An Alternating of Solar Radio Burst Type III and IV of Thermal and Non-Thermal Plasma Radiation

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ABSTRACT

A preliminary correlation study of the solar burst type III with a type IV solar burst of has been made. On the basis of this study and in combination with the observation in radio emission, an interpretation of the mechanism of the occurrence of this event has been proposed. We have noted that an individual type III burst also can be observed at 13:54-13:58 UT from 500 MHz. Based on 3 days observation beginning from 31st March 2015, the solar activity is gradual increased. The highest solar flare can be observed is only a class of M8 flare. There was a CMEs event that directed to the Earth is detected. From the selected event, although theoretically solar radio burst type III is alternating with type IV solar burst. This huge explosion generated the M-class flare which can affect the Earth and satellites. The solar wind velocity recorded is 384.2 km/second while the density of protons is 3.6 protons/cm³. The total magnetic field during this event also quite big which is 4.6nT. The alternating of solar burst type III and IV would probably depends on the tendencies to form the CMEs event. The morphology of thermal and non-thermal flare plasma is of particular significance because it holds many important signatures of the energy release process.

Keywords: Sun; low frequency; solar radio; burst, type III; type IV e-CALLISTO
1. INTRODUCTION

It is widely accepted that the solar radio burst type III plays a fundamental role in solar burst studies [1]. This burst can occur singularly, in groups, or storm. It also can be accompanied by a second harmonic. Solar flares can be related to the release of a huge amount of magnetic energy, which is distributed into kinetic energy, strong radiation of the plasma, as well as energetic non-thermal particles.

There are also other types of solar radio burst such as type II, IV, V, U, and sub-types are mostly related to the formation of type III [2]. The only difference is either type III form before or after the other burst. This burst also can associate with type U [3], type IV [4], type V [5] and type II burst [6]. The Type III radio burst is used as the indicator of the starting point of the magnetic reconnection. Strong evidence for the escape of energetic electrons would be presence of radio burst Type III. If the burst extends to the lowest frequencies seen near the Earth, then there must be direct field line connection from the reconnection region to the Earth.

The eruption mechanism of solar flares and radio burst Type III are currently an extremely active area to research, especially during the solar cycle is towards maximum. As we know, the total energy can exceed up to $10^{15}$ ergs. Flare is definitely considered as the rapid brightening in the photon spectrum of the Sun caused by a choking off the normal energy from the corona by the strong closed magnetic field of a plage [7]. The onset time of this type precludes the possibility of the CME driven shock [8]. This burst is based on the evolution of sunspot number and sunspot area [9].

Type III solar burst was first introduced by Wild in 1963 [10] in the frequency range 500 - 10 MHz. This fast drift burst is the most common of the meter wavelength bursts. It is normally found at the pre-flare stage that could be a signature of electron acceleration [11]. It is well known that an isolated type III solar burst can exhibit a wide range of forms [12]. However, [13] against the theory and strongly agree that type III [14] burst requires a very strong field to produce a fundamental and second harmonic of gyro frequency. The subject of nonlinear wave-wave interaction which involving interaction of electrostatic electron plasma that called as Langmuir waves active region radio emissions also have been studied [15-19].

Meanwhile type IV burst is an indicator of the formation of a new active region [2,20,21]. 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 [22]. 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 [23].

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 [24-26].
# EXPERIMENTAL SETUP AND OBSERVATION

During this event, there are several sites such as (a) BIR Ireland, (b) Glasgow and (c) Humain were successfully detected this burst between 13:46-14:04 UT on 2\textsuperscript{nd} April 2015 such as KASI Korea and SSRT Switzerland. Based on the data, the burst is formed within 28 minutes. There is also a long fast-drift type III solar burst was recorded before the formation type I\textsubscript{4} solar burst. This type III solar burst is ejecting intermittently before and after the formation of type IV solar burst.

The CALLISTO system is a dedicated to solar burst observation in the low frequency radio region. In principle, we used a Log Periodic Dipole Antenna (LPDA) which is mounted on the top of the rooftop of National Space Centre (ANGKASA) building at Sg. Lang, Banting, Selangor located at (N 02° 49.488' E 101° 36.168') that covered the range of frequency from 85-470 MHz [27]. This 5.5 meters antenna is connected to the CALLISTO spectrometer via cable RG 58 and the modification, calibration process and basic analysis of the antenna has been done in order to improve the feature of the system [28,32]. In order to improve the ratio of the gain, a preamplifier also is used. Several sites are also using the radio telescope with the antenna as a detector and this will improve the resolution of the burst.

# RESULTS AND ANALYSIS

This event of solar radio burst occurred in sequence. The first solar burst recorded is type IV, which is starts at 13:41 UT until 13:53 UT. The second solar burst is the complex solar radio burst type III (inside the circle) that occurred at 13:55 UT until 13:59 UT. Then it is followed by the third radio burst which is radio burst type IV occurred at 14:00 UT until 14:04 UT. Detail radio burst type IV and complex type III are presented in Figure 1 and Figure 2.

The huge explosion produced SRBT III and SRBT IV was proved as it showed the big explosion at this range of UT time. The video of extreme ultraviolet blast was recorded by NASA’s Solar Observatory. This huge explosion generated the M-class flare which can affect the Earth and satellites. The solar wind velocity recorded is 384.2 km/second while the density of protons is 3.6 protons/cm\textsuperscript{3}. The total magnetic field during this event also quite big which is 4.6nT.

Next, we consider the other parameters that related to the event. There are 11 sunspot of active region (AR) during this event which are AR12017, AR12018, AR12020, AR12021, AR12022, AR12024, AR12025, AR12026, AR12027, AR12028 and AR12029. However the most active region is AR 12027 which produced the M-class flares. Other solar parameters that contribute the event are presented in Table 1.

From the graph, it showed the highest peak on the 2\textsuperscript{nd} April 2014. There are 2 types of X-ray class during this event, which are M-class and C-class. The M-class showed is quite big which has the magnitude of M6.5 occurred at 13:18 UT. This M-class type produced a few a minutes before these Solar Radio Burst Type III and IV were recorded on the spectrograph. There are eight C-class recorded on that day and the highest was C3.2 which occurred at 06:21 UT.
Figure 1. The solar radio burst type IV at 14:00 UT until 14:04 UT (Credited to e CALLISTO)
Figure 2. The solar radio burst type IV and complex solar radio burst type III (Credited to e CALLISTO)
Figure 3. The next following solar radio burst type IV (Credited to e CALLISTO)
Figure 4. The huge explosion recorded by NASA’s Solar Observatory and The number of sunspot active region during this event (Credited to Spaceweather)
Table 1. The sunspot active region on 2nd April 2014.

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Location</th>
<th>Hale Class</th>
<th>McIntosh Class</th>
<th>Sunspot Area</th>
<th>Number of Spot</th>
<th>Flares History</th>
</tr>
</thead>
<tbody>
<tr>
<td>12017</td>
<td>N10W91 (944&quot;,163&quot;)</td>
<td>α/β</td>
<td>Axx/Cai</td>
<td>0010/0060</td>
<td>02/07</td>
<td></td>
</tr>
<tr>
<td>12021</td>
<td>S14W19 (304&quot;,-132&quot;)</td>
<td>βγ/βγ</td>
<td>Dai/Dai</td>
<td>0220/0160</td>
<td>18/18</td>
<td>C1.1(02:18)</td>
</tr>
<tr>
<td>12022</td>
<td>N17W04 (64&quot;,383&quot;)</td>
<td>α/α</td>
<td>Hsx/Hsx</td>
<td>0030/0030</td>
<td>01/01</td>
<td>/C3.3(00:43)C2.7(19:30)</td>
</tr>
<tr>
<td>12027</td>
<td>N13E41 (-615&quot;,294&quot;)</td>
<td>α/α</td>
<td>Hsx/Hsx</td>
<td>0100/0080</td>
<td>01/01</td>
<td>M6.5(13:18)</td>
</tr>
<tr>
<td>12028</td>
<td>S08E48 (-708&quot;,-61&quot;)</td>
<td>β/-</td>
<td>Dao/---</td>
<td>0030/----</td>
<td>03/--</td>
<td></td>
</tr>
<tr>
<td>12029</td>
<td>N18E28 (-429&quot;,386&quot;)</td>
<td>α/-</td>
<td>Hrx/---</td>
<td>0020/----</td>
<td>01/--</td>
<td></td>
</tr>
<tr>
<td>12018</td>
<td>N04W88 (956&quot;,70&quot;)</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>12020</td>
<td>S13W53 (748&quot;,-151&quot;)</td>
<td>/β</td>
<td>/Bxo</td>
<td>/0010</td>
<td>/02</td>
<td></td>
</tr>
<tr>
<td>12024</td>
<td>N17W37 (553&quot;,362&quot;)</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>12025</td>
<td>S24W61 (768&quot;,-340&quot;)</td>
<td>/β</td>
<td>/Cro</td>
<td>/0020</td>
<td>/04</td>
<td></td>
</tr>
</tbody>
</table>
4. CONCLUSION

In concluding this event, although the solar flare event is at a high stage, it is still possible to form the solar radio burst type III and IV which are associated with CME event. Nevertheless, understanding how energy is released in solar flares and CMEs and how do the alternating of solar burst type III and IV would probably depends on the tendencies to form the CMEs event. The morphology of thermal and non-thermal flare plasma is of particular significance because it holds many important signatures of the energy release process. To this point of discussion, the onsets of solar flares and Coronal Mass Ejections (CMEs) have been studied as well.

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