FAST FLARELESS CORONAL MASS EJECTIONS

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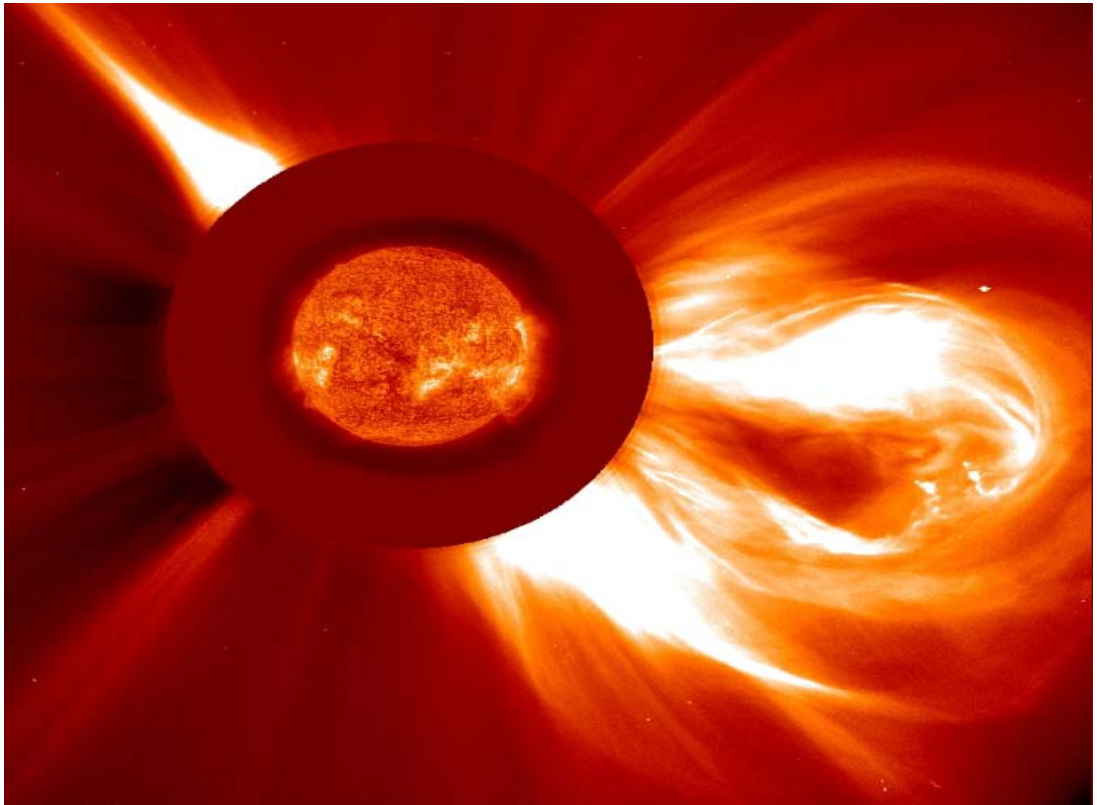
Objectives & Meaning

- **Coronal mass ejections (CMEs) are the most energetic eruptions in the solar system.**



Objectives & Meaning

- Previous studies have established that many CMEs are accompanied by flares, and some of the physical properties of CMEs and flares are closely related.

- 48% of CMEs were accompanied by X-ray flares(Harrison, 1995)
- the CME acceleration was also found to be related to the inferred reconnection electric fields (Qiu et al. 2004)

Objectives & Meaning

- There are also studies indicating that in some events CMEs and flares are only loosely connected.

- There exist CMEs without accompanying flares or only associated with hardly recognizable flares (Gosling et al. 1976; Sheeley et al. 1999)
- ~70% of C-level, 44% of M-level, and 10% of X-level flares are not associated with CMEs according to recent statistical studies (Yashiro et al. 2005; Wang & Zhang 2007).

Objectives & Meaning

- Two major processes have been proposed to convert coronal magnetic energy into the kinetic energy of a coronal mass ejection (CME):

- **resistive magnetic reconnection**
- **the global magnetohydrodynamic(MHD) flux-rope instability**

Objectives & Meaning

- Which energy release mechanism dominates in a specific event, and what is the relative contribution of each mechanism if both are important?

Objectives & Meaning

- In a recent numerical simulation of CMEs, Chen et al. (2007) modeled the flux-rope eruption within the framework of ideal MHD. It was found that CMEs as fast as 1000 km/s can be produced even in the absence of magnetic reconnections.

- Studied energetic but flareless CMEs, i.e., fast CMEs not accompanied by any flares

Data & Analysis

- The events of this study were selected through the online Coordinated Data Analysis Workshops (CDAW) database for CMEs observed by the LASCO on board the *SOHO in Solar Cycle 23*.
- front-side flareless CMEs (EIT)
- linear speed greater than 1000 km/s
- an angular width larger than 20◦

Data & Analysis

Table 1
Parameters of the 13 CMEs and Associated Filaments (See the Text for Details)

Event No./ Group	CME							Filament	
	First C2 Appearance Time/CME Start Time (UT)	CPA (°)	Ang. Wid. (°)	Velocity (km s^{-1})	Acce. (m s^{-2})	Mass (g)	Ek (erg)	Center Pos. (°)	Ang. Length (°)
01/B	1998 Jan 3 09:42/09:24	290	85	1020	21.8	2.8e15	1.4e31	N42W70	38
02/B	1998 Jun 5 07:02/06:30	205	132	1017	28.3	...	...	S36W7	23
03/B	1999 Sep 16 16:54/16:42	6	147	1021	49.3	...	...	N36W17	46
04/B	1999 Sep 23 15:54/15:36	262	77	1150	−5.8	3.4e15	2.2e31	S23W41	22
05/B	2000 Jul 24 16:54/16:29	220	50	1246	−48.7	3.2e15	2.4e31	S32W80	16
06/B	2002 Mar 2 15:06/15:00	124	149	1131	5.4	...	...	S28E74	48
07/A	2002 May 11 20:06/19:47	19	52	1003	5.4	1.1e15	5.5e30	N41E24	13
08/A	2002 Jul 13 11:30/10:55	147	40	1037	−21.6	1.5e16	5.2e31	S31E28	18
09/A	2002 Aug 6 18:25/17:35	218	134	1098	−0.5	...	...	S36W25	46
10/A	2002 Dec 21 02:30/02:04	2	225	1072	−3.0	...	...	N40E9	24
11/B	2002 Dec 26 18:30/18:07	80	24	1075	5.7	3.3e15	1.9e31	N14E73	7
12/A	2003 Jan 5 10:37/09:52	353	67	1183	14.2	1.3e15	9.2e30	N39E17	17
13/B	2005 Jan 4 09:30/09:14	288	102	1087	9.5	6.9e15	4.1e31	N8W58	31

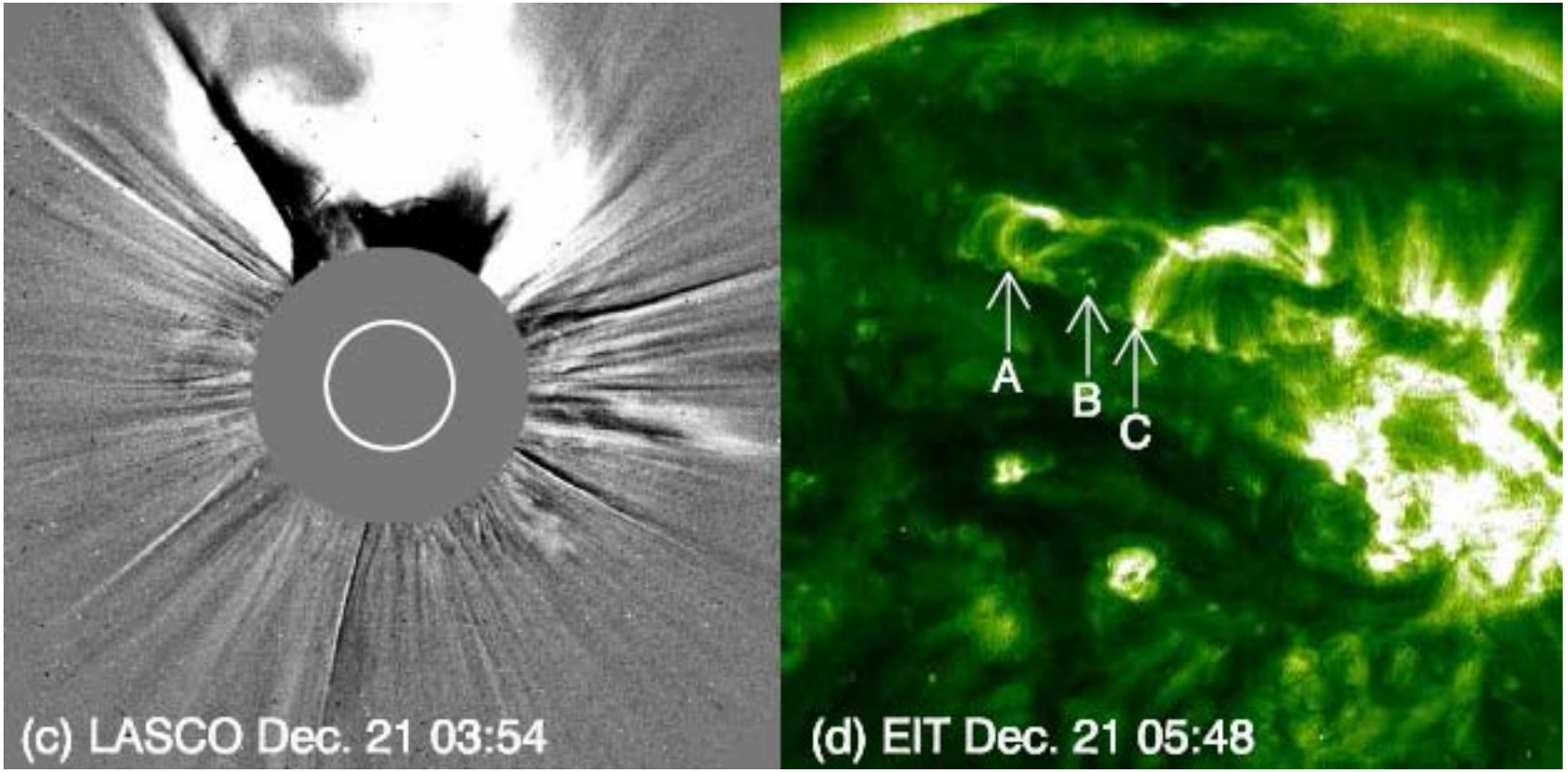
Data & Analysis

Table 2
Information of the 23 Flares Numbered in Figures 1 and 2

Flare No./Event No. /Group	Start Time (UT)	Peak Time (UT)	Stop Time (UT)	Class	Position (NOAA)
01/01/B	1998 Jan 3 12:12	12:20	12:26	C3.3	No Source Info.[a]
02/02/B	1998 Jun 5 04:39	04:45	04:51	C1.4	S26E43 (08232)[b]
03/02/B	1998 Jun 5 06:43	06:48	06:54	B9.0	S25E45 (08232)
04/05/B	2000 Jul 24 15:55	16:00	16:21	C2.8	S31E45 (09100)
05/06/B	2002 Mar 2 12:55	12:59	13:03	C1.1	No Source Info.[b]
06/07/A	2002 May 11 16:45	16:50	16:54	C2.7	S06E48 (09946)[b]
07/07/A	2002 May 11 17:32	17:38	17:41	C3.7	S17W58 (09934)[b]
08/07/A	2002 May 11 18:32	18:36	18:37	B9.7	S15W57 (09934)[b]
09/07/A	2002 May 11 21:46	21:50	21:53	C1.5	No Source Info.[a]
10/08/A	2002 Jul 13 08:12	08:15	08:18	C2.2	N17E35 (10030)[b]
11/09/A	2002 Aug 6 15:16	15:27	15:52	C7.6	S06W66 (10057)[b]
12/09/A	2002 Aug 6 20:05	20:09	20:11	C1.3	No Source Info.[a]
13/10/A	2002 Dec 20 23:17	23:21	23:24	C2.0	S25W37 (10226)[b]
14/10/A	2002 Dec 20 23:58	00:02	00:08	C1.7	S28W38 (10226)[b]
15/10/A	2002 Dec 21 02:46	02:52	02:57	C2.4	S27W45 (10226)
16/10/A	2002 Dec 21 03:39	03:49	03:56	C2.9	N19W19 (10229)[a]
17/10/A	2002 Dec 21 04:38	04:41	04:45	C2.2	No Source Info.[a]
18/10/A	2002 Dec 21 04:48	04:53	04:57	C4.6	S25W41 (10226)[a]
19/12/A	2003 Jan 5 07:54	07:58	08:02	C1.0	S08E27 (10242)[b]
20/12/A	2003 Jan 5 09:24	09:28	09:32	B9.2	S19W55 (10243)
21/12/A	2003 Jan 5 11:51	11:54	11:58	C1.3	No Source Info.[a]
22/13/B	2005 Jan 4 05:59	06:16	06:30	C3.3	N05W07 (10715)[b]
23/13/B	2005 Jan 4 10:53	11:13	11:29	C7.3	N05W11 (10715)[a]

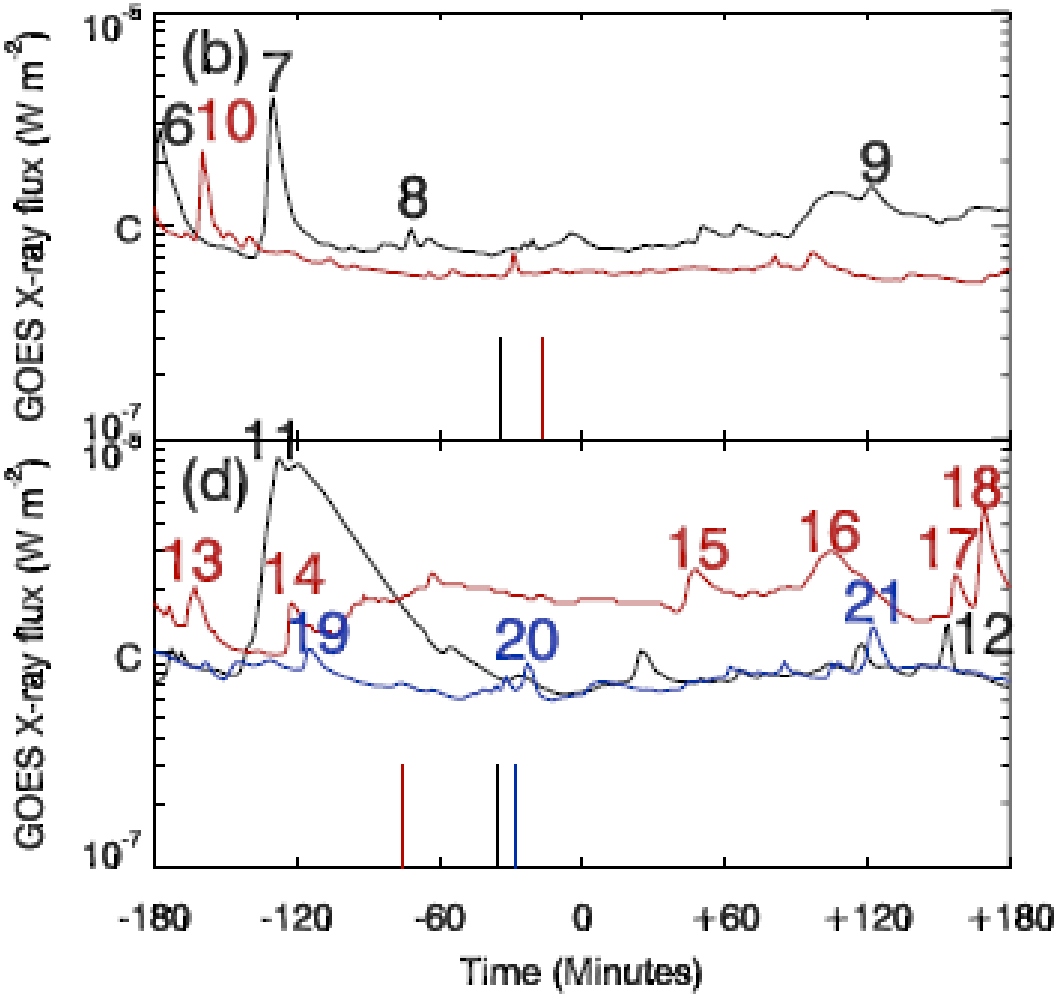
Notes.
[a] Flares started 1 hr after the CME appearance time in LASCO C2.
[b] Flares ended before the apparent rise of the associated filament.

Data & Analysis



Observations of the 2002 December 21 event (Event 10)

Data & Analysis



microwave bursts between event 7& 8; event9 10 12

None of these events are associated with significant microwave enhancements, say, reaching a level greater than

100 W m−2 Hz−1.

Data & Analysis

- (1) are front-side, flareless, fast, and relatively wide events;
- (2) are accompanied by post-eruption EUV loops, yet no considerable enhancements in X-ray, EUV, and microwave data;
- (3)originated from quiet-Sun regions related to extended magnetic structures of weak fields;
- (4) are associated with well developed filament eruptions.

Conclusions

- **During the eruption, we observed post-eruption ribbons and loops, in accordance with the standard flare picture, indicating the presence of magnetic reconnections in these events.**

Conclusions

- (1)The reconnection electric fields, as inferred from the product of the separation speed of post-eruption ribbons and the photospheric magnetic field measurement, were generally weak;

- (2) the period with a measurable reconnection electric field is considerably shorter than the total filament–CME acceleration time.

Conclusions

- These observational features strongly indicate that magnetic reconnections played only a minor role in accelerating the CMEs out of the corona.
- The fast events with strong flares usually originate from solar active regions, while all of our events are from EBRs with relatively weak fields in the quiet-Sun region. This difference of magnetic sources may be one important cause of the different characteristics of the above two types of fast CMEs.

Conclusions

- **We suggest that magnetic reconnection plays a less important role in accelerating CMEs in quiet-Sun regions of weak magnetic field than those in active regions of strong magnetic field.**

Thanks!