The Development of Long Series of Quasi-Periodic Pulsation in Active Region AR 2297

S. N. U. Sabri¹, Z. S. Hamidi¹,*, N. N. M. Shariff², C. Monstein³

¹School of Physics and Material Sciences, Faculty of Sciences, MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia
²Academy of Contemporary Islamic Studies (ACIS), MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia
³Institute of Astronomy, Wolfgang-Pauli-Strasse 27, Building HIT, Floor J, CH-8093 Zurich, Switzerland

*E-mail address: zetysh@salam.uitm.edu.my

ABSTRACT

This phenomena allow us to explore about suprathermal electron population that produced by plasma-magnetic field interactions in the solar corona about tens of minutes. The characteristics of the structures of the emission is influenced by wave-particle interaction and wave-wave interaction. The Callisto spectrometer recorded broadband of solar radio burst Type IV from 250-900 MHz. Using data from BLEN7M observatory, we aim to provide inclusive description about the formation and dynamics of solar radio burst type IV due to active region AR2297. About five minutes, the events revealed strong pulsations and “broad patterns” with details of solar radio burst type III with presence of CMEs. AR2297 is the most active region which produced X2-Class solar flares. The speeds of solar wind exceeds 376.0 km/second with 4.0 g/cm³ density of proton in the solar corona. The radio flux shows 121 SFU. Furthermore, there are two active regions, AR2298 and AR2299 also presents in the X2-class solar flares. Active region AR2297 have unstabe ‘Beta-Gamma-Delta’ magnetic fields that harbor energy for M class to X2-class eruptions. As a conclusion, we conclude that Sun activities are more active to achieve maximum cycle at the end 2015. Solar flares on 11th of March 2015 showed long series of quasi-periodic pulsation that deeply modulate a continuum and its drifting toward lower frequency. The corona extends from the top of a narrow transition region to Earth and has a temperature millions of degrees that still mysterious properties.

Keywords: Sun; solar burst; IV; radio region; X-ray region; solar flare; active region AR2222
1. INTRODUCTION

Sun is an active stars known as strongest sources which made up by hydrogen and helium. The evidence can be provided through out solar atmosphere. It also converting protons to alpha particles and this make the sun always shine. Besides, the energy will be transported from central regions of the suns by photon radiation somehow electron conduction also contributes in innermost region and convection influence near the surface. Solar activity is caused by large and changing magnetic fields passing the outer regions from convection zone to Corona to produce the sunspot, solar flare and Coronal Mass Ejection phenomena. Type IV burst is classified as a broadband quasi – continuum burst that involved with the decay phase of solar flares, continuum means persistent, smooth emission over a broad band of frequencies and it is attributed to electrons that trapped in a closed field lines in post flare that produced by flares [1-3].

Alternative theories based on whistler wave packets [4] or whistler solutions propagating across or along the region where the trapped electron distributions emit type IV continuum or inertial kinetic Alfvéén waves for type IV fine structures (have also been recommended. High concentration in magnetic field will discourage the heat to flow towards the surface which is from convection zone and produced sunspot. Type IV burst classified as a smooth continuum in broadband quasi-continuum burst in metric wavelengths which involved with the decay phase of solar flares and assigned to electrons that trapped in a closed field lines in post flares that produced by flares [5].

The region where the trapped electron emits type IV continuum were based on whistler wave packet along the region in alternatives theories. It should be noted that the direction of the source motion at a given frequency is on average found to be perpendicular between broadband radio pulsations (BBP) and zebra patterns (ZP) sources [6]. In the case of BBP, the frequency drift can be as high as ($\approx -250$ MHz s$^{-1}$) [7].

This type of burst is dominant a few days before solar flare and Coronal Mass Ejections explosion [8-10]. Moreover, the large fluxes of energetic electrons were injected in coronal loop. In plasma emission theory, the frequency drift of emission can be explained by non-thermal electron beams which usually in type III events and by whistler-mode waves. In this non thermal type IV emission involves complex gyrating particles and consisting structureless continuum. Magnetic energy that release in the solar corona released explosively before converted into thermal and kinetic energy in solar flares. The temperature of the explosion can be rise up to 10-20 MK that possibly eruption to be occur.

2. SOLAR BURST OBSERVATION

Variety type of burst are possible to detect during a major space event . It is possible to detect a variety types of burst during a major space weather event [11-13] from BLEIM site to monitor the solar burst. [14,15].

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. The Log Periodic Dipole Antenna has been constructed from 45 – 870 MHz [16-19]. The CALLISTO spectrometer is a low-cost radio spectrometer used to monitor metric radio bursts. We select the range of 240 MHz till 360 MHz for this data [20-22].
This range has a very minimum interference at KRIM site [23,24]. Most of the CALLISTO sites are focused the frequency range from the 45 MHz till 900 MHz region seems this is the best range with a very minimum of Radio Frequency Interference (RFI) [24-28]. Next, we will focused on detailed analysis of solar flares in an X-ray and radio region to evaluate the distribution of low and high energy.

3. RESULTS AND ANALYSIS

In this part, we will discuss briefly about the structure of active region that located at corona of the sun. Based on NASA’s Solar Dynamic Observatory (SDO) data, there are three active active region during this event. But, the most active region that produces flares and CMEs was AR2297 which gives M-class up to X-2 class eruption.

Figure 1. The location of the active region (AR2297) and flaring sources (credited to: Solar Dynamic Observatory (SDO)).
Figure 2. The active region (AR 2297) exploded a large eruption of X-2 solar flare (credited to: Solar Dynamics Observatory (SDO) and coronal holes.)
From observation, it also related with evolution type III and type V solar radio burst and burst was classified and characterized by its local environment. This event occurred from 16:22 UT (09:22 PDT) till few minutes.

Extreme ultraviolet radiation from the explosion ionized the upper layers of Earth’s atmosphere which causing HF radio fade-outs and other propagation effects on the dayside on Earth. There are also received notice by ham radio operators and mariners about complete blackout conditions at frequency below 10 MHz and it will disturb our satellite system and communication satellites.

There are natural radio emission from our sun that are produced by shock waves in the sun’s atmosphere and CME is emerging at 1,400 Km/s (3.1 million mph).

As shown in above figure, there is highly tendency to AR2297 possibly to explode a large solar solar flare based on the pattern solar flare since 16:15 UT.

So, from this event, space weather focussed to determine the causes radio blackouts on Earth. This events also unleashed a shortwave radio burst and it was super intense—one of the strongest bursts of the current solar cycle.

It also produced ham voices caused by solar burst and this radio sound are caused by beam of electrons. Burst are accelerated by an M4-flare as electrons slice through the sun’s atmosphere and generate a ripple of plasma waves besides radio emissions was detectable 93 million miles away on Earth.

Figure IV shows that moving Type IV solar burst which has slow frequency drift and smooth continuum with 250-900 MHz in frequency and with presence of solar burst Type III and solar flare which has highly possibilities eruptive prominence and magnetohydronamic shockwaves to be happen.

Table 1 shows the condition of the Sun during 11th March 2015.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Wind Speed</td>
<td>376.0 Km/sec</td>
</tr>
<tr>
<td>Density</td>
<td>4.0 protons/cm$^3$</td>
</tr>
<tr>
<td>Sunspot Number</td>
<td>2297</td>
</tr>
<tr>
<td>107.cm flux</td>
<td>121sfu</td>
</tr>
<tr>
<td>6-hr max</td>
<td>M1 (1851 UT)</td>
</tr>
<tr>
<td>24-hr</td>
<td>X2 (1622 UT)</td>
</tr>
</tbody>
</table>
Figure 3. The GOES X-Ray Flux profile showed X-2 flares on 11 March 2015. (Credited to NOAA/SWPC).
Figure 4. The light curve associated with Type X-2 solar flare on 11\textsuperscript{th} March 2015 at BLEN7M observatory.
4. CONCLUDING REMARKS

Active region AR2297 have unstable ‘beta-gamma-delta’ magnetic field that harbor energy for ‘radio-active’ explosions. There is 70 percent chance of M-class flares and 20 percent chance of X-flares on 13 March 2015. Their presence indirectly has acceleration possibly at the tops of loops. Besides that, the high degree of solar energetic particle events has long been interest in Space Weather. Solar flares on 11th of March 2015 showed long series of quasi-periodic pulsation that deeply modulate a continuum and its drifting toward lower frequency.

The corona extends from the top of a narrow transition region to Earth and has a temperature millions of degrees that still mysterious properties. There are two observations (radio and X-rays) has been dominant on the observational analysis and we cannot directly make a conformation as long it still in conformation. We have to consider other processes to explain detailed in injection, the losses in energy and the mechanism of the acceleration of the particles. It is believe that the distribution of flux energy or the burst is influenced by the numbers of solar storms.

The energy solar storms usually come from the solar magnetic fields which generated from the convection zone. Solar radio burst showed broadband and non-drifting nature due to electron trapped in closed magnetic field lines. Therefore, as a conclusion, solar burst characteristic of low frequency in Solar Radio Burst Type IV has been proved and observations from low frequency by using Space Weather will effects the originate from the sun’s atmosphere.

Acknowledgement

We are grateful to CALLISTO network, STEREO, LASCO.SDO/AIA, NOAA 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 Pendidikan Malaysia. Special thanks to the National Space Agency and the National Space Centre for giving us a site to set up this project and support this project. 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.

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.

Siti Nur Umairah Sabri is an undergraduate Physics student at the School of Physics and Material Sciences, Faculty of Sciences, MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia.

Dr Nur Nafhatun Md Shariff is a senior lecturer in Academy of Contemporary Islamic Studies (ACIS), MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia. Her current research is more on sustainability; environmental aspect. She is looking forward for cross-field research, i.e. solar astrophysics, light pollution measurement (mapping) and religious studies.
C. Monstein is a senior Engineer at Institute of Astronomy, Wolfgang-Pauli-Strasse 27, Building HIT, Floor J, CH-8093 Zurich, Switzerland and one of the researchers who initiated the CALLISTO system around the world.

References


(Received 15 April 2015; accepted 27 April 2015)