Investigation of Coronal Mass Ejections Related to Solar Flare Event and The Formation of The Small Geomagnetic Storm

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ABSTRACT

This paper is highlighted on the duration of time for the Coronal Mass Ejections (CMEs) to occur related to solar flare event and the class of solar burst type III that present within the two phenomenon. It is important to understand the evaluations of solar flare until CMEs mean to be appearing and know the basic characterization of solar radio burst type III. It can be observed that CME is even larger than the sun itself. 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 launch. The data on 23rd of April was selected whereby; solar radio burst type 3 was detected (about 17:36 UT – 17:44 UT). At 17:40 solar flare with a radio burst and CMEs were produced by the sun. Associated with this event, current condition of solar wind speed is 359.5 km/sec with density of 6.0 protons/ and sunspot number are 118. Those at the high latitude have a chance of aurora due to the small geomagnetic storm.

1. INTRODUCTION

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 the order of magnitude of the solar corona. Meanwhile, the solar flares are the most energetic phenomena that occur within our solar system. The huge amount of energy that is released by magnetic fields of active regions is used to characterize a flare. Solar corona and chromosphere are accelerated and electromagnetic radiation covering the entire spectrum is emitted during a flare. Besides thermal conduction, non-thermal conduction particle beam, radiation transport and the mass motions caused large amount of energy are transferred between corona and chromosphere. Coronal structure is mainly controlled by magnetic field due to the stronger magnetic force in the corona.

In radio region, type III burst is an indicator of the formation of an solar activity from an active region [1,2,3]. It reveals a wave-particle and wave-wave interactions in magnetic traps in the solar corona [4]. At meter wavelengths the type III burst is usually, though not invariably, preceded by others types of burst. 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. These burst radio emission are rather frequently observed, especially a few days before solar flare and Coronal Mass Ejection phenomena [6,7,8].

Metric radio burst is normally a non-thermal particles accelerated and trapped during those events. 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]. The next section will highlight the solar flare and solar bursts in X-ray and radio region.

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

The solar flare is one of the main event of the Sun that affect the space weather and climate changes [29,30,31]. 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. [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]. At present, more than 66 instruments have been installed at more than 35 locations, with users from more than 92 countries in the e-CALLISTO network. Figure 1 shows the schematic diagram of the CALLISTO system.

Figure 1. Schematic diagram of connection of e-CALLISTO (credit to: ROOPA Nandita PIRTHEE Sagar Girish Kumar Beeharry)

3. RESULTS AND ANALYSIS

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

Figure 2. X-ray region of solar flare image by SOHO and TRACE

The image in Figure 2 on the left and right show bright solar flare and CME exploding respectively. From the images it can be observed that CME is even larger than the sun itself. Meanwhile, flares are only erupting in an active region on the sun.

Both solar flare and CMEs are energetic events that occur on the sun and are associated with high energy particles. Both of them also depend on magnetic fields on the sun. However, CMEs are ejected into the space at high speeds and sometimes in the direction of the earth. Besides, CMEs are also larger eruptions compared to flares which are local events. The obvious difference that can

be highlighted is the spatial scale on which both events to be occurred. Solar flare and CMEs can take place in the absence of each other, but both of them are often occur together. Energetic explosion in the low solar atmosphere is called solar flare which can heat the surrounding material to millions of degrees in just few seconds or minutes. Besides, it occurs typically near to sunspots due to the concentrated magnetic field in the active region on the photosphere. Radiations of several bands of electromagnetic spectrum (white light, ultraviolet, x-rays, gamma rays) are also emitted and are observed by ground based and space based telescopes. Solar flares also accelerate particles which are ejected into space to emit large amount of radiation.

Figure 3. The continuous solar radio burst type III within 4 minutes (Credited to: E-Callisto network (BIR))

In this work, data was obtained from e-Callisto. The data on 23rd of April was selected whereby; solar radio burst type 3 was detected (about 17:36 UT – 17:44 UT). At 17:40 solar flare with a radio burst and CMEs were produced by the sun. The sign of the solar was detected within the region 115 MHz till 160 MHz. Associated with this event, current condition of solar wind speed is 359.5 km/sec with density of 6.0 protons/ cm^3 and sunspot number are 118.

Figure 4. The Active regions during 23rd April 2012 and the image of the Sun by X-ray from Space Weather Website (Credited to: NOAA/ SWPC)

Image above shows solar flare with radio burst and CMEs. NASA SWC is focused on providing critical space weather notification for NASA Robotic Missions. They predicted that CMEs will reach the earth on 27th of April 2012 at 5.49 UT with only minor impact. Those at the high latitude have a chance of aurora due to the small geomagnetic storm. Geomagnetic storms induced by CMEs and effect human activity the most. Aurora only occurs near the poles when solar wind is quiet and the magnetosphere is undisturbed. However, the aurora will expand and brighten and moves to lower latitude at the moment when the solar wind and the magnetosphere are disturbed.

4. CONCLUDING REMARKS

Magnetized plasma is hurled into space interrupting the steady solar wind during eruption of CME from the sun. Disturbance will be created when the ejected coronal materials moves through the solar wind. This disturbance may include a shock wave that moves ahead of the CME and accelerating some solar wind particles to high energies as it moves. Like what has been mention earlier, once the CME reaches the Earth there can be significant consequences to communications, satellite operations and power generation. Solar flare and CMEs often seem to occur together and also can take place in the absence of each other. Solar burst type III also appear within the events that assigned big eruptions also occur. CMEs that occur will effects magnetic field of the earth and caused disturbance to communications, satellite operations and power generation due to geomagnetic storm. Fortunately, if the geomagnetic storm is small it is only cause minor affect such beautiful aurora.

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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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