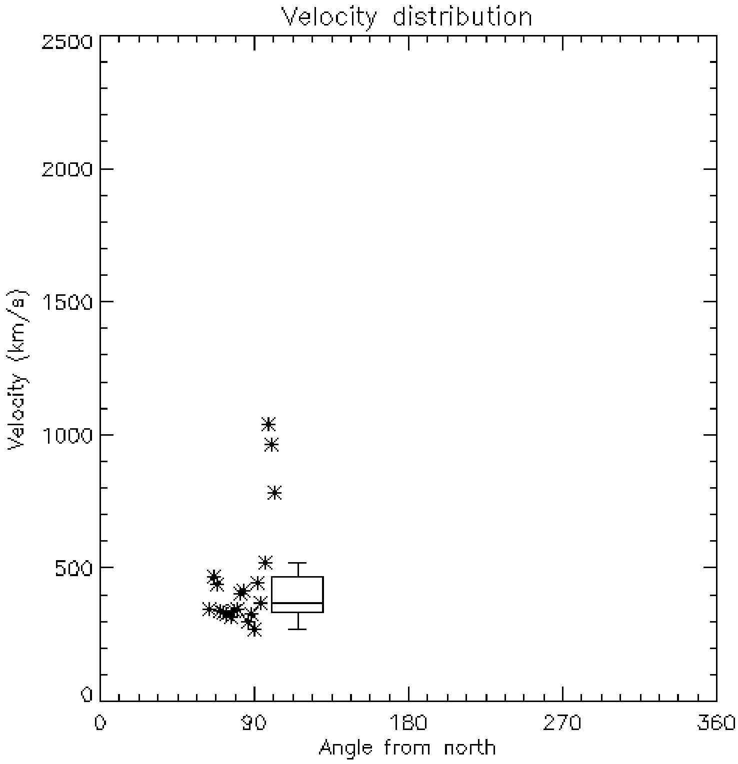

Figure 6. Distribution of CME velocity on 1st of Jun 2015(Credit to CACTUS)

Figure 6 shows the graph of CME velocity versus angle from north or 1st of Jun 2015. There are 18 CMEs occurring that day and the distributions of CME speed are between 200 ms^{-1} to 1100 ms^{-1} so that the average velocity of the CMEs that occur that day is 1025 m/s. This average velocity makes the CME on 1st of June to be classified as 'impulsive CME'.This event allows us to investigate how plasma–magnetic field interactions in the solar corona can produce suprathermal electron populations over periods from tens of minutes to several hours, and the interactions of wave-particle and wave-wave lead to characteristic fine structures of the emission. The burst occurred as low frequency compared to the previous events, but this event occurred longer compared to the previous event. It has been observed that the solar wind and density is low as the plasma frequency also low.

The drift rate for the SRBT III is,

$$D = \frac{80MHz - 20\ MHz}{270s} = 0.22MHz/s$$

And for the SRBT II is,

$$D = \frac{80MHz - 20\ MHz}{1800s} = 0.03MHz/s$$

Given that the CME temperature,

$$T_{CME} = 3 \times\ 10^7 (\frac{\boldsymbol{B}}{50\ G})^{\frac{6}{7}} (\frac{n_0}{10^9 cm^{-3}})^{\frac{-1}{7}} \times (\frac{L}{10^9 cm})^{\frac{2}{7}} K$$

$$= 3 \times\ 10^7 (\frac{5.0 \times 10^{19}}{0.005})^{\frac{6}{7}} (\frac{4.1}{10^9})^{\frac{-1}{7}} \times (\frac{4.7 \times 6.95 \times 10^{10}}{10^9})^{\frac{2}{7}} K$$

$$= 17810\ K$$

Based on the calculations, electron density of the burst is $4.838 \times 10^{12}\ e/m^3$ and the drift rate for both solar burst type III and II are $0.22MHz/s$ and $0.03MHz/s$ respectively. It shows that solar burst type II has a high dirt rate as compared to solar burst type II. This is because solar burst type II occurs in long duration as compared to solar burst type III.

4. CONCLUDING REMARKS

This event shows a strong radiation in radio region, but not in X-ray region. Therefore, we an only found a class B-solar flare during the time. However, it is a significant phenomena because there are 18 CMEs occurring that day and the distributions of CME speed are between 200 ms^{-1} to 1100 ms^{-1}. It might due to the unstable 'beta-gamma' magnetic fields that harbor energy for B-class flares. Their presence implies acceleration possibly at the tops of loops. Besides that, they have long been of interest in the Space Weather because they have a high degree of association with solar energetic particle events.

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