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Detailed Investigation of a Moving Solar Burst Type IV Radio Emission in on Broadband Frequency

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ABSTRACT

The moving type IV burst component of the solar radio region from 260-380 MHz observed using the CALLISTO spectrometer is discussed in detail. We used the *Compound Astronomical Low Cost Low Frequency Spectrometer Transportable Observatory* (CALLISTO) system connected to the Log Periodic Dipole Antenna (LPDA) at the National Space Centre, Selangor located (3.0833333°N 101.5333333°E) on 22nd February 2012. It is found that a strong burst that caused by extraordinary solar flares are due to magnetic reconnection effect potentially induced in the near-Earth magneto tail. From our observation the indication of signal potentially drives Coronal Mass Ejections (CMEs). We also compare our results with the Geostationary Operational Environmental Satellites (GOES) data. From our analysis, one possible reason behind the formation of this very complex long duration of this loop is the magnetic reconnection and disruption of the loops which is observed during flare maximum. The Active Region, AR 1429 active region was a site of several intense in several days. From the results, it showed that the burst is formed from the explosion of M-class solar flare which can be observed at 412UT. As a conclusion, a good agreement was reached and we believe that Sun's activities are more active to pursuit the solar maximum cycle.

***Keywords*:** Solar radio emission; solar burst type IV; e-CALLISTO; solar flare; Active Region 1429

1. INTRODUCTION

The radio observations specifically in low region provide an indication of Sun activities such as Coronal Mass Ejections (CMEs), solar flare, evolution of sunspots and others unpredictable phenomena. Solar radio emission plays an important role in understanding the mechanism of energy release, plasma heating, the particle acceleration and transfer in magnetized plasmas. The value of solar radio bursts at low frequencies lies in the fact that they originate in the same layers of the solar atmosphere in which geo-effective disturbances probably originate the layers where energy is released in solar flares, where energetic particles are accelerated and where Coronal Mass Ejections (CMEs) are launched [1]. This is important in order to detect the fine structures may help us to look into the dynamical process during the burst of flares [2,3].

The Type IV solar radio bursts have a high probability of being followed by geomagnetic disturbances. It can last from hours to a few days in the region of 20 MHz till 2 GHz. In general, it exhibits two distinct phases in its occurrence. At the beginning of the, the frequency is higher than 250 Mc/s and associated with centimeter-wave burst. In the second phase, this burst will associate with a type II burst; however, the frequency is lower than 250 Mc/s [4].

It is widely accepted that this solar type IV burst fine structures such as zebra pattern structures and fiber bursts superimposed on microwave bursts were classified and studied more than 20 years ago [5,6]. There are several mechanisms for the zebra and fiber structures, and one generally accepted theory is DPR [7].

In principle, a regular practice to distinguish metric solar radio burst signals is to record the digital dynamical spectra, extract sequences of single frequency events with limited discrete length and to determine quantitative characteristics on the basis of these observations. In this paper, we will discuss in detail our first light detection of solar burst type IV of solar radio burst.

2. EXPERIMENTAL SETUP AND METHODOLOGY

In this work, we used the Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO) system which is connected to the Log Periodic Dipole Antenna (LPDA) at the National Space Centre (ANGKASA), Selangor located at (3.0833333°N 101.5333333°E) with minimum Radio Frequency Interference (RFI) noise level, with an average – (85-100) dBm [8- 10].

Practically, a LPDA that can cover the range of frequency from 45-870 MHz is connected to the CALLISTO spectrometer. However, in order to minimize the noise level, we focus only in the region of 260 MHz till 380 MHz [11]. The distribution data radio flux density in burst versus the frequency range of the spectral peak and intensity level has been collected daily starting from 11.30 UT till 23.30 UT [12-16]. The basic data for each burst consists of 15 minutes of dynamic spectrum with 0.25 second time resolution. The bursts were selected by their appearance which was made simultaneously with digital recording.

3. RESULTS AND ANALYSIS

A solar flare, occurred on March 5th, 2012 in the Active Region 1429, located close to the limb of the solar disc, was recorded by the Geostationary Operational Environmental Satellites (GOES). During the impulsive phase of this flare (from 4:00 UT to 04:15 UT), three groups of Active Region at the center of the Sun (i) 1423, (ii) 1428 and (iii) 1423 respectively. These Active Region seems to be passive within this few days. We have selected a region from 260 MHz - 380 MHz.

Detailed zebra structure patterns are shown in Figure 3. It was found that a significant solar burst variations happened starting from 4.12 UT. Inappropriately, the continuous detailed data could not be taken due to the limitation of the period of observations.

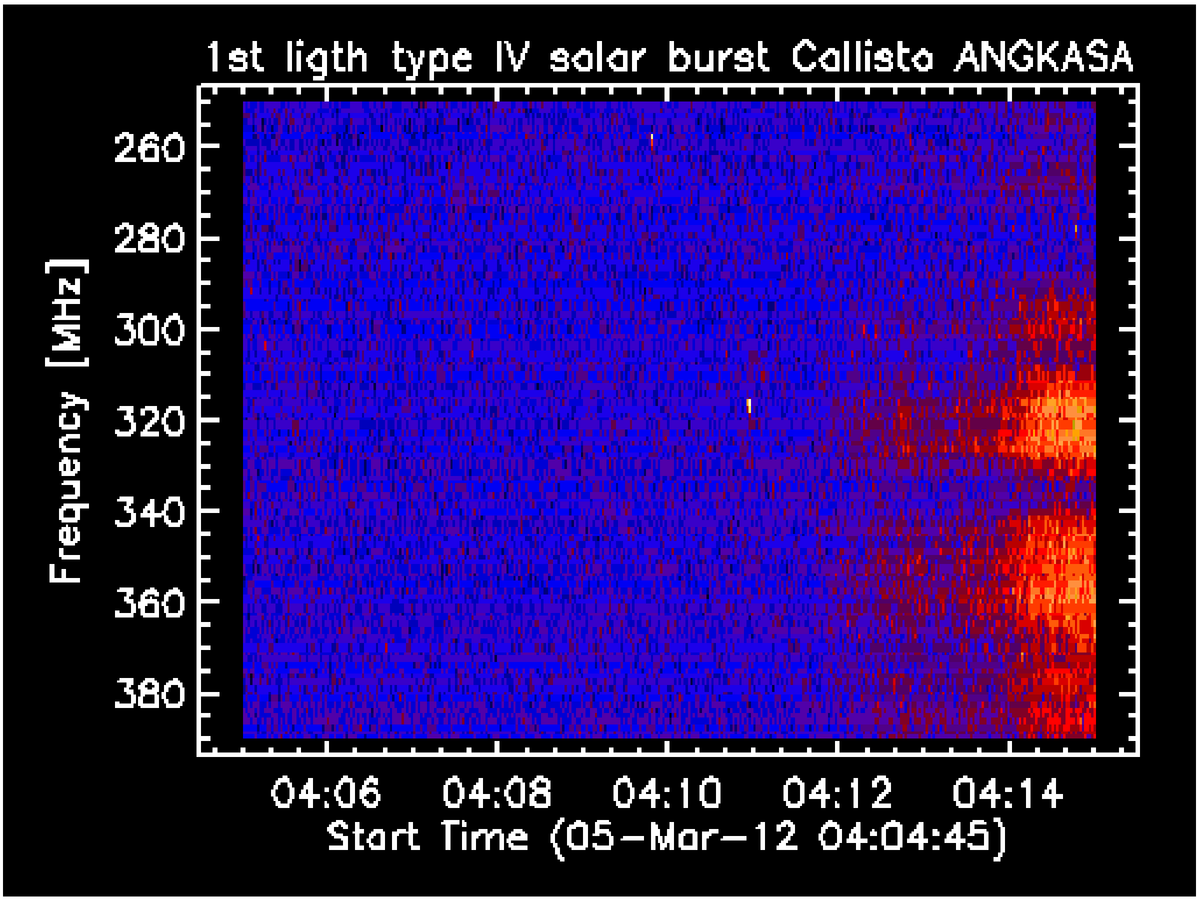

Figure 1. First light curve associated with a Type M 2.0 solar flare on 5th March 2012 at the National Space Centre, Banting Selangor.

From the observations, strong bursts that caused by extraordinary solar flares due to magnetic reconnection effect potentially induced in the near-Earth magneto tail. One could see the tenuous plasma in that region is then accelerated down magnetic field lines into the Polar Regions, striking Earth's atmosphere and exciting nitrogen and oxygen atoms as well as the other atoms present in our atmosphere.

Theoretically, time variability in the emission may due to the changes in the electron density. Though, these variations mainly proceed slowly. It is due to the change in the local ionization temperatures. In the next figure (Figure 2) shows the Active Region 1429 poses a threat for X-class solar flares at 4:12UT by using the Large Angle and Spectrometric Coronagraph LASCO2.

Thus, this active region has remained active in a few days. It is expected that it will be larger solar flares and CMEs in the next few days. Fortunately, this explosion is not directed in the direction to the Earth.

To confirm our results, we also compare our results with the GOES data. Radio observations combined with the Hard X-ray (HXR) observations can help us to analyze the release of flare energy and acceleration of energetic particles during the pre-phase of the flare.

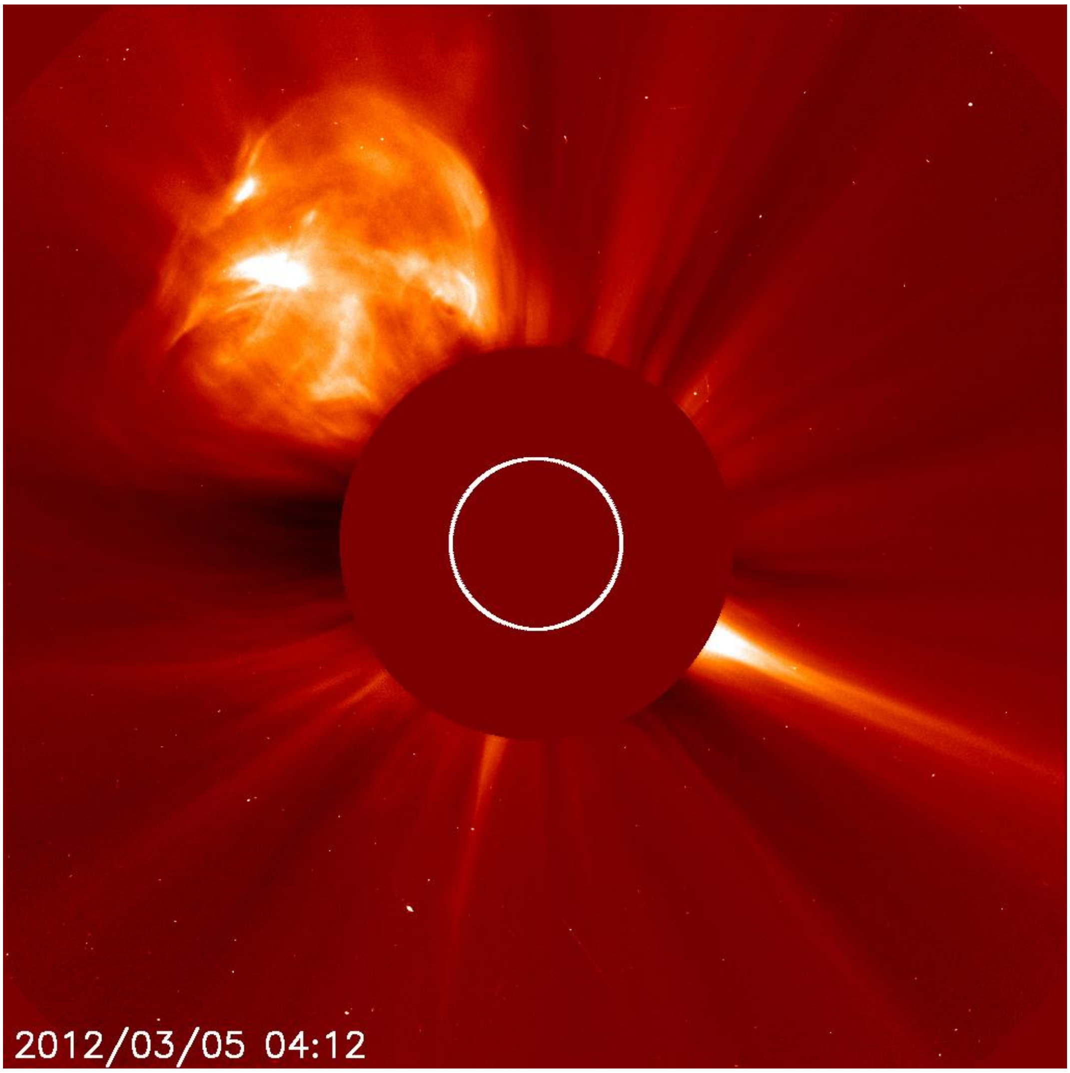

Figure 2. The Active Region 1429 poses a threat for the X-class solar flares at 4:12UT. Credited to: LASCO2

From our analysis, one possible reason behind the formation of this very complex long duration of this loop is the magnetic reconnection and disruption of the loops which is observed during flare maximum. The burst is originated in the same layers of the solar corona in which geo-effective disturbance probably initiates.

Although the main purpose of the instrument is to provide imaging data, in order to study a large number of bursts, we restrict ourselves to total power data without spatial resolution. Time variations in the emission may due to the changes in the electron density. One of the apparent disadvantages of the spectral expansion and the limited averaging procedure is that this data can be only automatically saved on a daily basis only. Another difficulty in the interpretation is due to the fact that the observations suggest a few non-axisymmetric harmonized. Inappropriately, the continuous detailed data could not be taken due to the limitation of the period of observations. However, we successfully obtained a significant data at the end of the observation.

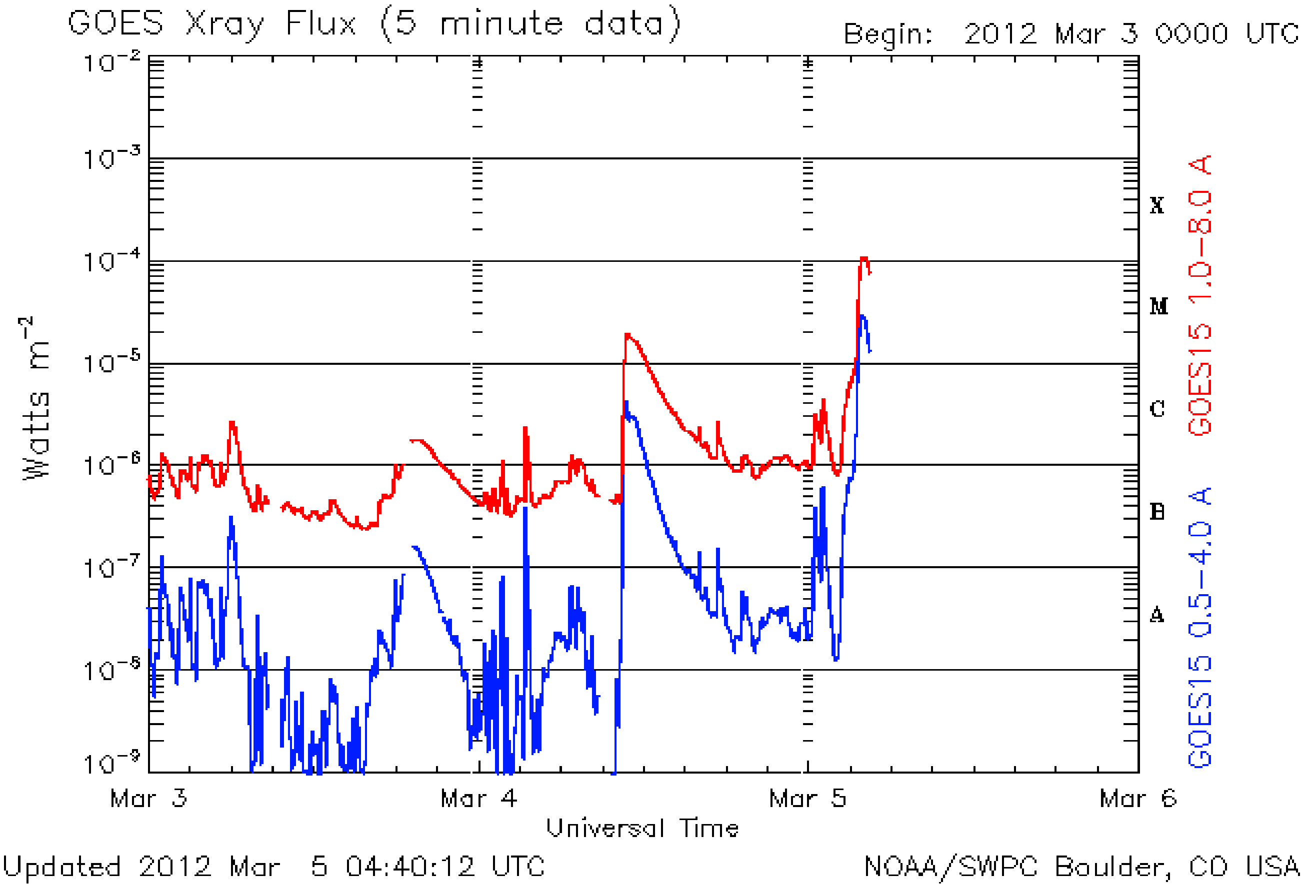

Figure 3. The X-ray flux from GOES within three days. Credited to: GOES.

4. CONCLUSION

To summarize, the burst characteristics of low-frequency solar radio bursts type IV has been deliberated. This is a zebra pattern burst structure. Thus, a broadband frequency is a good parameter to study this type of moving burst. There is an indicator that the Sun will be more active in this year. Observations in the radio region in the low frequency are the most can potentially diagnose the space weather effect originates from the Sun's atmosphere. It has also played an important role in monitoring the space weather sources. As conclusion, a good agreement was reached and we believe that Sun's activities are more active to pursuit the solar maximum cycle at the end of this year.

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BIOGRAPHY

Zety Sharizat Hamidi is currently a PhD candidate and study in Solar Astrophysics specifically in radio astrophysics at the Physics Department, Faculty of Science, University of Malaya. Involve a project under the International Space Weather Initiative (ISWI) and also a lecturer in School of Physics and Material Science, at MARA University of Technology, Shah Alam Selangor.

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