Determining a Complex Solar Radio Burst Type II on 2\textsuperscript{nd} November 2014 Driven by a Hydra Solar Flare As A Blast Waves

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ABSTRACT

Recent data of a complex solar radio burst type II is analyzed and reviewed. The monitoring 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 25 until 1000 MHz. During the inspection of the X-ray spectrum, we observed that the C3-category flare was caused by a filament of magnetism, which rose up and erupted between 0400 and 0600 UT. This occurred three hours before the signature of solar radio burst type II. There are some of the material in the filament fell back to the sun, causing a flash of X-rays where it hit the Sun surface. This is a Hydra Flare which occurred without sunspots. On the basis of these results, we suggest that a single shock in the leading edge of the CME could be the source of the multiple type II bursts and support the notion that the CME nose and the CME-streamer interaction are the two main mechanisms able to generate the bursts.

Keywords: Sun; solar burst; type II; radio region; X-ray region; Hydra solar flare; active region

1. INTRODUCTION

Solar radio type II is one of the main type that discovered roughly since 1947 by Payne-Scott, Yabsley, & Bolton in 1947 [1] lasting from a few minutes to a few hours. It can be divided into two sub-type (i) Harmonic and (ii) herring bone structure. Normally, two stripes with a frequency ratio about two are observed, being interpreted as the fundamental (F) and the second harmonic (H) emissions generated via a plasma radiation mechanism at frequencies determined by the local plasma density [2]. For instance, the aforementioned F and H branches may further split into two bands causing the well-known band-splitting phenomena [3].
The factor of this burst is still controversial until now. Previous studies have shown that this burst are produced by CME-driven shock [4,5]. However, there is an evidence and it is believed that the that the metric radio bursts stem from coronal shock waves driven by flares as blast waves Cane and Reames [6]. One can deduce the propagation speed of the driving shock wave from eruption region. Thus the CME kinetic energy is the indicator of the lifetime of the type II bursts [7].

In principle, the blast waves are generated in research environments using explosive or compressed-gas driven a shock tube in an effort to replicate the environment to develop better protection against blast exposure. A blast wave is an area of pressure expanding supersonically outward from an explosive core. It has a leading shock front of compressed gases. The blast wave is followed by a blast wind of negative pressure, which sucks items back in towards the center. In the next section will highlight the solar flare and solar bursts in X-ray and radio region.

2. SOLAR BURST OBSERVATION

The monitoring 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 25 until 1000 MHz [8]. On our site, 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 [9,10,11]. This antenna covered from 45 - 870 MHz [12,13]. This spectrometer is a low-cost radio spectrometer used to monitor metric and decametric radio bursts, and which has been deployed to a number of sites space world to allow for 24 hour monitoring of solar radio activity [14,15,16,17,18]. In this case, we focused the range of 35 MHz till 80 MHz [19,20]. The selected region is the best region with minimum interference at Blein, Switzerland site [21]. We have selected the data from the 45 MHz till 900 MHz region seems this is the best range with a very minimum of Radio Frequency Interference (RFI) [22,23,24,25]. In this paper, we have focused on the intensity of flux in an X-ray and radio region to evaluate the distribution of high and low energy [12].

3. RESULTS AND ANALYSIS

An Active Region AR2203 is growing rapidly but it does not yet pose a threat for strong flares. The development of thios active region has started since 1st November 2014. There are also a coronal holes can be detected on 2nd November 2014. Figure 1 show the position of this active region and Table 1 shows the main parameters of the Sun during that day.
Figure 1. The Active regions during 2\textsuperscript{nd} November 2014 and the image of the Sun by X-ray from Space Weather Website (Credited to: NOAA/ SWPC).

Table 1. Main parameters of the Sun.

| Parameter                     | Value          |
|-------------------------------|----------------|
| Solar wind speed              | 451.7 km/sec   |
| Solar wind density            | 6.3 protons/cm$^3$ |
| X-ray Solar Flares 6-hr max   | C9             |
| X-ray Solar Flares 24-hr max  | C9             |
| Sunspot number                | 82             |

During the inspection of the X-ray spectrum, we observed that the C3-category flare was caused by a filament of magnetism, which rose up and erupted between 0400 and 0600 UT. This occurred three hours before the signature of solar radio burst type II. There are some of the material in the filament fell back to the sun, causing a flash of X-rays where it hit the Sun surface. This is a Hydra Flare which occurred without sunspots. The rest of the filament flew out into space, forming the core of a massive CME. After a few hours a data from the Solar and Heliospheric Observatory shows the CME billowing away from the Sun. However, it will not hit the Earth.
Figure 2. The plasma eruption during 2nd November 2014 and the image of the Sun by X-ray from Space Weather Website (Credited to: NOAA/ SWPC).

Figure 3. The continuous solar radio burst type II within 16 minutes (Credited to: E-Callisto network (BLEIN7M)).
Our main results are as follows: (1) the complex and splitting harmonic structure of type II bursts occurred successively at 16 minutes intervals and displayed various emission structures and frequency drifting rates; (2) Hydra Flare could be the source of the multiple type II bursts; (3) this burst also can be detected at several sites of CALLISTO system such as Daro, Essen, Glassgowl, Rwanda and Ooty sites.

4. CONCLUDING REMARKS

On the basis of these results, we suggest that a single shock in the leading edge of the Hydra Flare could be the source of the multiple type II bursts. During the inspection of the X-ray spectrum, we observed that the C3-category flare was caused by a filament of magnetism, which rose up and erupted between 0400 and 0600 UT. This occurred three hours before the signature of solar radio burst type II. There are some of the material in the filament fell back to the sun, causing a flash of X-rays where it hit the Sun surface. This is a Hydra Flare which occurred without sunspots.

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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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References

[1] R. Payne-Scott, D.E. Yabsley, J.G. Bolton, Relative Times of Arrival of Bursts of Solar Noise on Different Radio Frequencies, Nature 160 (1947) 256-257.

[2] V.L. Ginzburg, V.V. Zheleznyakov, On the possible mechanisms of sporadic solar radio emission (radiation in an isotropic plasma), Sov. Astron. 2 (1958).

[3] Vrˇsnak.B, H. Aurass, J. Magdalenic, N. Gopalswamy, Band-splitting of coronal and interplanetary type II bursts. I. Basic properties Astron. Astrophys. 377 (2001) 321-329.

[4] E.W. Cliver, McNamara, L. F., & Gentle, L. C., AFGL 85 (1985).

[5] Z. Hamidi, Probability of Solar Flares Turn Out to Form a Coronal Mass Ejections Events Due to the Characterization of Solar Radio Burst Type II and III, International Letters of Chemistry, Physics and Astronomy 16 (2014) 85.

[6] N. Gopalswamy, N. Nitta, P.K. Manoharan, A. Raoult, M. Pick, X-ray and radio manifestations of a solar eruptive event, Astronomy and Astrophysics 347 (1999) 684-695.

[7] N. Gopalswamy, H. Xie, S. Yashiro, I.G. and Usoskin, Coronal mass ejections and ground level enhancements, in: B.e.a. Sripathi Acharya (Ed.), 29th International Cosmic Ray Conference, Pune, India, 2005, pp. 169–172.

[8] Z. HAMIDI, N. SHARIFF, Z. ABIDIN, Z. IBRAHIM, C. MONSTEIN, E-Callisto Collaboration: Some Progress Solar Burst Studies Associated with Solar Flare Research Status in Malaysia, Malaysian Journal of Science and Technology Studies 9 (2013) 15-22.

[9] Z.S.Hamidi, N.N.M.Shariff, Evaluation of Signal to Noise Ratio (SNR) of Log Periodic Dipole Antenna (LPDA) Business Engineering and Industrial Applications Colloquium 2013, IEEE, Langkawi, Malaysia, 2013, pp. 434-438.

[10] Z. Hamidi, N. Shariff, Determination of Flux Density of the Solar Radio Burst Event by Using Log Periodic Dipole Antenna (LPDA), International Letters of Chemistry, Physics and Astronomy 7 (2014) 21-29.

[11] Z. Hamidi, N. Shariff, C. Monstein, The Different Between the Temperature of the Solar Burst at the Feed Point of the Log Periodic Dipole Antenna (LPDA) and the CALLISTO Spectrometer, (2014).

[12] Z.S. Hamidi, Z. Ibrahim, Z. Abidin, M. Maulud, N. Radzin, N. Hamzan, N. Anim, N. Shariff, Designing and Constructing Log Periodic Dipole Antenna to Monitor Solar Radio Burst: e-Callisto Space Weather, International Journal of Applied Physics and Mathematics 2 (2011) 3.

[13] Z. Hamidi, N. Shariff, C. Monstein, Evaluation of Spectral Overview and Radio Frequency Interference (RFI) Sources at Four Different Sites in CALLISTO Network at the Narrow Band Solar Monitoring Region, (2014).

[14] Z.S.Hamidi, S. Chumiran, A. Mohamad, N. Shariff, Z. Ibrahim, N. Radzin, N. Hamzan, N. Anim, A. Alias, Effective temperature of the sun based on log periodic dipole antenna performance in the range from 45 Mhz to 870 Mhz, American Journal of Modern Physics 2 (2013) 4.
[15] Z.S.Hamidi, Z. Abidin, Z. Ibrahim, N. Shariff, C. Monstein, Modification and Performance of Log Periodic Dipole Antenna, *International Journal of Engineering Research and Development* 3 (2012) 36-39.

[16] Z.S.Hamidi, Z. Abidin, Z. Ibrahim, C. Monstein, N. Shariff, Signal Detection Performed by Log Periodic Dipole Antenna (LPDA) in Solar Monitoring, *International Journal of Fundamental Physical Sciences* 2 (2012) 32-34.

[17] Z.S.Hamidi, N.M.Anim, N. N.S.Hakimi, N.Hamzan, A.Mokhtar, N.Syukri, S.Rohizat, I.Sukma, Z.A. Ibrahim, Z.Z.Abidin, N.N.M.Shariff, C.Monstein, Application of Log Periodic Dipole Antenna (LPDA) in Monitoring Solar Burst at Low Region Frequencies Region *International Journal of Fundamental Physical Sciences* 2 (2012) 4.

[18] Z.S.Hamidi, N.N.M. Shariff, Determination of Isotropic Source Spectral Power of the Log Periodic Dipole Antenna (LPDA), *International Journal of Science and Mathematics* 2 (2014) 3.

[19] Z.S.Hamidi, Z. Abidin, Z. Ibrahim, N. Shariff, Indication of radio frequency interference (RFI) sources for solar burst monitoring in Malaysia, ICPAP 2011, AIP Publisher, Indonesia, 2012, pp. 6.

[20] Z.S. Hamidi, N.N.M. Shariff, C. Monstein, High Time Resolution Observation of Solar Radio of A Group Type III And U Burst Associated of Solar Flares Event, *The International Journal of Engineering* 1 (2012) 3.

[21] Z.S. Hamidi, Z.Z. Abidin, Z.A. Ibrahim, N.N.M. Shariff, U.F.S.U. Ibrahim, R. Umar, Preliminary analysis of investigation Radio Frequency Interference (RFI) profile analysis at Universiti Teknologi MARA, IEEE, 2011, pp. 311-313.

[22] Z.S.Hamidi, N.N.M.Shariff, R.Umar, Influence Factors of Radio Frequency Interference (RFI) for Solar Radio Astronomy Purpose at National Space Centre, Malaysia Thailand Journal of Physics 3 (2012) 6.

[23] R. Umar, Z.Z. Abidin, Z.A. Ibrahim, M.S.R. Hassan, Z. Rosli, Z.S. Hamidi, Population density effect on radio frequencies interference (RFI) in radio astronomy, AIP Conference Proceedings 1454 (2012) 39.

[24] R. Umar, Z. Abidin, Z. Ibrahim, N. Gasiprong, K. Asanok, S. Nammahachak, S. Aukkaravittayaapun, P. Somboopon, A. Prasit, N. Prasert, The Study of Radio Frequency Interference (RFI) in Altitude Effect on Radio Astronomy In Malaysia And Thailand, *Middle East Journal of Scientific Research* 14 (2013).

[25] N. Anim, Z. Hamidi, Z. Abidin, C. Monstein, N. Rohizat, Radio frequency interference affecting type III solar burst observations, 2012 NATIONAL PHYSICS CONFERENCE:(PERFIK 2012), American Institute of Physics, 2013, pp. 82-86.

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