

An Analysis of Solar Burst Type II, III, and IV and Determination of a Drift Rate of a Single Type III Solar Burst

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ABSTRACT

The main feature of solar radio type II, III and IV burst is outlined. In this event there are three combinations of bursts that related to the solar flare phenomenon on 6th July 2012. This event is one of good example to observe how far the influence of type II burst could impact the formation of type IV burst and III solar bursts. At first stage, it was observed that a sub-type of H burst form within 2 minutes before type IV solar burst form. The type IV burst is due to the eruption of active region AR 1515 with a fine structure (FS). We used a Blein CALLISTO data in this case. Further analysis also showed that the total energy of the burst are in the range of 4.875×10^{-25} J to 8.48×10^{-25} J and plasma frequency is equal to 1.24×10^4 Hz. Therefore, we could say that in this case, before the solar burst type III occurred, the ejection of CMEs already ejected.

Keywords: Sun; solar burst; type II, III,IV; radio region; X-ray region; solar flare; active region

1. INTRODUCTION

Type IV burst is an indicator of the formation of a new active region [1-3]. It reveals a wave-particle and wave-wave interactions in magnetic traps in the solar corona [4]. However, the fully developed type IV event is very complex. At meter wavelengths the type IV burst is usually, though not invariably, preceded by a type II (slow-drift) burst. There are two main categories of solar radio burst type IV, which is (i) broadband radio pulsations (BBP) and (ii) zebra patterns (ZP). The fine structures (FS) of solar type IV radio bursts are of principal interest in flare plasma diagnostics in the low corona [5]. We will understand the necessary conditions in the coronal sources. On the other hand, the BBP source starts near the active region and decays away from it [6]. Interestingly, the motion follows the predominant magnetic field direction, the apparent speed is a significant fraction of the speed of light. These BBPs and ZPs in solar type IV radio emission are rather frequently observed, especially a few days before solar flare and Coronal Mass Ejection phenomena [7-9].

Meanwhile, solar radio burst type III solar burst is the most dominant with the solar flare phenomenon was first introduced by Wild in 1963 [10] in the frequency range 500 – 10 MHz [11-13]. 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 [14]. It is found that 60 % of fast drifts (type III) solar radio bursts are synchronized in time with solar flares [15]. 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 [16]. But 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 [17-21]. 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 [22,23]. The dynamic structure of the Type III solar burst is well known due to the ejection of plasma oscillations localized disturbance due to excited atoms in the plasma frequency incoherent radiations such as gyro synchrotron and free-free emissions appear in the radio wavelengths play a dominant role at the meter and decimeter wavelengths [24,25]. The common occurrence of 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 [26,27].

Type II solar burst was also discovered roughly more than 60 years ago [28,29]. It can be divided into two main components which is (i) fundamental (F) and (ii) harmonic (H) structure and a slow drift burst [30]. The temperature that implied between these two classes of emission is from 10^7 - 10^{13} K [31,32]. There are two main categories of this burst which is (i) herringbone emission and (ii) backbone emission [33]. The onset time of this type precludes the possibility of the CME driven shock causing it [34]. The motion of the shock through the radial plasma density profile can be observed based on the decreasing of the signal in frequency. One can deduce the propagation speed of the driving shock wave from eruption region. SRBT II were first identified by [35] and also discovered by [36] and classified as a broadband lasting from 20 minutes to a few hours. Thus the CME kinetic energy is the indicator of the life time of the type II bursts [37,38]. Nevertheless, it is important to analyze in radio and x-ray region to understand the distribution of high and low energy [39-42]. The next section will highlight the solar flare and solar bursts in X-ray and radio region.

2. SOLAR FLARE OBSERVATION

Solar flare is one of the main event of the Sun that affect the space weather and climate changes [43-45]. The observation of solar radio burst was done by using the Compact Astronomical Low cost, Low frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO) from BLEIN 7 meter dish telescope at ETH, Zurich in frequency range of 45 until 870 MHz. [46,47]. On our site, we also have constructed a log-periodic antenna is a broadband, multi-element, unidirectional, narrow-beam antenna that has impedance and radiation characteristics that are regularly repetitive as a logarithmic function of the excitation frequency [31,32,45,48,49]. This antenna covered from 45-870 MHz [50-53]. The CALLISTO spectrometer is a low-cost radio spectrometer used to monitor metric and decametric radio bursts, and which has been deployed to a number of sites space world to

allow for 24 hour monitoring of solar radio activity [54,58]. In this case, we focused the range of 150 MHz till 900 MHz [59,61]. This region is the best region with minimum interference at Blein, Switzerland site [62,63]. 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) [63,67-69]. 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 [50].

3. RESULTS AND ANALYSIS

A class of the M2 solar flare is continuously being observed in X-ray region for 24 hours since 1541 UT and maximum M1 detected on 0140 UT. Based on the calculation, the total energy is high due to high frequency. Then, the plasma frequency also is high which about 1.24×10^4 Hz. The drift rate also greater as the burst occur in high frequency and in a short time. It should be noted that the solar wind is when a steam of plasma released from the upper atmosphere of the sun and it is consists of mostly electron and proton.

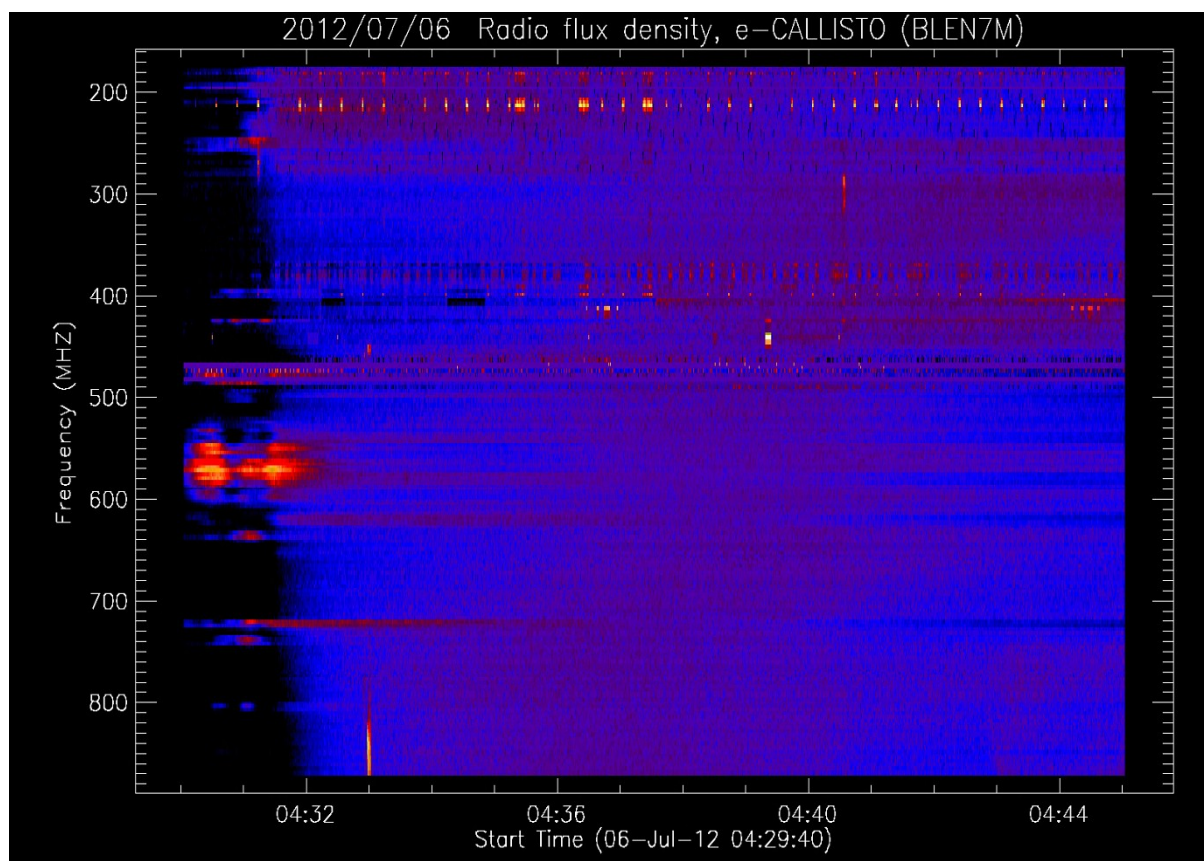


Figure 1. The continuous solar radio burst type IV within 10 minutes (Credited to: E-Callisto network (BLEIN7M)).

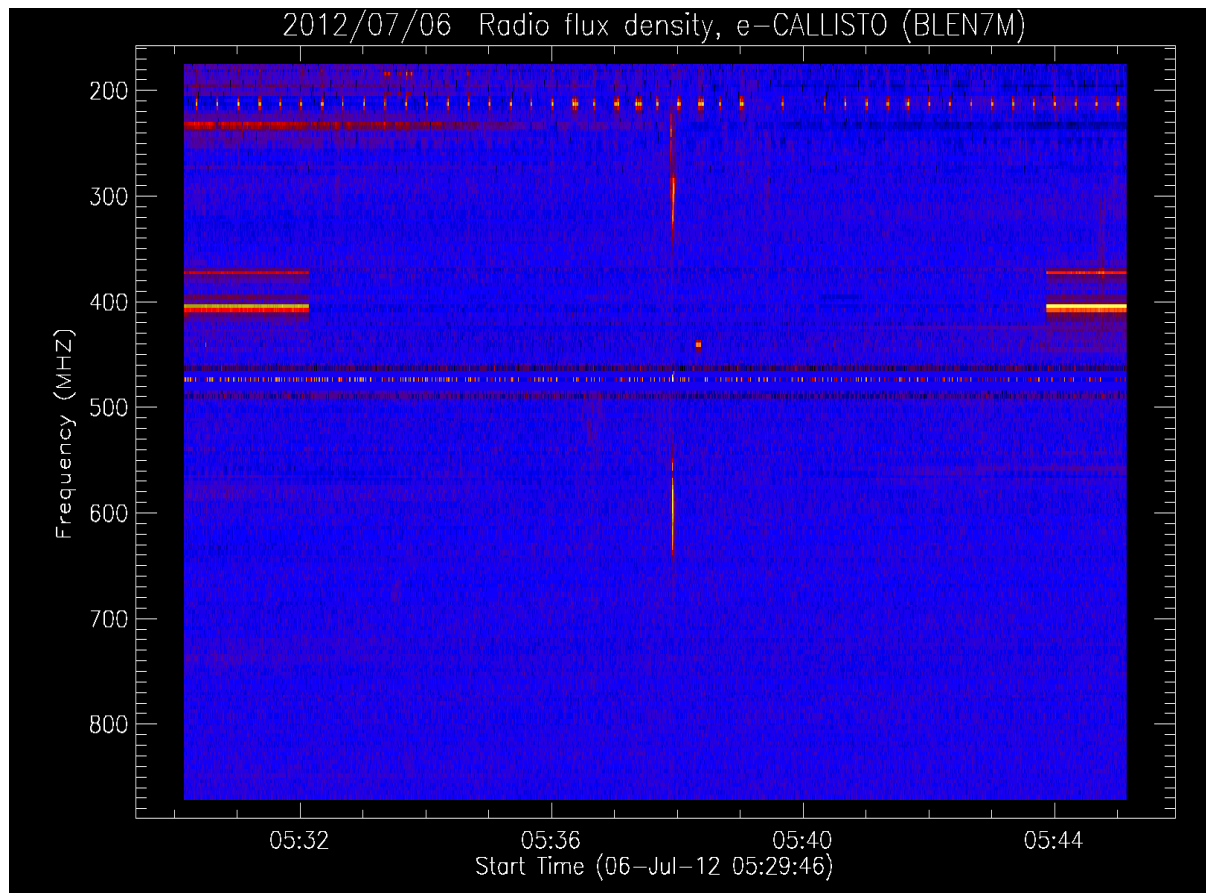


Figure 2. A single solar radio burst type III appears 45 minutes after solar radio burst type IV (Credited to : E-Callisto network (BLEIN7M)).

Based on calculations, energy for the burst, the total energy of the burst are in the range of 4.875×10^{-25} J to 8.48×10^{-25} J. The energy released is higher than the first case because of their occurred at high frequency. From the theoretical point of view, the drift velocity also calculated based on the formula as shown below:

$$\frac{df}{dt} = \frac{f \text{ high} - f \text{ low}}{t \text{ high} - t \text{ low}} \quad (1)$$

$$\frac{df}{dt} = \frac{(800 - 460) \text{ Mhz}}{(1) \text{ Second}} \quad (2)$$

$$= \frac{130 \text{ MHz}}{1 \text{ second}} \quad (3)$$

$$= 340 \text{ MHz/second} \quad (4)$$

We can also possible to find the plasma frequency calculated,

$$\nu_p = \frac{\sqrt{e2Ne}}{4\pi\epsilon_0 m_e} \quad (5)$$

$$= \sqrt{81Ne} \text{ Hz} \quad (6)$$

$$= 1.24 \times 10^4 \text{ Hz} \quad (7)$$

Here, we can conclude that the plasma frequency is directly proportional to solar wind as the solar wind increased, the plasma frequency increased as well.

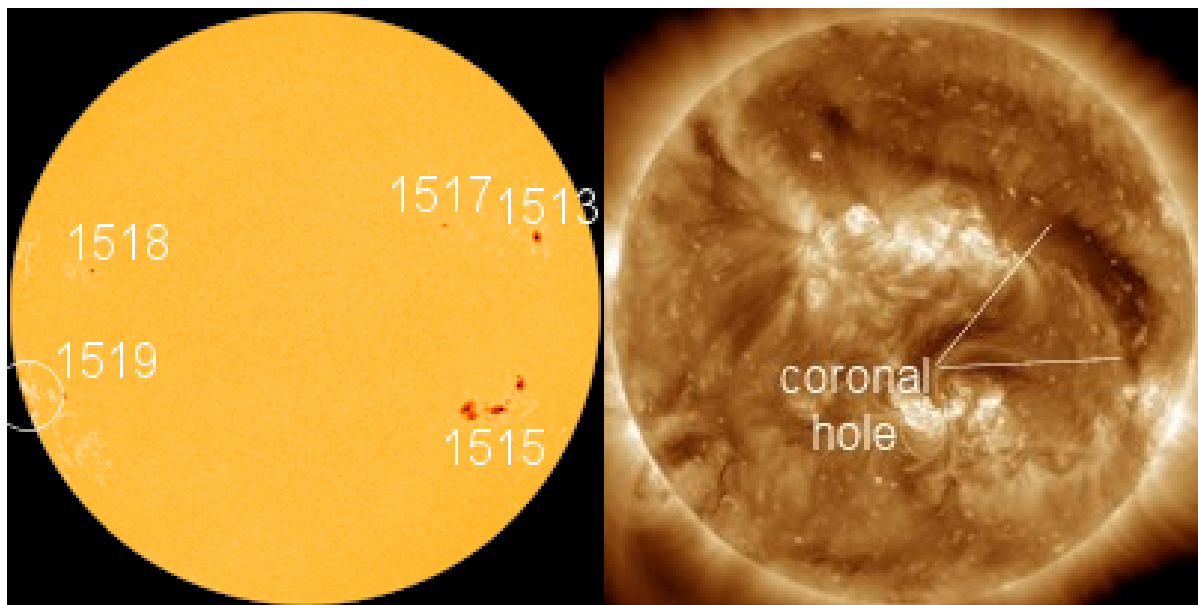


Figure 3. The Active regions during 6th July 2012 and the image of the Sun by X-ray from Space Weather Website (Credited to: NOAA/ SWPC).

It was found that there are five Active Regions on with coronal holes on the Earth-facing side of the Sun. From the Figure 4. The active region AR1515 play the roles to eject the solar flares.

The number of sunspots during the day is up to 122 with the radio flux also high which is 165 SFU. The speed of the solar wind also exceeds 480.1 km/second with a high density of protons in solar corona which is 1.9 protons/cm³.

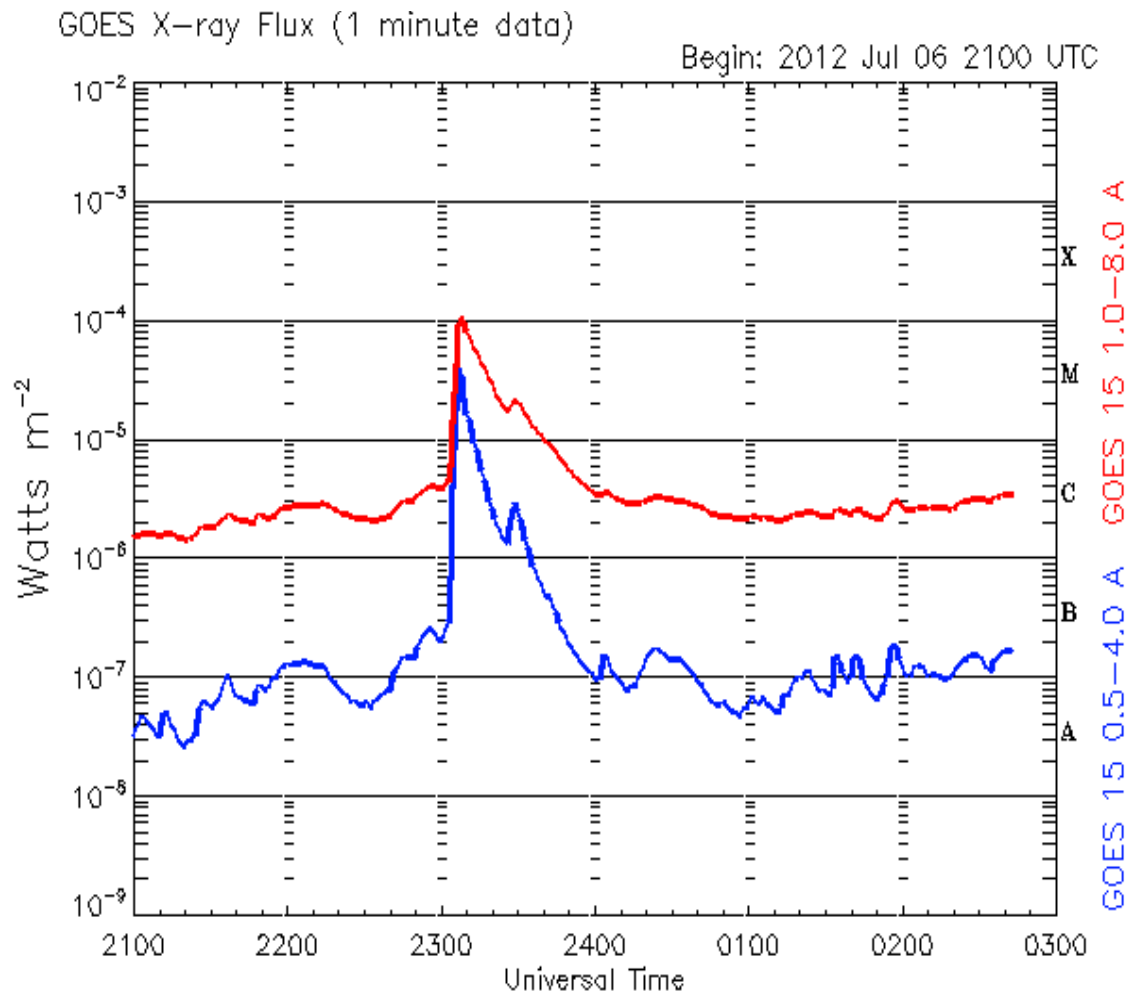


Figure 4. The variability of solar flare during 6th July 2012 (Credited to NOAA Space Environment Centre).

4. CONCLUDING REMARKS

This event is one of good example to observe how far the influence of type II burst could impact the formation of type IV burst and a single type III solar burst. At first stage, it was observed that a sub-type of H burst form within 2 minutes before type IV solar burst form. It has been observed that before the burst type III occurred, solar radio burst type IV and Type II also occurred.

It is well known as Type II occurred due to the ejection of Coronal Mass Ejections (CMEs). Then after a few hours, type III burst occurred at very high frequency. The solar flare occurred also is classified as an M - class during the day. Therefore, we could say that in this case, before the solar burst type III occurred, the ejection of CMEs already ejected.

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Biography

Dr Zety Sharizat Hamidi is currently a senior lecturer and focused in Solar Astrophysics research specifically in radio astrophysics at the School of Physics and Material Sciences, Faculty of Sciences, MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia. Involve a project under the International Space Weather Initiative (ISWI) since 2010.

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