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Relativistic Energy Associated with a Moving Fiber Burst Type μIV Associated with The Class A Solar Prominence

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ABSTRACT

The relativistic energy electron emission is found to occur only during proton events. Solar prominences usually occur in loop shape and can last for weeks or months. This event allows us to investigate the electron density and drift rate of solar burst type IV During 21st September 2015. During that time the Sun has the highest number of sunspots. The radio sources responsibly for Ivm appear to expand spherically through the solar corona after eject on y solar flare. This event shows a strong radiation in radio region, but not in X-ray region. This burst intense radio phenomena that follow with solar flares. It has a wide band structure from 1412-1428 MHz. It can be considered as an intermediate f drift burst (IMDs). This fiber burst has a negative drift rate where the drift is interpreted by the group velocity of the whistler-mode waves. Their bandwidth is approximately 2% of the emission frequency. The are accompanied a parallel-drift absorption band in the background continuum radiation. The occurrence of the event is interesting in many aspects which is also in ZSIS site. From the dynamic spectra of the CALLISTO, it can be observed that there a moving type IV burst. This burst appears is single SRBT III for approximately 16 minutes at 708UT till 716UT. This burst duration is longer compared to the other events. It can be considered as a Ivμ because it begins at the same time as the explosive phase of solar flare. The solar optical, radio and X-ray emission associated with these various energetic particle emissions as well as the propagation characteristics of each particle species are examined in order to study the particle acceleration and emission mechanisms in a solar flare. At the same time, the number of particles traveled a given path in reconnecting area falls exponentially with increase of this path because of losses owing to a leaving of particles the acceleration volume due to drifts.

***Keywords*:** Sun; solar burst; type IV radio region; X-ray region; solar flare; Coronal Mass Ejections (CMEs)

1. INTRODUCTION

Solar prominence occurs when there are hot ionized gases at the magnetic fields of the sunspot. In 1861, where the spectroscopy was developed, the yellow D3 line at 5877Å was observed for the first time in prominences during the eclipse in 1868 which then identified as coming from solar He emission. Solar prominences are typically observed to be high loops of hot ionized gases, which follow the geometry of the magnetic fields associated with pairs of sunspots. Prominences are known before as it is visible during the eclipses. In simple words, solar prominence is a large, bright and gaseous feature extending outward from photosphere then go to chromosphere before extending outward into the corona. Solar prominences can be seen in absorption at coronal temperatures. Due to the low temperature, the prominence core is made of partially-ionized plasma. The properties of the prominences may vary over a wide range. Due to the differences, variety of classifications of prominences have been made in terms of their location, activity and on the properties of the magnetic field in the photosphere. Prominences properties depend on the environment where they are formed and the magnetic field below them. Solar prominences also one hundred times cooler and denser than the coronal material which shows that they are thermally and pressure isolated from the surrounding environment. These properties made them appear on the limb as bright features when observed with optical or the EUV lines while on the disk they appear darker than the background which indicate the presence of a plasma absorption process where we called it as filaments. This kind of activity is a part of mechanism of transportation of energy of the Sun. The energy is carried to the surface of the Sun in the form of light and heat, through a process known as convection. It has been proved that our the mass of the Sun is 1.989×10^{30} kg and its luminosity is 3.85×10^{26} W [1]. The relativistic energy electron emission is found to occur only during proton events. The solar optical, radio and X-ray emission associated with these various energetic particle emissions as well as the propagation characteristics of each particle species are examined in order to study the particle acceleration and emission mechanisms in a solar flare.

Filaments are usually found above the neutral lines separating opposite polarities of the photospheric magnetic field (Polarity Inversion Line, PIL). For filaments and local magnetic field to be closely interrelated with the extension of the PIL depends on the strength and distribution of the local magnetic field. Particularly during the solar maximum of the solar cycle, PILs can be found everywhere in the sun and so can prominences. Their appearance may differ a lot for all these reasons. Last but not least, the mechanism of energy release, plasma heating, the particle acceleration and transfer in magnetized plasmas is actually not easy to be understood during the explosion of solar prominence.

The solar activities such as solar flare and Coronal Mass Ejections phenomena are due to large and changing magnetic fields threading the outer regions from Convective zone to Corona and produce the sunspots [2]. It is found that solar flares can be divided into three categories depending on their energetic particle emission: (1) small flares with no accompanying energetic phenomena either in particles, radio or X-ray emission; (2) small flares which produce low energy electrons and which are accompanied by type III and microwave radio bursts and energetic (~ 20 keV) X-ray bursts; and (3) major solar flare eruptions characterized by energetic solar proton production and type II and IV radio bursts and accompanied by intense microwave and X-ray emission and relativistic energy electrons. It refers to the occurrences that naturally occur within the outer atmosphere of the sun when it magnetically heated [3]. Sometimes, it due to the strong magnetic field and a chaotic dynamo near the surface of the sun which caused a smaller magnetic fluctuation [4]. Until now, one still unresolved puzzle about the chromospheres is why at some frequencies (at least 10 −100) GHz the polar coronal holes appear brighter than the rest of the quiet Sun due to corresponds to an elevated temperature in the upper chromosphere in coronal holes relative to the normal quiet Sun [5]. Understanding the variety of prominences and how does it contribute to the solar flare and Coronal Mass Ejections (CMEs) will get the better knowledge of the structures and their environment can provide valuable information on the physics of the solar atmosphere.

Meanwhile, the Coronal Mass Ejections (CMEs) ejected from the sun are one of the main solar phenomena and the Earth-directed CMEs have a close connection with a geomagnetic storm. The higher speed of solar wind which comes from the CMEs will enhance magnetic field and generate geomagnetic storm that involves reconnection with the Earth's magnetosphere [6]. Geomagnetic storms can cause electrical power outages and damaged communications satellite. On the other hand, the solar flare will release energetic and non-thermal particles into the space [7]. An appreciative of both solar flare and CMEs are required to understand and predict the space weather and its effects to the climate of the earth [8-17]. There are various of data of CMEs, with the use of data from various instruments, time profiles of velocity, acceleration and geometric characteristics of CMEs immediately after their initiation were obtained in any wavelength [18,19].

Type IV burst is confined to frequencies ≤ 1000 MHz, and can divide into 2 categories (i) a moving burst and (ii) static type IV bust [20]. This burst bursts characteristically happen at around the time of the soft X–ray peak in a solar flare and are identified by a slow drift to lower frequencies with time in dynamic spectra. [21-23]. It is related to the generation of solar cosmic rays and plasma clouds that related to the mechanism of solar particles.

2. OPTICAL AND RADIO OBSERVATION

There are three types of telescope at Telok Kemang Solar Observatory, Port Dickson, Negeri Sembilan Malaysia. The three telescopes are Takahashi TOA150, Vixen 103mm ED103s and Lunt Solar 100mm H-Alpha. For a better result of view of the solar prominences, solar flares or coronal mass ejection (CME), it is better to use the Lunt Solar 100mm with H-Alpha filter. This is because the sun's chromosphere is red due to the hydrogen atom emit energy in the red portion of the visual spectrum. When a hydrogen nucleus emits energy, the electron moves downward and produces an emission line. Electrons jump from the third to the second orbit produces Hydrogen alpha emission line at 653.3 nanometers while hydrogen alpha Etalons let us see the light. Figure below show the optical system at Teluk Kemang Negeri Sembilan, Malaysia.

In radio observation, the CALLISTO spectrometer is designed and built to detect the intensity of radio emission at radio frequencies between 45-870 MHz. The receiver system consists an antenna, a front end equipped with a low-noise amplifier (LNA) unit and a hybrid amplifier, and a back-end with units of a power combiner, a spectrum analyzer and a personal computer (PC). [25,26]. Due to the development of the technology, more advanced system was implemented to 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 [27,28].

Figure 1. The Lunt Solar 100 mm H-Alpha Telescope, Takahashi TOA150 and Vixen ED103S at Teluk Kemang, Negeri Sembilan, Malaysia

A CCD camera (ZWO ASI120MM or DMK 21 AU04) was attached to the Lunt Solar 100 mm H-Alpha telescope and linked to a software to see the images of the sun. A setting of the camera was set in the software such as the frame number and color setting. Then, searched for the desired images, for example the solar flares, sunspots, filaments or solar prominences and started capturing the images. The captured images, then will be edited by using AutoStakert, RegiStax and Adobe Photoshop to get the best image result of the sun. After the images were processed, all the data of the solar prominences was collected (sunspot number, solar wind, etc.). Then, the images of solar prominences by using an optical telescope was compared with the radio telescope images of the type of burst produced.

Figure 2. CCD camera and optical telescope at Teluk Kemang, Negeri Sembilan, Malaysia

3. RESULTS AND ANALYSIS

Here, we measured event is the event is on the 21st of September 2015. The occurrence of the event is interesting in many aspects which is also in ZSIS site As can be seen from Fig.3. From the dynamic spectra of the CALLISTO, it can be observed that there a moving type IV burst. This burst appears is single SRBT III for approximately 16 minutes at 708UT till 716UT. This burst duration is longer compared to the other events. It can be considered as a Ivμ because it begins at the same time as the explosive phase of solar flare.

We need to consider a few parameters such as a burst duration, drift rate, energy of the photon, and the structure of the burst. The current conditions of space weather were taken from the space weather website provided by NASA and the images of the structure of sunspot on the Sun, data and other images revealed by SOHO Observatory, Solar Monitor, SWPC and CACTUS which also have a collaboration with NASA. Then we compare with the optical image.

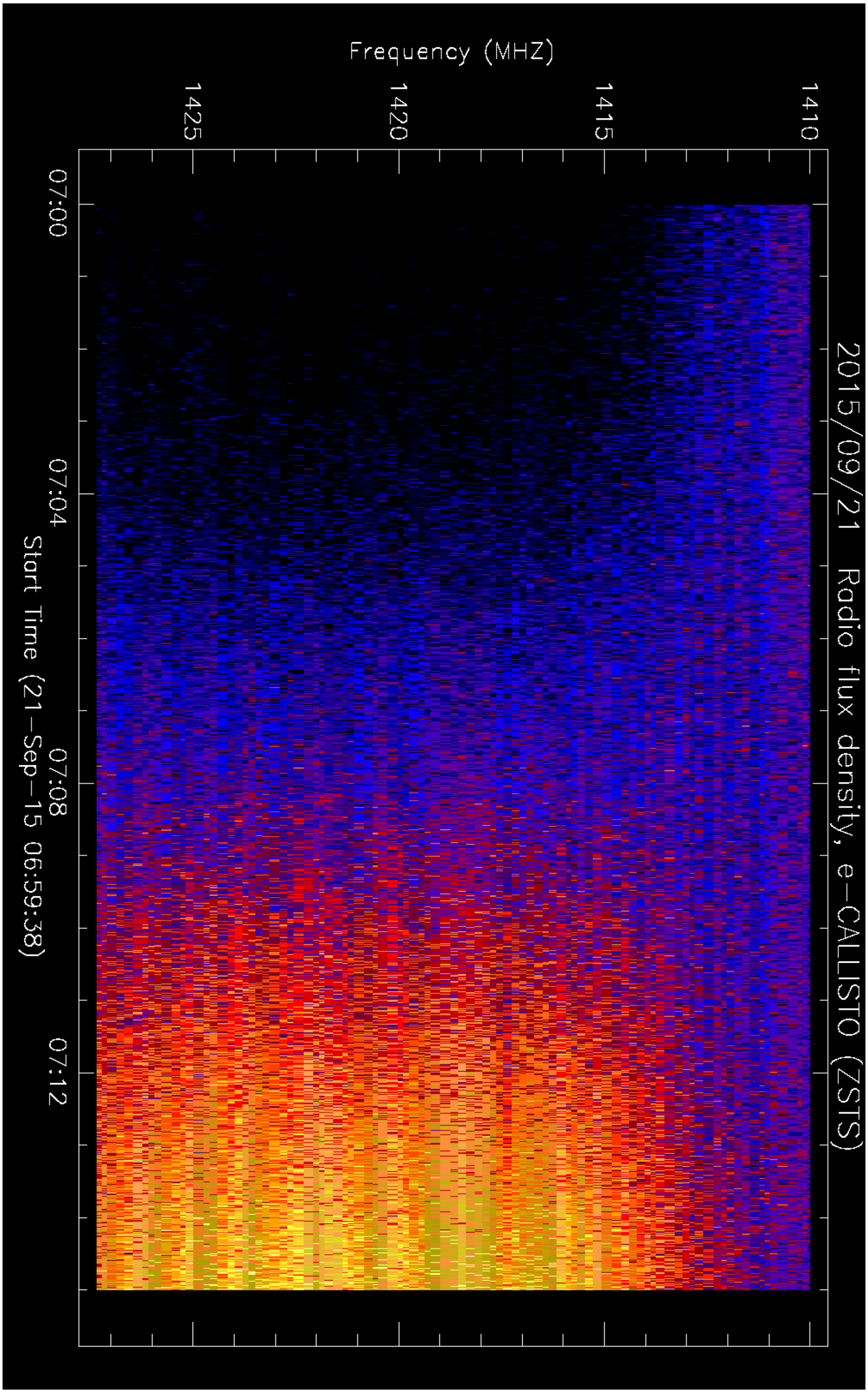

Figure 3. Solar radio burst type IV on 21st September 2015

Table 1. Shows the current condition during 21st September 2015.
The current condition of the Sun (Credit to spaceweather.com)

Parameter	Value
Sunspot Number	74
The Radio Sun	110 sfu
Solar Wind Speed	463.0 km/Sec
Proton Density	5.2 protons/cm^3
Interplanetary Magnetic Field	4.3 nT

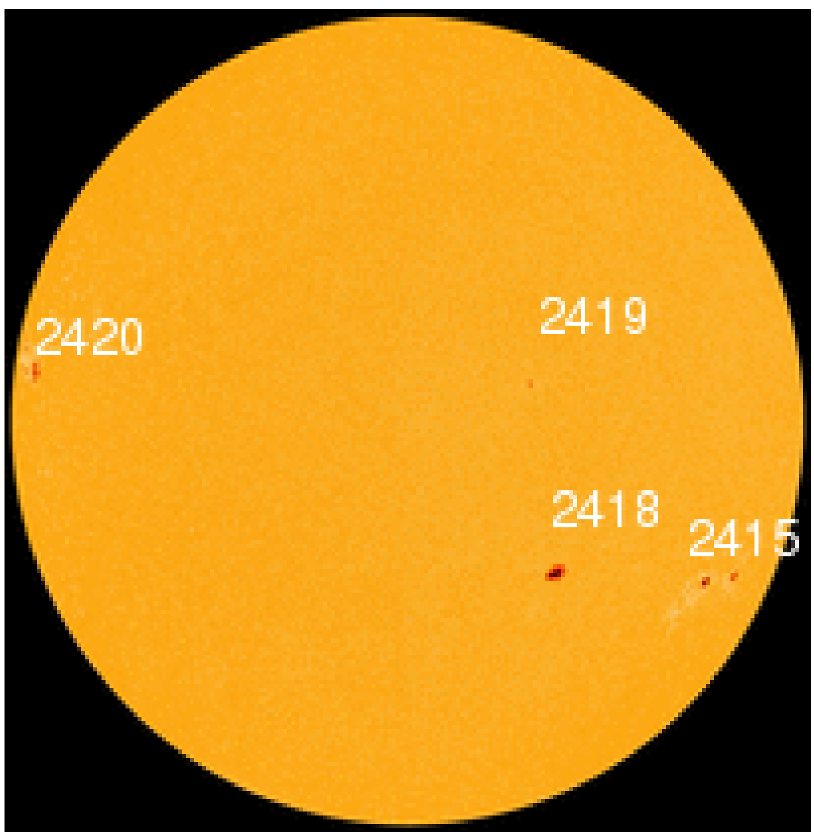

Figure 4. Location of the Sunspot (Credit: SDO/HMI)

The prominence observed as shown in Figure 5 was occurring at 07:10 [UT]. This prominences were captured by Lunt Solar 100 mm H-Alpha telescope by using ASI120 CCD camera.

Figure 5. Prominences Class A (Quiet Region Filament), a hedgerow, curtains, floating arches, arcs, fans, etc prominences) at 0710 UT
(Credit: Telok Kemang Solar Observatory, Malaysia)

One of important results is that during that time the Sun has the highest number of sunspots. The number of sunspots is used by the scientists to track the solar cycles (spaceweather.com). Most of the solar prominence occurred at active region instead of the quiet sun region. The 10.7 cm flux means that a wavelength of the radio emission of the Sun is 10.7 centimeters and related to sunspot number. The trends in solar activity indicated by the 10 cm flux which can be used as daily index or monthly index (Commonwealth of Australia 2016, Bureau of Meteorology, 2016). At the same time, the number of particles traveled a given path in reconnecting area falls exponentially with increase of this path because of losses owing to a leaving of particles the acceleration volume due to drifts.

4. CONCLUDING REMARKS

The radio sources responsible for IVm appears to expand spherically through the solar corona after ejection of solar flare. This event shows a strong radiation in radio region, but not in X-ray region. This burst intense radio phenomena that follow with the solar flare. It has a wide band structure from 1412-1428 MHz. It can be considered as an intermediate drift burst (IMDs). This fiber burst has a negative drift rate where the drift is interpreted by the group velocity of the whistler-mode waves. Their bandwidth is approximately 2% of the emission frequency.The are accompanied a parallel-drift absorption band in the background continuum radiation. It is believed that this burst consisting an interaction of a Langmuir and whistler-mode wave where it produce a left-handed polarized ordinary (L-O) mode wave that can escape from the emission region.

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References

[1] M. Stix, The sun: an introduction, (2004).

[2] Z. Hamidi, N. Shariff, C. Monstein, Understanding Climate Changes in Malaysia Through Space Weather Study, *International Letters of Natural Sciences* (2014).

[3] J. P. Wild, Smerd S. F. and Weiss, A. A., *Ann. Rev. Astron. Astrophysicsv* 10 (1972).

[4] Z. Hamidi, N. Shariff, C. Monstein, First Light Detection of A Single Solar Radio Burst Type III Due To Solar Flare Event, (2014).

[5] J. G. Andrews, *J. Inst. Maths. Applic.* 15 (1976).

[6] G. D. Fleishman, Gary, D. E. & Nita, G. M., *ApJ* 593 (2003).

[7] A. O. Benz, *Sol. Phys.* 96 (1985).

[8] H. T. Classen, & Aurass, H., *A & A* 384 (2002).

[9] A. Shanmugaraju, Y.-J. Moon, K.-S. Cho, M. Dryer & Umapathy S., Sol. Phys. 233 (2006).

[10] H. S. Hudson, & Warmuth, A. , ApJ 614 (2004).

[11] K. S. Cho, Y.J. Moon, M. Dryer, et al., *JGR* 110 (2005).

[12] K. S. Cho, J. Lee, Y.J. Moon, et al., *A & A* 461 (2007).

[13] S. Pohjolainen, & Lehtinen, N.J., A & A 449 (2006).

[14] M. J. Reiner, Krucker, S., Gary, D.E., et al., *ApJ* 657 (2007).

[15] B. Vrˇsnak, Warmuth, A., Temmer, M., et al., *A & A* 448 (2006).

[16] C. Dauphin, N. Vilmer, S. & Krucker, *A & A* 455 (2006).

[17] Y. Liu, Luhmann,, B. J.G., S.D., R.P. & Lin, *ApJ* 691 (2009).

[18] D.M. Rust, D.F. and Webb, Soft X-ray observations of large-scale coronal active region brightenings, *Solar Phys.* 54 (1977) 403-417.

[19] N. Gopalswamy Coronal Mass Ejections and Type II Radio Bursts, in Solar Eruptions and Energetic Particles, *Geophysical Monograph Series* 165 (2006).

[20] N. Gopalswamy, A. Lara, M. L. Kaiser, J. L. Bougeret, Near-Sun and near-Earth manifestations of solar eruptions, *J. Geophys. Res.* 106 (2001a) 25261-25278.

[21] 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.

[22] E. Aguilar-Rodriguez, N. Gopalswamy, R.J. MacDowall, S. Yashiro, M.L. Kaiser, A Study of the Drift Rate of Type II Radio Bursts at Different Wavelengths, Solar Wind 11/SOHO, 2005, pp. 393-396.

[23] N. Gopalswamy, S. Akiyama, S. Yashiro, Major solar flares without coronal mass ejections, in: N. Gopalswamy, D.F. Webb (Eds.), Universal Heliophysical Processes, 2009a, pp. 283-286.

[24] Z. S. 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, Scientific Publishing, 2014, pp. 85.

[25] 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).

[26] Z. Hamidi, N. Shariff, C. Monstein, W.W. Zulkifli, M. Ibrahim, N. Arifin, N. Amran, Observation of the Radio Frequency Interference (RFI) at the National Space Centre, Malaysia, *International Letters of Natural Sciences* (2014).

[27] 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.

[28] 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.

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