

# The Evolution of Unstable 'Beta-Gamma' Magnetic Fields of Active Region AR 2222

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## ABSTRACT

This event allows us to investigate how plasma–magnetic field interactions in the solar corona can produce suprathermal electron populations over periods from tens of minutes to several hours, and the interactions of wave-particle and wave-wave lead to characteristic fine structures of the emission. An intense and broad solar radio burst type IV was recorded by CALLISTO spectrometer from 240-360 MHz. Using data from a the KRIM observatory, we aim to provide a comprehensive description of the synopsis formation and dynamics of a a single solar burst type IV event due to active region AR2222. For five minutes, the event exhibited strong pulsations on various time scales and “broad patterns” with a formation of a group type III solar burst. AR 2222 remained the most active region, producing a number of minor C-Class solar flares. The speed of the solar wind also exceeds 370.8 km/second with 10.2 g/cm<sup>3</sup> density of proton in the solar corona. The radio flux also shows 171 SFU. Besides, there are 3 active regions, AR2217, AR2219 and AR2222 potentially pose a threat for M-class solar flares. Active region AR2222 have unstable 'beta-gamma' magnetic fields that harbor energy for M-class flares. As a conclusion, we believed that Sun's activities more active in order to achieve solar maximum cycle at the end of 2014.

**Keywords:** Sun; solar burst; IV; radio region; X-ray region; solar flare; active region AR2222

## 1. INTRODUCTION

It is well known that the solar activity is due to large and changing magnetic fields threading the outer regions from Convective zone to Corona and produce the sunspots, solar flare and Coronal Mass Ejections phenomena. This sunspots occurs by high concentrations of the magnetic field which inhibit the flow of heat to the surface from the convection zone below. 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 [1,2,3]. 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 Alfvén waves for type IV fine structures (have also been recommended. It related are related to the injection of large fluxes of mildly energetic electrons into a coronal loop. This nonthermal type IV emission consisting of both a structureless continuum, and the gyrating particles is complex, with a number of fine structures referred to as pulsations, fibers, spaghetti, zebra bursts, and numerous explanations [5].

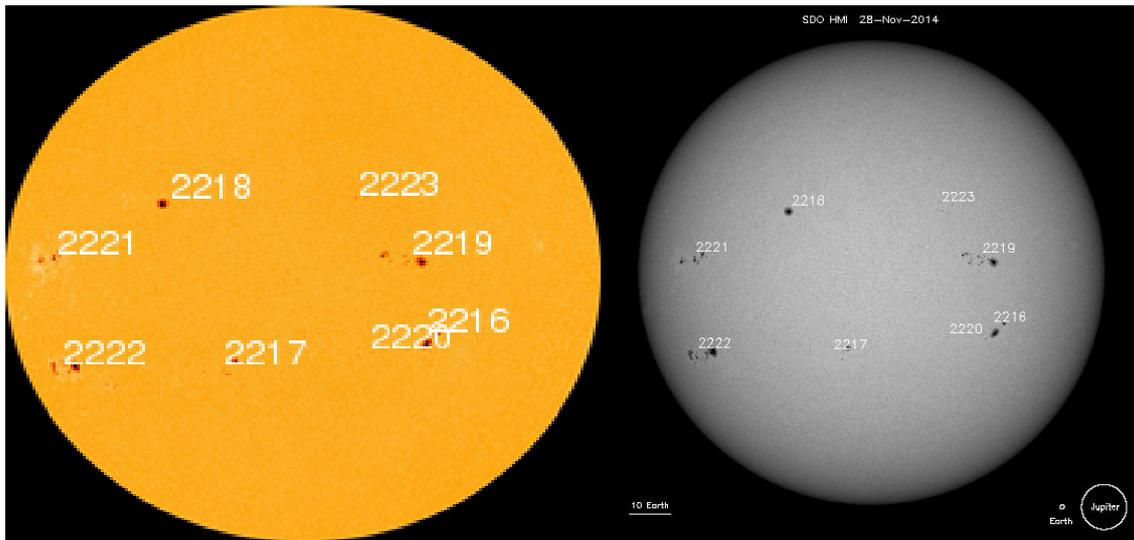
Typically, the emission stripes the source drift over distances up to several  $\times 10^4$  km, with apparent velocities up to  $10^5$  km s<sup>-1</sup>. It should be noted that the direction of the source motion at a given frequency is on average found to be perpendicular between broadband radio 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<sup>-1</sup>) [7]. This type of burst is dominant a few days before solar flare and Coronal Mass Ejections explosion [8,9,10].

## 2. SOLAR BURST OBSERVATION

It is possible to detect a variety types of burst during a major space weather event [11,12,13] from KRIM 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 [16,17,18,19]. 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 [20,21,22]. 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) [24,25,26,27,28]. The next section will highlight the detailed analysis of solar flares in an X-ray and radio region to evaluate the distribution of high and low energy.

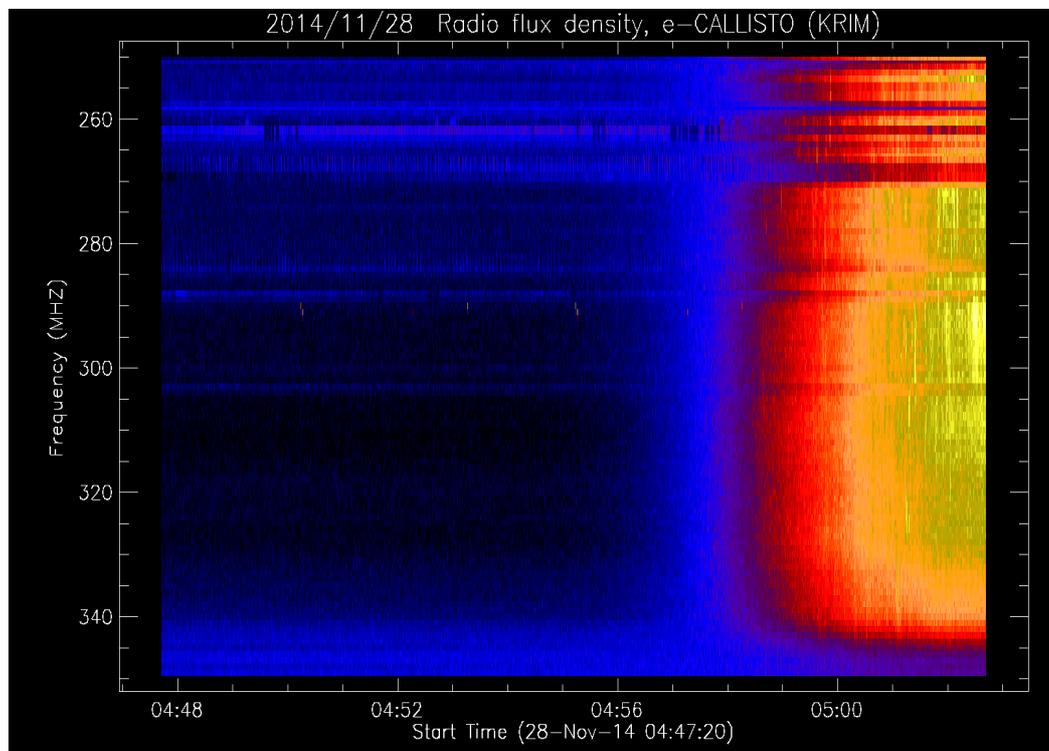
## 3. RESULTS AND ANALYSIS

We will describe the event, with emphasis on the unique features. Based on the observation, there are eight active regions during this period. These active regions can potentially create a large formation of solar flare. At lower frequencies, a noise storm persisted during the entire event between 240 and 350 MHz. The resulting incoherent radio emission in the metric wavelength range maps out the location and motion of the loop in the solar corona.



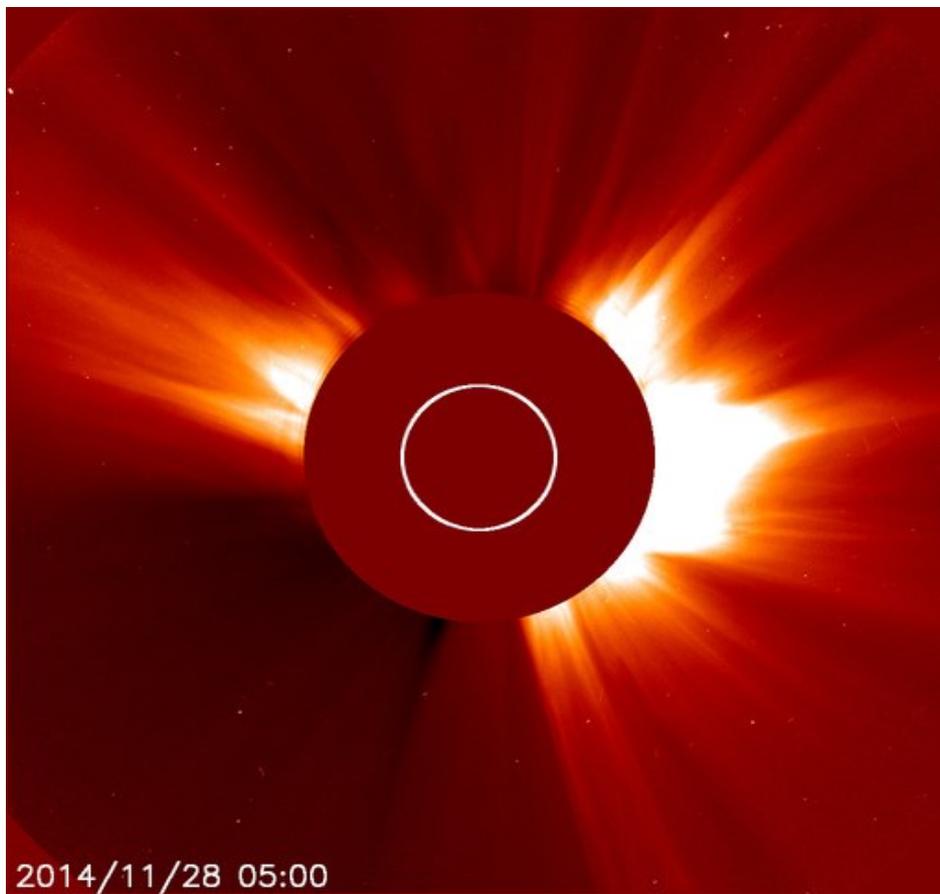
**Figure 1.** The Active Region 2222 in 28th November 2014 compared with the size of the Earth and Jupiter.

Another property observed was that the 8 active region at the surface of the Sun would potentially create a plasma eruption and a large solar flare. The type IV solar burst with duration of 5 minutes can be observed from 240-350 MHz. The class of C solar flare is evolving at this point. This type is the moving burst and could take a few hours. The active Region 2222 poses a threat for the M-Class solar flares at 5:00UT This flare is the highest point during that day.



**Figure 2.** The light curve associated with a Type M solar flare on 28<sup>th</sup> November 2014 at the KRIM observatory.

Figure 1 shows spectra of a meter type IV solar radio burst detected at the KRIM observatory. From the observations, strong solar burst type IV can be observed starting from 4:58 UT and this is considered as a broadband subtype of burst. The differences in the emission due to changes in the electron density and spectral expansion and limited averaging procedure which only saved in data basis form and has difficulties in interpretation due to non axis symmetric harmonics. Besides that, the time variability in the emission proceeds slowly and classified as Moving. This type of burst burst as it has frequency more than 240-350 MHz. It associates with post-flare loop due to low spatial resolution typical of long waves. It is expected that there will be large solar flares in the next few days. Moreover, data from the Space Weather Web Site is used. Owing to the complex structure of Active Region 2222, the spatial distribution of the dynamical energy transport in the region is very complex. There are eight active regions, mostly at the center part of the Sun.

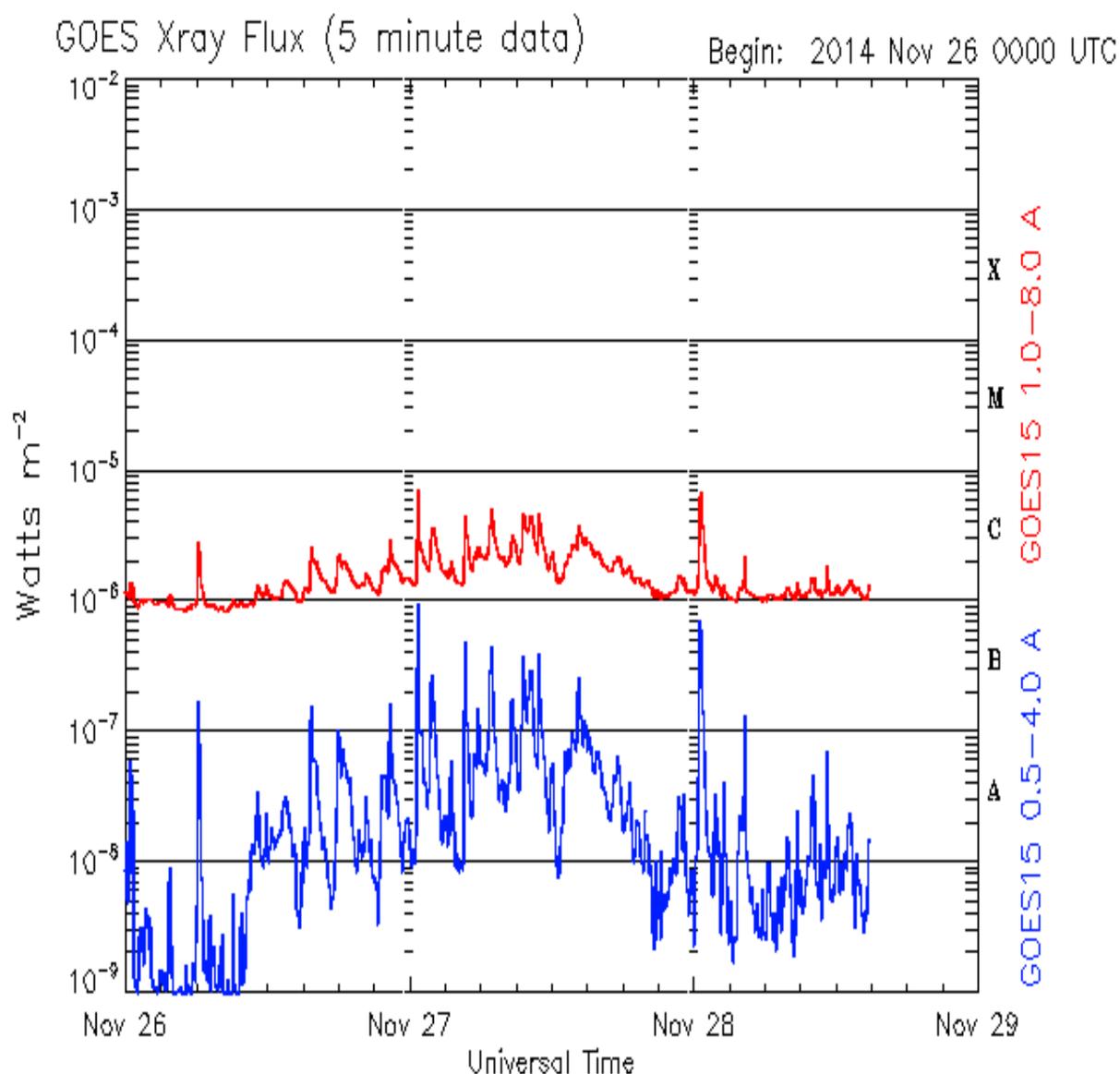


**Figure 3.** The active Region 2222 poses a threat for the M-Class solar flares at 5:00UT. Credit to : LASCO2.

From our analysis, the possible reasons for this formation is because of magnetic reconnection and disruption of the loops during solar flares. The burst usually located the same layer with the solar corona which was defective disturbance started. It also effected by trapping electrons this variation in the emission also affected by the changes in the electron density and due to lower in broadband frequency which in between 45 MHz to 870 MHz. Other than that, it also acts as an indicator of corpuscular emission from the Sun which both

mediums have high energy of protons and attenuation of two definite and distinct components. The large variations in intensity and high degree of polarization in the ordinary mode, which usually occurs at meter wavelengths in large outburst.

The speed of the solar wind also exceeds 370.8 km/sec with  $10.2 \text{ g/cm}^3$  density of proton in the solar corona. The radio flux also shows 171 SFU. Besides, there are 3 active regions, AR2217, AR2219 and AR2222 potentially pose a threat for M-class solar flares. The Solar flare class C7 is continuously being observed in X-ray region for 24 hours since 1943 UT and a maximum class C4 can also be detected within 6 hours period. Solar wind flowing from the indicated coronal hole could reach Earth on Nov. 31-Dec. 1. The Figure 4 shows the variability of the X-ray flux from 26-29 November 2014.



Updated 2014 Nov 28 15:05:12 UTC

NOAA/SWPC Boulder, CO USA

**Figure 4.** The variability of X-ray flux from 26<sup>th</sup> – 29<sup>th</sup> of November November 2014 (Credited to NOAA Space Environment Centre).

This event allows us to investigate how plasma–magnetic field interactions in the solar corona can produce suprathermal electron populations over periods from tens of minutes to several hours, and the interactions of wave-particle and wave-wave lead to characteristic fine structures of the emission. The burst occurred as low frequency compared to the previous events, but this event occurred longer compared to the previous event. It has been observed that the solar wind and density is low as the plasma frequency also low.

#### 4. CONCLUDING REMARKS

Active region AR2222 have unstable 'beta-gamma' magnetic fields that harbor energy for M-class flares. Their presence implies acceleration possibly at the tops of loops. Besides that, they have long been of interest in the Space Weather because they have a high degree of association with solar energetic particle events. The broadband and non-drifting nature of Type IV emission is due to electron trapped in closed magnetic field lines. To summarize, the of Solar Burst Type IV has burst characteristics of low-frequency have been proved. This is burst fine structure of Solar Burst Type IV. Therefore, a broadband frequency is a good source to study this type of stationary burst structure. Observations in the radio region, which in low frequency are mostly can potentially diagnose by using space weather effects that originates from the sun's atmosphere and it also played an important role in the way to monitor the space weather sources. As a conclusion, we believed that Sun's activities more active in order to achieve solar maximum cycle at the end of 2014.

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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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