Photometric Analysis of CME in the rising phase of solar cycle 24

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ABSTRACT

As world become more technologically advanced it become more important to study and forecast solar events which materialize by solar activity, the Sun goes through solar activity cycle, where every 11 year. In this investigation the highest position in the rising phase of solar cycle 24 had been studied by analyzing the photometric observations of coronal mass ejection (CME) for the year 2013 for the months 2,3,4,5 that were derived from Large Angle and Spectrometric Coronagraph Experiment (LASCO), which is one of the scientific systems in the spacecraft Solar and Heliospheric Observatory (SOHO), that was located close Lagrangian point L1. From all previous observations and from the intensity time profile of it, the onset time had been calculated and from it the injection time of CME had been measured in order to find the lift of time and the associated flares. And also from the intensity-time profile any clear raising from background give indication for solar event, thus, the roots of the eruption in the sun will be determined. It had been concluded that The important event for this year in March and May also the acceleration of the energetic particle not only in the interplanetary, but also in the location of the event in the corona of the Sun, and it had been found that the event increased gradually with adopted months (2, 3, 4, 5). Also it has been noticed that most of solar events have multi eruption phenomena.

Keywords : solar cycles; coronal mass ejection-solar activity: flares; SOHO-LASCO-ERNE: Data base.

التحليل الفوتومتري للمقذوفات الأكليلية للطور الصاعد للدورة الشمسية 24

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الملخص

من اولويات التقدم التكنلوجي العالمي هي دراسة وتنبؤ الأحداث الشمسية و المتمثلة بالنشاط الشمسي، ويكون هذا النشاط على شكل دورات شمسية لكل 11 سنة. في هذا البحث تمت دراسة اعلى نقطه للطور الصاعد للدورة الشمسية 24 وذلك عن طريق تحليل الأرصاد الفوتومترية للمقذوفات الأكليلية لسنة 2013 للأشهر (شباط ، آذار ، نيسان وأيار) والمأخوذة من منظومة لاسكوLASCO المحمولة على المختبر الفضائي سوهو SOHOوالمثبت في نقطة لاكرانج ألأولى L1 في الفضاء المحيط بالأرض . من الأرصادات المشار اليها ومن منحني الشده الزمني الذاتي للمقذوفات الأكليلية CME تم حساب وقت البداية وزمن الحقن لمنحنى الشده الزمني للمقذوفات الأكليلية لإيجاد زمن نمو المقذوفات الأكليلية والتوهجات المرافقة اليها. فمن خلال منحني الشده الزمني الذاتي وجد بان اي ارتفاع ملحوظ عن الخلفية الكونية هو عباره عن نشاط شمسي وهكذا فان جذور الانفجارات الشمسية ستحدد. وقد تم الاستنتاج بان الأحداث الشمسية في سنة 2013 هي في شهر (آذار وأيار) وكذلك وجد بان تعجيل الجسيمات الشمسية هي ليس فقط في فضاء ما بين الكواكب بل في موقع الحدث (الهالة الشمسية)، ووجد ايضا بان الأحداث تزداد تدريجيا مع ألأشهر المعتمدة في التحليل (5,4,3,2) وهذا يؤكد العلاقة بين المقذوفات الأكليلية الشمسية والصعود الحاصل في الدورة الشمسية. وقد لوحظ ان جميع الأحداث الشمسية هي ظواهر متعددة الانفجارات.

الكلمات الدالة: الدورات الشمسية؛ المقذوفات الأكليلية– النشاط الشمسي:التوهجات؛ سوهو، لاسكو– ايرنا: قاعدة البيانات.

1.INTRODUCTION

The Sun goes through what it call a solar activity cycle, where every 11 year it will go from a very low period of solar activity, meaning a Sun spot and solar wind to another period of law activity and in between it goes through what it call solar maximum. At solar maximum, sun has a very complicated magnetic field structure, and there for it creates a lot more sun spot and solar wind like flare and Coronal Mass Ejection, it is very important to be able to forecast and investigate solar events because they can affect our technology, satellite, they can power grids to be affected. Coronal Mass Ejections (CMEs) have been observed since the 1970s but in the last 15 years they have moved to the forefront of coronal research as evidenced by hundreds of publications [1]. This large amount of work is driven by the availability of continuous solar observations from the instrumentation aboard the SOHO mission [2] which is located in L1. The Large Angle and Spectroscopic Coronagraph (LASCO) suite [3], in particular, has revolutionized CME analysis with high cadence, high spatial resolution and high sensitivity observations of these events. Since the early phases of the mission, a concerted effort was initiated to generate a comprehensive event list based on visual inspection of the images and manual measurements of several CME properties such as speed, width, and position angle. The LASCO CME list grew to more than 21,000 events by mid-2013 and is the largest collection of CME properties readily available online. This resource has been used extensively to study various CME properties [4][5]. In 2008, the LASCO instruments reached another milestone. They provided the first ever CME database to cover a full solar cycle with a single instrument, thus opening investigations to the solar cycle dependence of CME properties[5] without having to worry about inter-instrument differences. Most of the previous analyses have focused on the properties of speed, width, rate of occurrence, acceleration and association with flares and other low coronal phenomena. In particular photometric observation had been analyzed for the rising phase of solar cycle 24 especially the year 2013 by using the photometric scale observation from LASCO in order to find speed of the coronals, its width, acceleration and the central position angle (CPA), however the intensity- time profile, energy and the shape of events obtained from energetic and relativistic nuclei electrons detector ERNE. LASCO and ERNE are scientific instruments boarded by SOHO [6]. The aim of this study is to determine the eruption on the Sun and find the injection time of CME in order to find the effective events (distinguish the event from background).And thus to realize the impact of these events on the solar cycle 24.

2.OBSERVATIONS AND DATA ANALYSIS

Coronal mass ejections (CMEs) represent an important source of solar variability from the point of view of plasma and magnetic field: CMEs remove billions of tons of magnetized plasma from the Sun and dump them into the Sun-Earth connected space once every other day during solar minimum and several times per day during solar maximum [5]. CMEs also provide dramatic variable energy input to the magnetosphere, in addition to and sometimes in combination with the high speed streams that originate from coronal holes. CMEs are the source of major disturbances in the interplanetary medium, and can be directly observed up to 32 solar radii (R⊙) from the Sun.

Coronal Mass Ejections (CMEs) are routinely identified in the images of the solar corona obtained by the Solar and Heliospheric Observatory (SOHO) mission's Large Angle and Spectrometric Coronagraph (LASCO) since 1996. The identified CMEs are measured and their basic attributes are cataloged in a data base known as the SOHO/LASCO CME Figure.(1).The catalog also contains digital data, movies, and plots for each CME so detailed scientific investigations can be performed on CMEs and related phenomena such as flares, radio bursts, solar energetic particle events, and geomagnetic storms.

The Large Angle and Spectrometric Coronagraph (LASCO) on board SOHO has unprecedented dynamic range and large field of view obtaining coronal images of very high quality [3].Although CMEs originate from closed magnetic field regions such as active regions, filament regions, or a combination. There are several groups involved in developing models of CMEs to understand CME initiation and interplanetary propagation with the ultimate aim of quantifying the CME impact on earth and hence on the society. Both empirical and physics-based models need real data to test with. CME observations were obtained by visual inspection of coronagraph images, and many of these "manual" catalogs of CMEs observed by LASCO C2 and C3 coronagraphs are now on-line [8] [9]. These catalogs have in recent times been augmented by additional on-line catalogs of CMEs detected by automatic methods.

The intensity-time profile of many events for the year 2013 had been investigated in order to find the injection time, speed, width, acceleration, the central position

angle CPA and lift of time. All these can be provided through the two ERNE detectors, High Energy Detector (HED) and Low Energy Detector (LED), the intensity-time Profile had been examined through two ways:

1- The linear profile provided by *http* : //*www:decent.fi/soho/index:php*.

2- The logarithmic profile provided by *http* : //*www.srl.utu.fi/erne_data/*.

In the linear fit the changes during high-intensity periods are more visible than in logarithmic view and thus it might be easier to see if the changes were due to local effect or they have a velocity dispersion and belong to an event on the Sun. Logarithmic scale is used by most researchers and gives the general view of the events [11].

SOHO LASCO CME CATALOG

YEAR	MONTH											
1996	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	Jan	Feb	Mar	Apr	May							

Figure.(1): The top page of the SOHO/LASCO CME Catalog. One row corresponds to all the months in the year. Months not underlined (no link) have no data [10].

The explosions associated with Solar Energetic Particles (SEPs) can give different ratios and energies of the species, which it can be seen in different kinds of

changes in the intensity-time profile. And from the intensity-time profile the onset time must be calculated in order to find the injection-time which represents the time needed to release particles from the Sun and give the acceleration time for the particles. As to the particle events, we determined the onset time for particles traveling at the Archimedean spiral length of 1.2 Astronomical Unit (AU), which is often used in the event onset studies [12]. It is possible to fit the release time of particles from the Sun to the path length travelled [11]. The deducing of the release time for the particles at the Sun using fixed path length of 1.2 AU and assuming that the particles suffered little scattering. This cannot be done without finding the ratio of velocity of particles to the velocity of light which is called relativistic velocity coefficient (β)[13].

$\beta = V/C$……………1

Where C is the speed of light.

$$\beta = \sqrt{1 - \left(\frac{938}{E+938}\right)^2}$$

Where E is the kinetic energy of the proton in the MeV, 938 MeV standard for proton rest mass energy was $E=mc^2$

But $V = S/t_f$ …………..2

Where t_f is the flight time of particles from the source to the detector

$t_f = S/\beta C$……………3

S is the fixed path length for the particles as 1.2 AU. Then injection time is calculated as [13]:

$t_{in} = (t_\circ - t_f) + 8$ min…………4

Where t_{in} is the injection time, t_o onset time, 8 min have been added to represent the time for the light to pass the distance from the Sun to Earth.

3.APPLICATIONS AND DISCUSSION

In this study the data for the year 2013 for the months February, March, April and May have been analyzed. For January the data was not clear for technical reason related to the space lab. ERNE. From the analysis of the data through the intensity-time profile as shown in Figures.(2,3,4,5,6,7) and by using the above equations, firstly the important events have been identified, secondly CPA, the speed and width of CME and the acceleration have been calculated .Table.(1) shows all these results. The roots of eruption in the Sun have been determined. All data were taken for resolution time of 10 Min from ERNE.
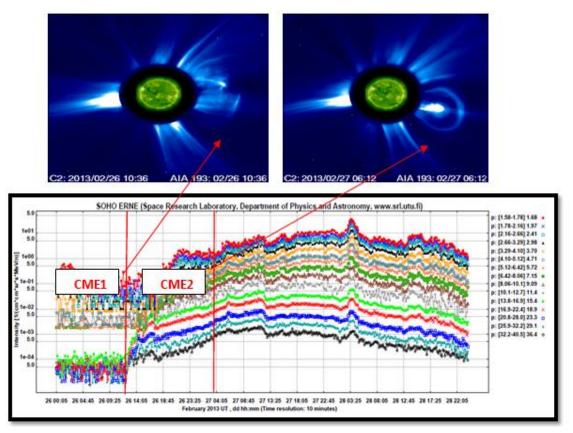

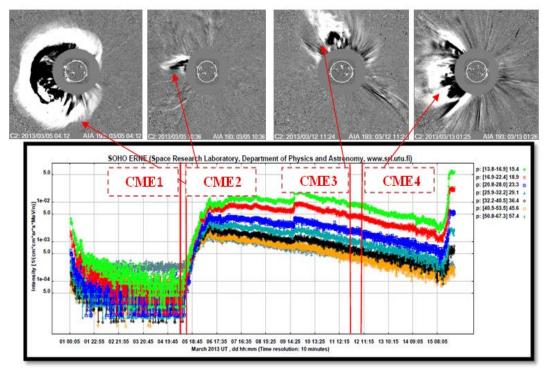**Figure.(2):** The intensity-time profile with important events for 26,27,28 February 2013

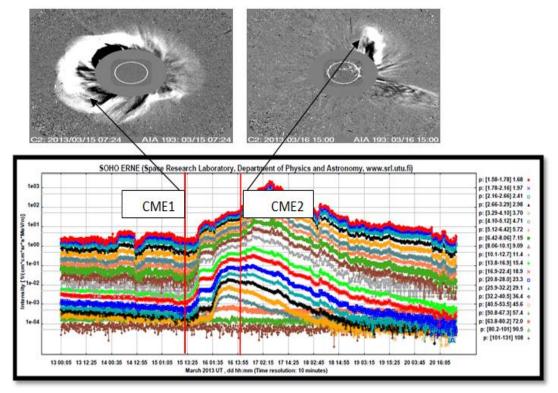**Figure.(3):** The intensity-time profile with important events for (1-5) March 2013

Figure.(4): The intensity-time profile with important events for (13-20) March 2013
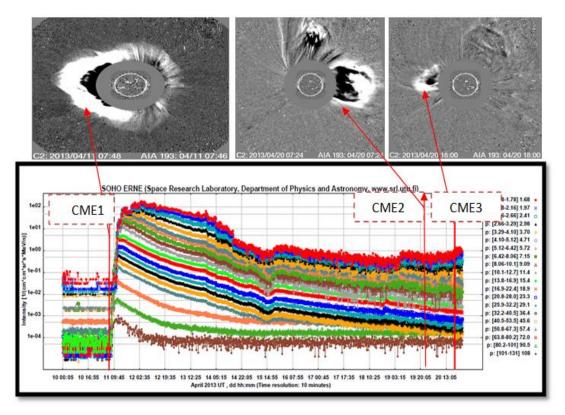
Figure.(5): The intensity-time profile with important events for (10-20) April 2013
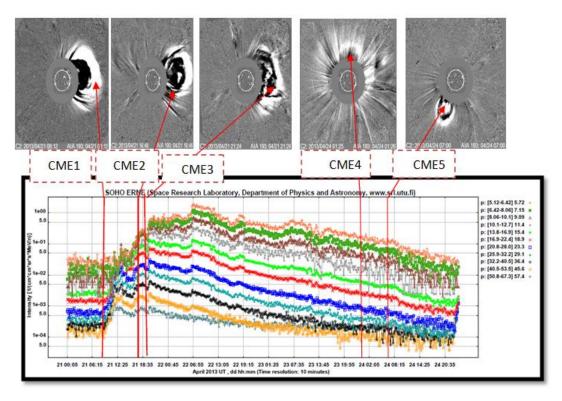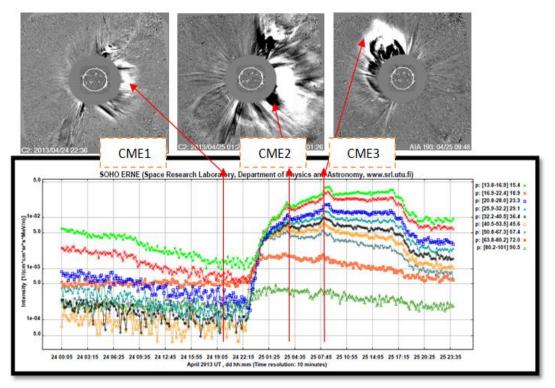

Figure.(6): The intensity-time profile with important events for (21-24) April 2013

Figure.(7): The intensity-time profile with important events for (24-25) April 2013
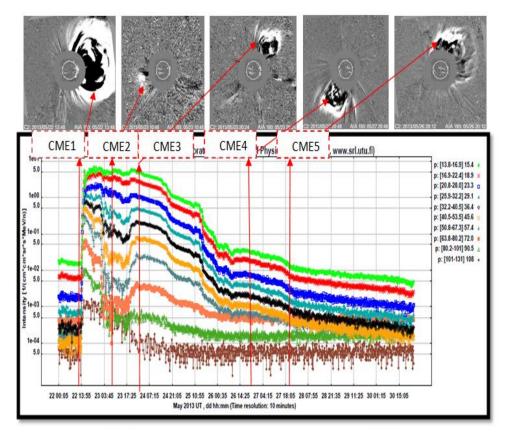

Figure.(8): The intensity-time profile with important events for (22-30) May 2013

From Figure.(2) for February it have been noticed that there are two effected events it means two coronal mass ejections, the first one at 9:13 UT in 26.2.2013 of halo CPA and the other one of 259 CPA at 4:0 UT in 27.2.2013, this give indication that the first one mask the second one. From Figures.(3)&(4) for March there are six significant events, couple of them of halo CPA, three of them of high speed and one of them with high acceleration. Figures.(5),(6)&(7) shows the presence of eleven effective events four of them of halo CPA, where two of them happen in the same time at 7:24 UT the first one in 11.4.2013 the other 21.4.2013.

Figure.(8) represents the events of May, there were five effective events one of them Of halo CPA with high speed approaches 1466 Km/sec and acceleration of -13.2 Km/sec^2 at 13:25 UT in 22,5,2013, so this is the strongest event through this analyzed period of the year 2013.

Table.(1): The characteristics of CME with the significant event

	Events		Characteristics of related CME			
N0.	D.M.YYYY	First obs. inC2[UT]	CPA Dig.	Width Dig.	speed [Km/s]	Acceleration Km/sec^2
1	26.2.2013	9:12	HALO	360	987	90.3
2	27.2.2013	4:00	259	138	622	19.0
3	5.3.2013	03:48	HALO	360	1316	5.1
4	5.3.2013	10:12	73	59	569	-46.5
5	12.3.2013	10:36	1	196	1024	-4.1
6	13.3.2013	00:24	116	>127	523	2.6
7	15.3.2013	07:12	HALO	360	1063	25.8
8	16.3.2013	14:48	323	147	786	-5.3
9	11.4.2013	07:24	HALO	360	861	-8.1
10	20.4.2013	06:00	283	153	741	17.3
11	20.4.2013	17:48	86	94	740	-20.2
12	21.4.2013	07:24	HALO	360	919	-4.2
13	21.4.2013	16:00	273	130	857	-5.0
14	21.4.2013	20:36	255	212	561	-8.3
15	24.4.2013	00:48	HALO	360	699	6.6
16	24.4.2013	06:12	157	84	596	-4.6
17	24.4.2013	22:12	HALO	360	594	-34.7
18	25.4.2013	00:36	232	161	826	-5.5
19	25.4.2013	08:48	70	209	743	0.3
20	22.5.2013	13:25	HALO	360	1466	-13.2
21	23.5.2013	10:24	121	84	640	-28.4
22	23.5.2013	19:12	325	64	515	-3.1
23	26.5.2013	19:12	293	256	549	-19.9
24	27.5.2013	19:24	164	126	528	1.9

4.CONCLUSINS

It have been concluded that the acceleration of the energetic particle not only in the interplanetary, but also in the location of the event in the corona of the Sun. We found that the event increased gradually with adopted months (2, 3, 4, 5) for the year 2013 and that's affects the rising phase of the solar cycle 24. Also it had been noticed that most of events have multi eruption phenomena.

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