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Enormous Eruption of 2.2 X-class Solar Flares on 10th June 2014

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ABSTRACT

The observational of active region emission of the Sun contain an critical answer of the time-dependence of the underlying heating mechanism. In this case, we investigate an X2.2 solar flare from a new Active Region AR2087 on the southeast limb of the Sun. The solar flare peaked in the X-rays is around 11:42 UT. It was found that the snapshot of this event from the Solar Dynamics Observatory (SDO) channel with the GOES X-ray plot overlayed. The flare is very bright causes by a diffraction pattern. We explore a parameter space of heating and coronal loop properties. Based on the wavelength, it shows plasma around 6 million Kelvin. At the same time, data from the NOAA issued an R3 level radio blackout, which is centered on Earth where the Sun is currently overhead at the North Africa region. This temporary blackout is caused by the heating of the upper atmosphere from the flare. The blackout level is now at an R1 and this will soon pass. Other than the temporary radio blackout for high frequencies centered over Africa this event will not have a direct impact on us. Until now, we await more data concerning a possible Coronal Mass Ejections (CMEs) but anything would more than likely not head directly towards Earth. An active region AR2087 just let out an X1.5 flare peaking at 12:52 UT. This shows plasmas with temperatures up to about 10 Million Kelvin. This event is considered one of the massive eruption of the Sun this year.

***Keywords*:** Sun; X-ray region; solar flare; active region

1. INTRODUCTION

The Sun is an ideal object of blackbody with a large and complex magnetic field. In solar activity specifically solar flare phenomenon, the magnetic reconnection is one of the most significant factors of the Sun that can simplify a better understanding of our nearest star [1,2]. The transportation of energy from the central regions of the Sun is primarily through photon radiation, although electron conduction contributes in the innermost region and convection dominates near the surface [3]. Before going into details of observations, it would be instructive to give some basic information on solar activities such as solar flares. In general, there are three types of acceleration commonly quoted in solar flares which is (i) Direct electric field acceleration that can boost a particle to high energies simply via the Coulomb force from the electric field and may drive in the current sheet or in the reconnection site, but it is hard to maintain a large-scale coherent direct current, DC electric field. (ii) Shock or first-order Fermi acceleration can energize particles by making them repeatedly pass through the shock front back and forth and this mechanism may be present in the fast shock produced by the super-magnetosonic outflow jet from the reconnection region. However, it would be difficult to reflect the particles in the upstream region. (iii) Stochastic (second- order Fermi) acceleration by turbulence or plasma waves is the most likely mechanism for solar flares, compared with the shortcomings of the other two mechanisms [4].

In principle the magnetic energy in the solar corona is explosively released before converted into the thermal and kinetic energy in solar flares [5,6]. The eruption could possible released a temperature of the explosion could exceed up to 10-20 MK. In this case, these particles will accelerate by parallel electric fields, drift velocities caused by perpendicular forces which is (E x B drifts) while gyromotion caused by Lorentz forces of the magnetic field [7]. This solar flare will associated with the solar radio burst type III plays a fundamental role in solar burst studies [8]. It forms as a short, strong burst which move rapidly from around 500 MHz to lower frequencies and eject high energy electrons away from the Sun at about 1/4 the speed of light. This factor is due to the motion of the plasma and other particles through the convection mechanism inside the Sun [9].

Meanwhile, metric radio burst is normally a non-thermal particles accelerated and trapped during those events [10,11]. In the presence of flares, strong solar radio burst type III are is observed over a broad frequency range. Type III solar burst, a fast drift burst is the most common of the meter wavelength bursts. The Type III solar burst was first introduced by Wild in 1963 [12] in the frequency range 500-10 MHz [13,14]. It can be considered as a pre-flare stage that could be a signature of electron acceleration [15]. This type is related to solar flares and typically occurs before optical events. Further evidence presented that type III are generated in a weak-field region comes from the absence or low degree of circular polarization of the bursts [16]. 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 [17-21]. The Langmuir waves originate from the nonthermal electrons, and the intensity of the radio bursts depends on the nonthermal electron density and energy. It is believed that a beam-plasma system is unstable to the generation of Langmuir waves, which are high frequency plasma waves at the local plasma frequency [22,23].

In the currently widely accepted scenario, the basic physical processes involved and the observational signatures are as follows. Magnetic reconnection, as the primary energy release mechanism occurring high in the corona, rapidly heats the plasma and accelerates particles. It is well known that process by which magnetic lines of force break and re-join into a lower-energy configuration, which magnetic energy is converted into plasma kinetic energy [24]. The reconnection is dominated by repeated formation and subsequent coalescence of magnetic islands (known as “secondary tearing” or “impulsive bursty” regime of reconnection), while a continuously growing plasmoid is fed by newly coalescing islands. The impulsive phase of the flare coincides with the acceleration phase of the CMEs Some particles escape along the open magnetic field lines into the interplanetary space, with electrons producing various radio bursts and some electrons [25] and ions being detected at 1 AU. In what manner and when the magnetic reconnection in the solar flare occur is remain as one of the long outstanding questions in solar physics, holding clues about the onset of structure formation in the first light of solar burst detection. It is believed that metric radio observation plays an important role in order to understand the behaviour of magnetic reconnection due to solar burst type III characteristic [26].

2. SOLAR FLARE OBSERVATION

The solar flare observation has been monitored by using the Compound Astronomical Low-frequency, Low-cost Instrument for Spectroscopy Transportable Observatories (CALLIISTO) system is used in obtaining a dynamic spectrum of solar radio burst data [27]. We have constructed the Log Periodic Dipole Antenna (LPDA) and this system was mounted on the top of the rooftop of National Space Centre (ANGKASA) building at Sg. Lang, Banting, Selangor [28-30]. This antenna covered from 45 - 870 MHz [31,32]. This antenna is connected to the CALLISTO spectrometer via cable RG 58 and the modification, calibration process and basic testing of the antenna has been done in order to improve the quality of the system [33-37]. A preamplifier also is used to maximize the gain of the signal and all the data are automatically saved in FIT files [38]. However, to avoid the interference signal, we focused the range of 150 MHz till 350 MHz [39,40]. This region is the best region with minimum interference at our site [41]. We have selected the data from 220 - 380 MHz region seems this is the best range with a very minimum of Radio Frequency Interference (RFI) [42-45]. In this paper, we have focused the study area of solar flares in an X-ray region only [31].

3. RESULTS AND ANALYSIS

In this section, we will discuss in detailed the structure and active region that active at the corona of the Sun. Our next analysis will focus on the active region of the surface of the Sun. Based on Solar Dynamic Observatory (SDO) data, there are seven active regions during that event (AR2086, AR2082, AR2079, AR2077, AR2080, AR2084, and A2085). However, the flaring region can be observed on the West part of the Sun by AR 2087. A coronal holes also has been found at the center and South of the Sun. Figure 1 illustrates the position of Active Region and flaring sources.

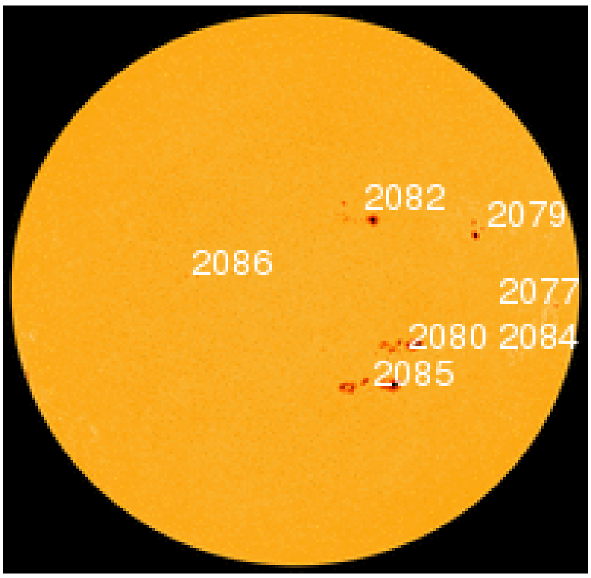

Figure 1. The position of Active Region and flaring sources (Credited to: Solar Dynamics Observatory (SDO).

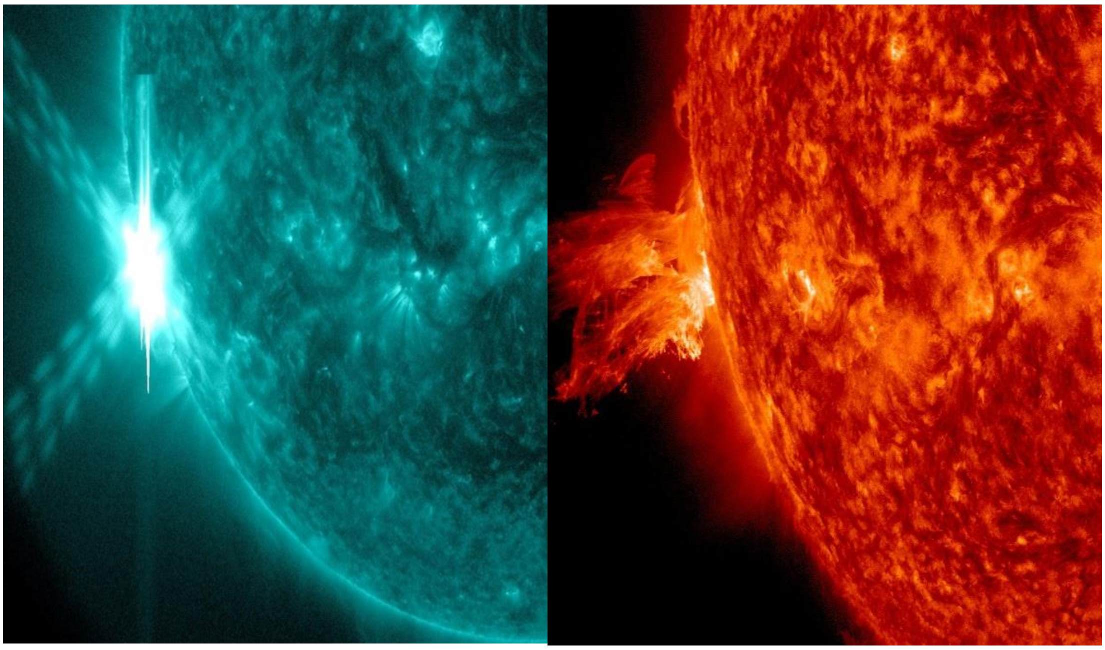

Figure 2. The Active Region 2087 exploded a large eruption of X2.2 solar flare (Credited to: Solar Dynamics Observatory (SDO).

This observation allows for the mechanisms of evolution type III solar burst and local environment of the burst to be characterized. This event occurred from 11:42 UT till few hours. It was found that the snapshot of this event from the Solar Dynamics Observatory (SDO) channel with the GOES X-ray plot overlayed. The flare is very bright causes by a diffraction pattern. Based on the wavelength, it shows plasma around 6 Million Kelvin. At the same time, data from the NOAA issued an R3 level radio blackout, which is centered on Earth where the Sun is currently overhead at the North Africa region. This temporary blackout is caused by the heating of the upper atmosphere from the flare. The blackout level is now at an R1 and this will soon pass. Other than the temporary radio blackout for high frequencies centered over Africa this event will not have a direct impact on us. Until now, we await more data concerning a possible Coronal Mass Ejections (CMEs) but anything would more than likely not head directly towards Earth. An active region AR2087 just let out an X1.5 flare peaking at 12:52 UT.

Observation, there a few peaks of solar flares can be detected. GOES 15-0.5-4.0A shows 5 class of solar flares consistently formed in this period. At the same time, GOES 15 1.0-8.0 A also shows a significant peak of C-class solar flares that increases drastically as can be seen in Figure 3.

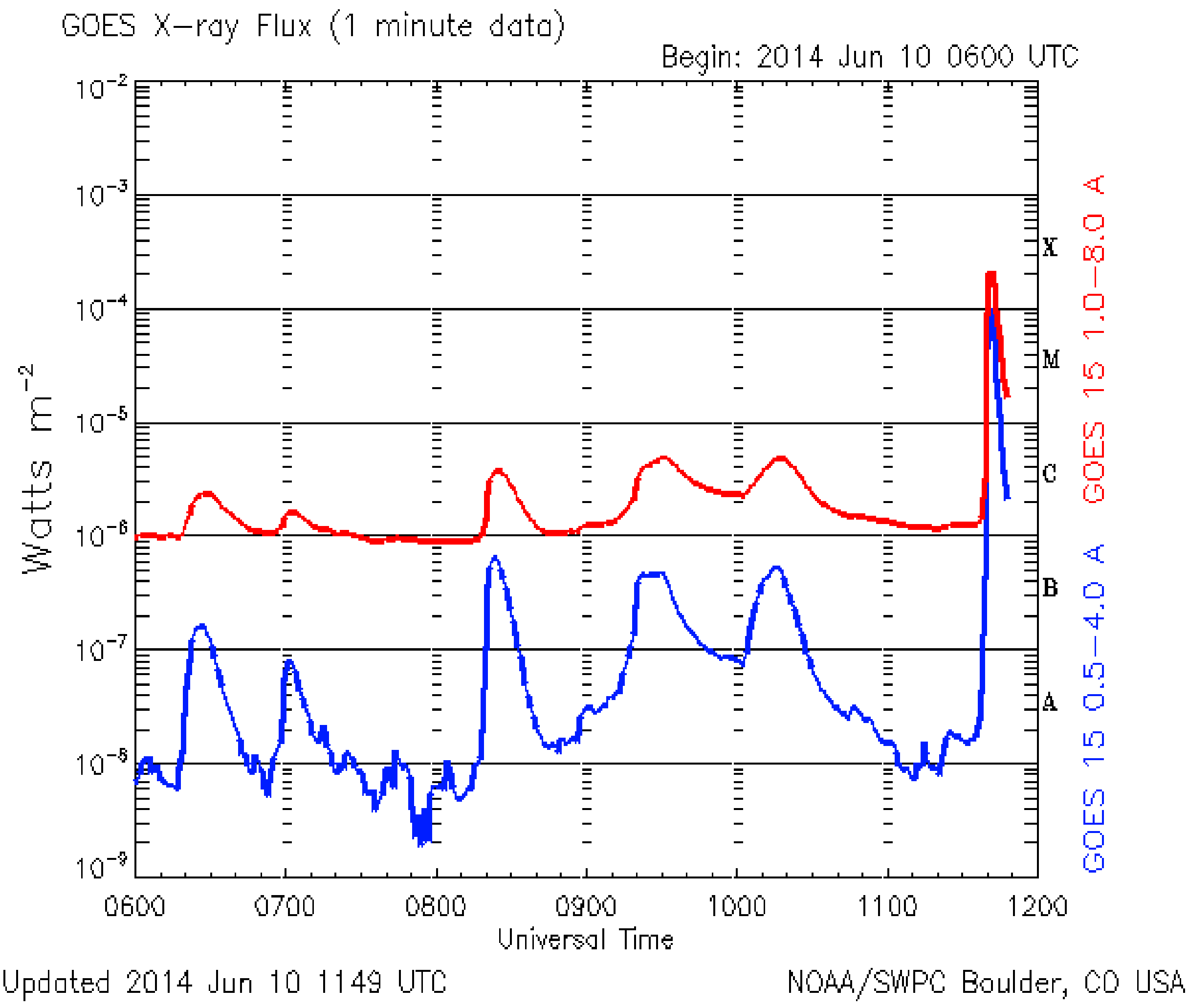

Figure 3. The GOES X-ray flux profile (Credited to: NOAA/ SWPC).

As shown in the next Figure, there is a tendency that AR2087 could possible to explode a large solar based based on the pattern of solar flare since 6:00 UT. Within 6 hours observation, there a few peaks of solar flares can be detected. GOES 15-0.5-4.0A shows 5 class of solar flares consistently formed in this period. At the same time, GOES 15 1.0-8.0 A also shows a significant peak of C-class solar flares that increases drastically as can be seen in Figure 3.

Table 1 displays the detailed parameter of each active region that can be observed directly from ground and space observation during 10^h June 2014. There are eight active regions and this is the indicator that the Sun is currently active. Some of the active region also remains exploded a huge particle and potentially eject the solar flares. Most the active regions radiate a Beta radiation. The location of the active region can be found in the East region of the Sun.

Table 1. The condition of the Sun during 10th June 2014 (Credited to Space Weather).

Parameter	Value
Solar wind speed	423.9 km/sec
Density	4.4 protons/cm^3
Sunspot number	152
10.7 cm flux	161 sfu
6-hr max	X2
24-hr	X2

4. CONCLUDING REMARKS

Solar flares on June 10, 2014, show a long series of quasi-periodic pulsations deeply modulating a continuum and slowly drifting toward lower frequencies. Until now, the corona extends from the top of a narrow transition region to Earth and beyond has a temperature millions of degrees which is still considered as a mysteries properties. Although these two observations (radio and X-rays) seem to be dominant on the observational analysis, we could not directly confirmed that this is the only possibility, and we need to consider other processes to explain in detailed the injection, energy loss and the mechanism of the acceleration of the particles. Indirectly, it is believed that the large solar flares with a few numbers of solar storms contribute the distribution of flux energy or the burst.

This energy of solar storms comes from the solar magnetic field which is generated from the convection zone. It should be noted; however, there are many complex models which propose how this occurs, yet most models at some point invoke magnetic reconnection. In conclusion, the percentage of energy of solar flare becomes more dominant rather than the acceleration of particles through the solar flares and that will be the main reason why does the Coronal Mass Ejections (CMEs) is not formed.

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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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