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Metric Type II Bursts with and without Coronal Mass Ejection During 20 Years

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Abstract

Metric type II bursts are formed from shocks driven by CME or flares which is indicative of particles (SEPs) accelerated to high energies. This work aims to investigate the metric type II bursts, CMEs and flare for twenty years (1996-2016, inclusive) over two solar cycles 23 and 24. The total metric type II bursts was 1378 events divided into two groups: first group associated with CMEs regardless their properties and this group has (1147) events. The second group associated with flares which has (231) events. The interstice fraction of this research is the metric type II associated with CME is 83% whereas only 17% with flare where this very close to the previous study in 2005 which found 81% despite it was for only six years. This agreement between the two studies may lead to there are a regular emission of CMEs and flares over long periods.

Keywords: Coronal mass ejection (CME), metric type II burst, flare.

النبضات الراديوية المترية من النوع الثاني خلال عشرون عام مع وبدون مقذوفات الهالة الكتلية

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الخلاصة

النبضات الرادوية المترية التي تتشكل من انبثاق مقذوفات الهالة الكتلية ومن الفلير ممكن ان تستخدم كدليل على تعجيل الجسيمات الشمسية الطاقية. في هذا البحث تم الكشف على النبضات الرادوية المترية ومقذوفات الهالة الكتلية والفلير خلال عشرون عام من 1996 لغاية 2016 وعلى طول الدورتين الشمسيتين 23 و24. العدد الكلي للنبضات الرادوية المترية المستخرجة 1378 قسمت الى مجموعتين المجموعة الاولى ترتبط مع مقذوفات الهالة الكتلية وكان عددها 1147 والمجموعة الثانية كانت مرتبطة مع الفلير وكان عددها 231. النسبة الجوهرية والمهمه في هذا البحث هي ان نسبة ارتباط النبضات المترية مع المقذوفات كانت 83% بينما نسبة ارتباطها مع الفلير كانت 17% هذه النسبة قريبة جدا من دراسة كانت عام 2005 على الرغم من ان تلك الدراسة كانت لستة سنوات فقط وهذا يقود الى الاعتقاد بان هناك شبه انتظام في انبعاث المقذوفات والفلير من الشمس خلال فترات طويلة.

1. Introduction

In 1947 Scott et al. [1] notice a several solar radio bursts that drifted from higher to lower frequencies and have a speed of ~500–700 km/s similar to eruptive prominences. They also noted the association of the radio burst with a solar flare then these bursts are called type II radio bursts [2]. Also

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Uchida 1960 [3] suggested it to be due to MHD shocks. The current interpretation of the type II burst emission is as follows: electrons accelerated in the MHD shock front generate plasma waves, which get converted into electromagnetic radiation at the fundamental and harmonic of the local plasma frequency (two Langmuir waves coalesce to produce electromagnetic waves at twice the local plasma frequency). This radio emission generated at coronal mass ejection (CME) shocks has been shown to be a useful tool to track CMEs through the coronal and interplanetary medium [4, 5]. Also shocks driven by CMEs accelerated the Large solar energetic particle (SEP) events , so type II bursts may also indicate shocks that accelerate ions [6]. They take ≈ 8.3 minutes to arrive to Earth and hence they can be used as alarm to sudden commencement of geomagnetic storms (SSC) [7]. Therefore more and more studies of iterative data-theory comparison procedure might be used to extract the time-varying position and velocity of the CME [8], which determines whether the CME will hit Earth's magnetosphere and if associated space weather effects will be significant [9].

Type II which mostly appear below 150 MHz [10], but occasionally can reaches 500 MHz [11] is classified according to wavelength bands (from 12 m to 50 cm [12]) into metric (m), decametric-hectametric (DH) and kilometric (km) where most information of solar bursts in this range. Lower limit can penetrate the ionosphere (ionospheric cutoff) and could be received by radio ground telescopes is 15 MHz see (Fig 1). Every band has a physical cause behind it and specific occurring distance at the sun corona or heliocentric, where metric wavelength correspond to the 1-2 R_{Θ} and km wavelength corresponds to region close to the earth while DH between them, therefore observing type II indicate the region and the cause of the event (see Table-1) where well establish that type II classes and its life time (duration) depending on CMEs kinetic energy. CMEs more energetic (wider and faster) than the general population of CMEs it is formed metric type II but only more energetic CMEs associated with DH type II bursts [13].

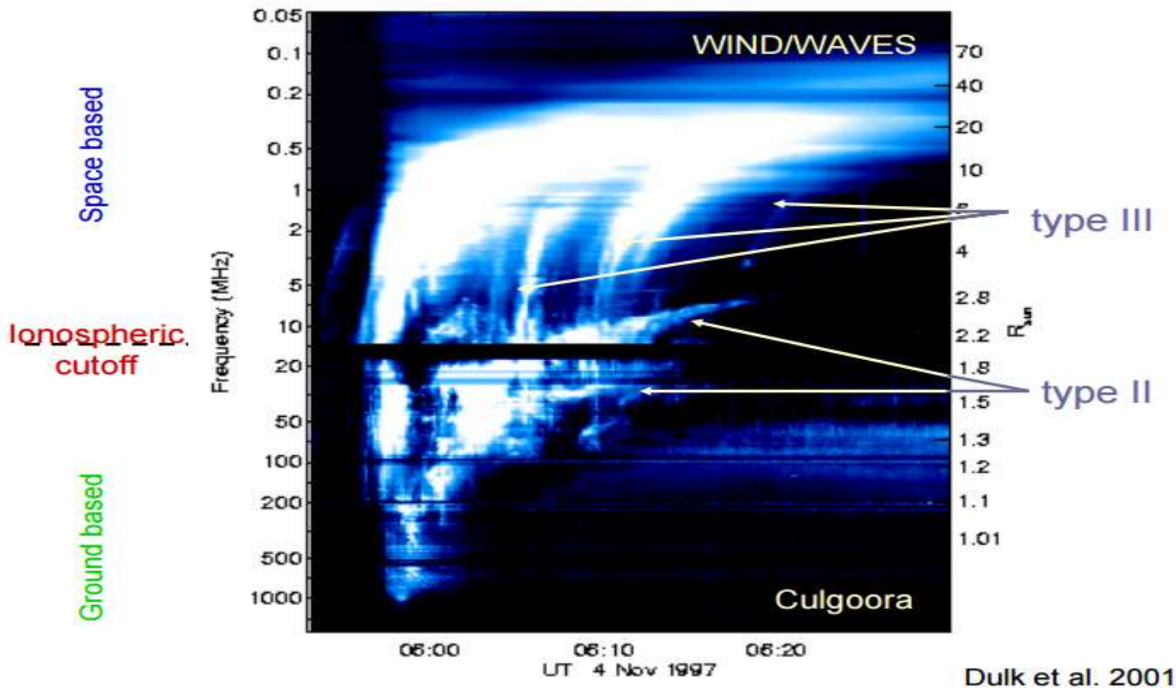

Figure 1- Show the associated the space satellite record (WAVES) event with ground based telescope (Culgoora), noted the ionospheric cutoff [14].

The type II bursts a good opportunity to remotely observe the formation and propagation of shocks in solar corona and interplanetary spaces (IP). Shock formation depends on CME kinematics and the properties of ambient corona, shocks accelerate SEPs (which is observed after type II) and hence m-type II burst give first indication of strong coronal shock capable of accelerating particles. All large SEP events found associated with the three types of type II (m, DH, and km) where Gopalswamy et al.

2005 [13] in study on 23 Solar cycle they found that (78%) of the (m, DH, and km) type II bursts associated with SEP.

Table 1- The classes of type II events, their frequencies and distance from Sun.

Type II class	Range of frequency MHz	Distance from sun $R_\odot$
DH	0.3-14	2-10
Metric	15-150	1-2
Kilometric	0.3-0.003	> 10

The drivers of shocks associated with the metric (or coronal) type II radio bursts are still controversial: CME-driven shocks as in IP type II bursts (Cliver et al., 1999 [15]; Cho et al. 2011[16]) and flare blast waves (Vršnak et al., 1995 [17]; Magdalenić et al. 2008 [18]) or the two possibilities (Yashiro et al., 2014 [19]).

2. Instruments and data

There are many ground observatories over the word recorded the metric type II bursts. Commonly, type II bursts are relatively rare especially at longer wavelengths were only most energetic of CMEs drive shocks for into the IP medium. Solar type II bursts are slow drift bursts from high to low frequencies can reach it which indicate a shock moving through the solar corona [20], the rate of drifting is 0.3MHz/s [21] this feature determined the shock speed. In this research investigated the all m-type IIs for ground radio telescopes (which are contain of 10 stations) at the Solar Geomagnetec Data center (SGD) [https://www.ngdc.noaa.gov/stp/space-weather/solar-data/solar-features/solar-radio/radio-bursts/ reports/spectral-listings/] and the Space Weather Prediction Center (SWPC) [ftp://ftp.swpc.noaa.gov/] since 1996 (the SOHO era) until recent time (1996-2016), two solar cycles 23 and 24.

Table 2-The ground telescopes coordinates and frequency ranges.

Station	**Abr.**	**country**	**Location coordinate**	**Frequency range**
Sagamore Hill	**SGMR**	Massachusetts, USA	Longitude: 70.82 W Latitude: 42.63 N	25-75MHz
San Vito	**SVTO**	Italy	Longitude: 17.43 E Latitude: 40.40 N	25-75MHz
Potsdam	**POTS**	Tremsdorf, Germany	Longitude: 13.1 E Latitude: 52.4 N	40-800 MHz
Palehua	**PALE**	Hawaii, USA	Longitude: 158.06 W Latitude: 21.24 N	25-75MHz
Culgoora	**CULG**	Australia	Longitude: 149.6 E Latitude: 30.30 S	18MHz - 1.8GHz
Hiraiso	**HIRA**	Japan	Longitude: 140.6 E Latitude: 36.4 N	25-2500 MHz
Izmiran	**IZMI**	Moscow, Russia.	Longitude: 37.32 E Latitude: 55.47 N	25–270 MHz
Learmonth	**LEAR**	Northwest Cape, Australia	Longitude: 114.60 E Latitude: 22.12 S	25-75MHz
Holloman	**HOLL**	New Mexico, USA	Longitude: 106.9 W Latitude: 34.1 N	25-75 MHz
Bleien Observatory	**BLEN**	Switzerland	Longitude: 8.7 E Latitude: 47.4 N	0.1– 4 GHz
Gauribidanur Observatory	**GAUR**	Gauribidanur, India	Longitude:77.44° E Latitude:13.60° N	35-70 MHz
Green Bank Solar Radio Burst	**GBSRBS**	West Virginia, USA	Longitude: 79.83° W Latitude: 38.42° N	10–850 MHz

The data of CMEs collected from the two catalogues by Large Angle and Spectrometric Coronagraph (LASCO) [22] which is a three coronagraph package has been jointly developed for the Solar and Heliospheric Observatory (SOHO) mission. The first is Coordinated Data Analysis Workshop (CDAW) catalogue [http://cdaw.gsfc.nasa.gov/CME_list]. While the CDAW of CME catalogue is wholly manual in its operation, the SEEDS catalogue [http://spaceweather.gmu.edu/seeds/] is an automated CME detection algorithm for tracking an intensity thresholded CME front in running-dierence images from LASCO/C2 [23]. Finally the flare from Geostationary Operational Environment Satellite (GOES) can obtaine data from SWPC and SGD.

3. Data analysis

We analyses the data of the metric type II bursts over two solar cycles 23 and 24 from 1996 to 2016 then divided them in two groups. The first group was CMEs associated with metric type II bursts regardless their speed and angular width Table- 3, this group contains 1147 events. The second group was a type II bursts with flare without CMEs Table- 4, this group has 231 events.

Table 3-The example of CME and metric type II bursts association.

Date	FirstC2 app.of CME	liftoff of CME	SGMR	VTO	POTS	PALE	CULG	HIRA	IZMI	LEAR	HOLL	BLEN	GAUR	GBS RBS
22/08/1996	08:38:43	06:58 ±50	NR	07:59-08:13;14	07:58-08:10;12	NR	NR	07:59-08:07;08	07:58-08:09;11	07:59-08:10;11	NR	NR	NR	NR
07/10/1997	13:30:05	12:34 ±00	11:59-12:03;04	11:59-12:06;07	11:59-12:01;02	NR	NR	NR	11:56-12:02;06		NR	NR	NR	NR
27/11/1998	08:30:05	07:38 ±01	NR	07:32-07:51; 19	NR	NR	07:30-07:45; 15	NR	NR	07:32-07:57;25	NR	NR	NR	NR
5/9/2005	09:48:05	09:38 ±00	NR	NR	NR	19:37-19:45 ; 08	NR	19:39-19:51 ; 12	NR	NR	NR	NR	NR	19:35-19:55 ; 20

Note: NR for not recording of the event by the station.

Table 4- The example of metric type II bursts associated with flare.

Date	Obs.	start time	end time	intensity	start freq.	end freq.
09/11/1996	CULG	2325	2326	3	40	30
	CULG	2325	2326	2	90	60
	CULG	2325	2330	2	100	60
	LEAR	2325	2328	3	80	30
	LEAR	2325	2328	3	55	32
	CULG	2326	2328	1	40	30
09/11/1996	LEAR	2331	2334	1	61	38
11/11/1996	CULG	112	119	2	110	60
	LEAR	114	123	1	80	60
	HIRA	114.8	116.2	1	90	60

The huge total inspected metric type II 1378 bursts could be used to do statistical percentage to understand some space weather influenced by CMEs. Figure- 2 shows a histogram of the total metric type II as well as the two groups of events (i.e. with CMEs and flares). .

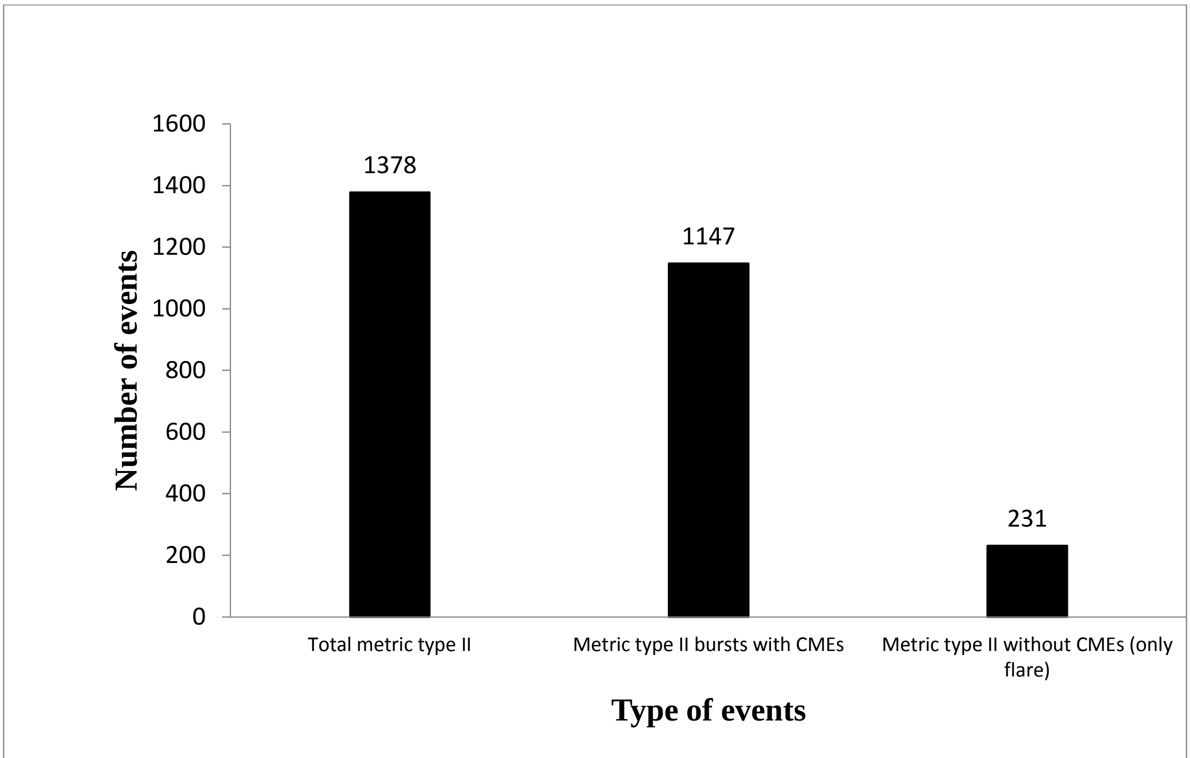

Figure 2- Number of metric type II bursts with CMEs and with flare.

The fractions of the metric type II events associated with CMEs and flares are 83% and 17% respectively. These results have been compared with the results of previous study [24] which found 81% despite it was for only six years.

4. Conclusions

The metric type II bursts with CMEs (regardless of its characteristics) are 83% (1147/1378) and about 17% (231/1378) associated with only flares. This result is comparable with that of a previous study in spite of relatively its short period (2000-2005) which found about 81% of metric type II bursts with CMEs. The similarity of the results of both studies despite of their different periods indicates that there are steady states of release and mechanism of eruption of Sun, therefore may they can build the prediction system to alarm the space weather influenced by CMEs.

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