Solar Radio Burst Type III due to M 2.9 Class Flare with a Geomagnetic Disturbance

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ABSTRACT

Varying forms of solar radio burst were classified by their frequent changes in time, which are known as drift rate. There are 5 types of radio emission were named type I, II, III, IV and V. This paper is highlighted on the type III event which occurred on 27\textsuperscript{th} August 2015. In the IP medium, type III solar radio burst can be classified in three different groups which representing three different situations of electron beam production and propagation which are isolated, complex and storm type III burst. The most powerful manifestation of solar activity is solar flare together with coronal mass ejections, eruptive prominences and the solar wind are the solar events which affect the earth's atmosphere and can cause geomagnetic disturbance. In this study, the effect of M class flare with solar radio burst type III was investigated. During the day, the solar wind proton density seems to be high which is 8.4 protons/cm\textsuperscript{3} and accompanied by normal solar wind speed of 348.7 km/Sec. Spaceweather.com reported that there is one sunspot was detected (AR2403) and M class of the flare was detected during the day at 0544 UT. The data geomagnetic signal shows that during the day only geomagnetic disturbance that occur no such geomagnetic storm since the sunspot not facing the earth directly.
Keywords: solar radio burst; solar storm; flare; geomagnetic disturbance

1. INTRODUCTION

The investigation of the solar radio burst has made great progress in beginning 1940’s and become one of the most significant current discussions on solar physics issue. Solar radio burst is highly variable, and is often much brighter than can be expected in terms of thermal radiation from the solar corona [1]. It usually shown in dynamic frequency spectra and are classified into five distinctive type of dynamical spectrum. A meter burst was originally classified into three types denoted I, II, and III according to their appearance on a dynamic spectrum [2,3]. Type IV and V are extended later [4]. Of these types, type II, III and IV are dominant with CMEs evolution [5]. For instance, type II is due to electrons accelerated in shocks while type III burst can be observed based on the accelerated electrons propagating along open magnetic field lines. Although type IV always related with the indication of new sunspot, it could be formed because of an electrons trapped in post-eruption arcades behind CMEs [6].

Figure 1. Schematic diagram of correlation between the solar flare phenomena and different types of burst (M. R. Kundu, 1965).
In nature, solar radio bursts are common during years of high solar activity. It is believed that this burst are formed by several mechanisms of excitation: i) streams of electrons, individual, in groups of ten or so, or during storms of tens of thousands, ii) shock waves by the radiation coming either from near the shock or distant from it by electrons accelerated by the shock, and iii) configurations of magnetic field that contain energetic electrons. The concepts of solar radio burst are characterizations by complex variability patterns including both non-stationarities and non-linearities. This is due to non-linear injection processes and the properties of the complex ambient coronal structures. Meanwhile, solar radio bursts in decimetric is the key in understanding not only the mechanism of acceleration and the location of the energy release but also on propagation, escape or trapping of energetic particles. This solar burst does not occur simultaneously but instead of different drift to lower frequencies at later times. Next figure shows the schematic diagram of correlation between the solar flare phenomena and different types of burst.

Varying forms of solar radio burst type their drift rate, which is how their frequency change with time. Initially they are three types of radio emission introduced by Wild and McCready (1950) were named type I, II and III, then the types IV and V were introduced later [1]. Type III bursts were first discovered at metric wavelength by ground base telescope in the frequency range 10-500MHz [2]. The high drift and broad bandwidth are the main feature of solar radio bursts type III [3]. In the dynamic spectrum type III burst appears as almost vertical features because of the high drift from low to high frequency [2]. Type III burst in the IP medium can be grouped in three broad classes representing three different situations of electron beam production and propagation as shows in the figure below [2,4]:

![Diagram of solar radio burst types]

**Figure 2.** The sub-types of solar radio burst type III.

The most common type produced by energetic electrons is an isolated type III burst which escaping from small scale energy release site on the sun. Besides, it is also closely associated with He³ event, the class of solar energetic particle. The complex type III burst occurs in conjunction with CMEs. The burst was produced by electron beams accelerated in blast-wave shocks and injected along open magnetic field lines. Meanwhile, type III storms consist of thousands of short-lived type III-like burst in rapid succession. Due to electron from small scale, the storm type III burst were thought to happen.
Figure 3. (a) complex type III burst and (b) type III storms.
Figure 4. Isolated type III burst.
Whereby quasi-continuous energy release into closed magnetic structure of active regions. Thus, these storms symbolize energy release without an explosion of the associated magnetic field structure. The figure below shows the example of dynamic spectrum of these three types of burst. In our solar system the Sun is the most powerful source of energy. It mainly emits energy in the form of electromagnetic radiation and the magnetic structure of the Sun photosphere varies constantly transient processes such as micro flare, shock waves, erupting prominence flare and Coronal Mass Ejections. The increasing in the intensity of the emitted radiation produced an intense and short lived solar flare [7]. In general, emission from the Sun at the centimeter wavelength is due primarily to coronal plasma trapped in the magnetic fields overlying active regions [8]. There are two mechanisms can contribute to the radio emission from non-flaring coronal plasma which are a thermal bremsstrahlung (free-free) and thermal gyroemission [6,9]. Thermal bremsstrahlung is the minimum possible radio intensity emitted by the plasma. The emission originates from thermal electrons spiralling along coronal magnetic field lines, and its intensity depends on the coronal density, temperature, magnetic field strength, and angle between the magnetic field and the line of sight [2,10-13].

It is believed that solar radio emission is a rich source of information about electrons accelerated during a solar flare and CMEs [14,15]. The intensity and spectrum of the emitted radiation depend on the emission mechanism, which in turn depends on the temperature, density and magnetic field of the source plasma as well as on the distribution of the accelerated electron population. It is believed that solar radio emission is a rich source of information about electrons accelerated during a solar flare and CMEs. The intensity and spectrum of the emitted radiation depend on the emission mechanism, which in turn depends on the temperature, density and magnetic field of the source plasma as well as on the distribution of the accelerated electron population. The classification of the flare is based on the maximum X-ray power output permitting to the order of magnitude of the peak burst intensity. The categories are: X, M, C, B, and A from the higher to the lower value, respectively, and each category has nine subdivisions from 1 to 9 [5,16]. Hodgson and Carrington (1859) discovered that a solar flare is one of the most powerful manifestation of the solar activity together with coronal mass ejections, eruptive prominences and the solar wind are the solar events which affect the earth's atmosphere [6]. Solar flare, solar proton events and coronal mass ejections are the components of solar storms. However, not all solar storms produce all these elements, but large solar storm does [7]. When the solar storm interact with the earth magnetic field, it will produce geomagnetic storm. The research of solar radio burst provides in many ways considerable possibilities for the study of important phenomena in solar physics [3]. In this study, the effect of my class flare with solar radio burst type III is investigated.

2. METHODOLOGY: e-CALLISTO SOLAR SPECTROMETER NETWORK

CALLISTO is a radio spectrometer used to monitor solar radio emission that operating for 24 hours per day. This spectrometer designed and built to detect the intensity of electromagnetic radiation at radio frequencies between 45-870 MHz [4,17]. It consists three main components which are the receiver, a linear polarized antenna and control/logging software [18].
On few decades on, solar burst had been recognized over wide range from millimeters to decimetre using ground based instruments. Their radio observations provide important information concerning physical conditions in the solar corona. In the solar corona, there are many particle acceleration phenomena that are caused by the interaction between coronal magnetic field and plasma [19]. The non-thermal electrons accelerated in the solar corona emit radio waves in the metric range resulting in many types of observed solar radio burst [18].

Due to the development of the technology, more advanced system was implemented in 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. The instrument automatically collects and sent data on a daily basis via the internet, all the data from all stations are gathered in a database and a public web www.e-callisto.org is where the data can be accessed free.

3. RESULT AND DISCUSSION

Indirectly, solar burst potentially produced many negative impacts to the Earth. These solar radio bursts will give an impact toward our satellites. Not only that, their powerful UV and X-ray radiation will shortening the orbital life of our satellites and lowering the orbital of satellites. As a result, our communication systems also will be affected. Due to this issue, it is very important to monitor the Sun activities especially during solar cycle maximum.

The high sensitivity of the radio waves to the medium and small-scale density inhomogeneities of the corona is both a limitation and an advantage, compared to the X-ray, EUV and optical ranges. Analysis of data also shows the distributions of burst (frequencies from 10 to 70 MHz) and meter wavelengths. It is well known that solar radio burst type III is a good indicator for a big eruption to occur. On 27\textsuperscript{th} August, there were type III storm solar radio bursts are observed. The duration of both bursts lower than one minute with a drift rate of 1, 2, respectively. These fast drifts confirm that they are type III solar radio burst.

<table>
<thead>
<tr>
<th>Table 1. Solar Wind Condition.</th>
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<td><strong>Speed</strong></td>
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<td><strong>Density</strong></td>
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Among the reasons for this international space observation program, is the importance of solar observations in improving our knowledge of the solar activities in short region. During the day, the solar wind proton density seems to be high which is 8.4 protons/cm\(^3\) and accompanied by normal solar wind speed of 348.7 km/Sec. Spaceweather.com reported that there is one sunspot was detected (AR2403) and M 2.9 class of the flare was detected during the day at 0544 UT. This M class of the flare is believed to erupt from that active region.
Figure 5. Group of Type III Solar Radio Bursts.
Figure 6. Geomagnetic signal.
Table 2. Active region and class of flare on 27th of August 2015.

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<tr>
<th>Active Region</th>
<th>Class of Flare</th>
<th>Time (UT)</th>
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<tbody>
<tr>
<td>12403</td>
<td>C 1.4</td>
<td>20:24</td>
</tr>
<tr>
<td></td>
<td>M2.9</td>
<td>04:48</td>
</tr>
<tr>
<td></td>
<td>C1.3</td>
<td>03:25</td>
</tr>
<tr>
<td></td>
<td>C1.0</td>
<td>02:33</td>
</tr>
<tr>
<td></td>
<td>C9.5</td>
<td>13:41</td>
</tr>
<tr>
<td></td>
<td>C1.5</td>
<td>02:56</td>
</tr>
<tr>
<td>12404</td>
<td>No flare</td>
<td>-</td>
</tr>
</tbody>
</table>

The data geomagnetic signal shows that during the day only geomagnetic disturbance that occur no such geomagnetic storm since the sunspot not facing the earth directly. Even though the sunspot is no longer facing the earth, it still poses a threat for geo effective explosion. The flare from the active region can potentially cause radio blackout and radiation storm as long as the sunspot remains visible. Indeed, it should be recalled that 90% of the time the geomagnetic activity is dominated by the effects of coronal structures rather than flares and CME’s.

4. CONCLUSION

The solar burst type III radio burst observed on the 27th of August was due to the M class of flare. As mention earlier, solar activities such flare will cause geomagnetic disturbances on the earth when it hit the earth’s magnetosphere. Hence, there was a geomagnetic disturbance detected during the event. Since it is only geomagnetic disturbance, it does not cause major impacts such geomagnetic storm does because the sunspot no longer facing the earth.

Acknowledgement

We are grateful to CALLISTO network, STEREO, LASCO, SDO/AIA, NOAA, TESIS and SWPC make their data available online. This work was partially supported by the 600-RMI/FRGS 5/3 (135/2014) and 600-RMI/RAGS 5/3 (121/2014) UiTM grants and Kementerian Pengajian Tinggi Malaysia. Solar burst monitoring is a project of cooperation between the Institute of Astronomy, ETH Zurich, and FHNW Windisch, Switzerland, MARA University of Technology and University of Malaya. This paper also used NOAA Space Weather Prediction Centre (SWPC) for the sunspot, radio flux and solar flare data for comparison purpose. The research has made use of the National Space Centre Facility and a part of an initiative of the International Space Weather Initiative (ISWI) program.
References


(Received 02 March, 2016; accepted 14 March, 2016)