Coronal and Stellar Mass Ejections
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Coronal Mass Ejections and the Largest Solar Energetic Particle Events

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Abstract. We studied the association between SEP events during 1977-2003 and related CMEs and found each GLE event was associated with a primary CME, which was faster (average speed ∼1762 $km \cdot s^{-1}$) and wider (average angle width of 317^0) than an average CME . All SEP-related CMEs distributed within solar source regions of latitude strip of S30^0-N40^0, while 11 (85%)GLE-related CMEs originated from the western hemisphere. These fast halo CMEs (75% full-halo and 25% partial-halo) were associated with type II radio bursts in the decameter hectometer (DH) wavelengths.

Keywords. Sun: coronal mass ejections (CMEs), particle emission, radio radiation

1. Observation

Large solar energetic particles (SEPs) are thought to be accelerated by CMEs-driven shocks (see, e.g., Reames, 1999; Kahler, 2001). Nevertheless, It is still not known what makes a CME an SEP accelerator, especially for those largest SEPs or GLEs. In this paper we study the CMEs associated with SEP events which are divided three classes, the 13 GLE, 30 moderate SEP(10-100 pfu,E>10 MeV) and 62 minor SEP (1-10 pfu, E>10 MeV) during 1997-2003. Using Data are from SOHO/LASCO, SGD, EIT, SXT and GOES, we identified related CMEs and flares and collected their measured properties. CMEs and flares correlated with 13 GLEs were listed in table 1. The columns from left to right represent GLE date, peak flux time of x-ray flare, optical flare class, peak flux of SEPs with energies above 10 MeV, onset time, angular width (AW) and velocity of CME, heliocentric coordinates of solar source, NOAA active region number. Whether associated or not a decameter hectometer (DH) type II burst ("y" for yes and "n" for no). Solar surface source region distribution was plotted in figure 1 and the speed distribution of three classes of CMEs was plotted in figure 2.

2. Results

Main results of this study are: (1) Each GLE event corresponds a fast halo CME, including 9 (75%) full-halo CMEs and 3 (25%) partial-halo CMEs. (2) 9 GLEs (69%) originated from the southern hemisphere and 11 GLEs (85%) originated from the western hemisphere. Latitude of the solar source region is within a strip of S30^0-N40^0. Longitude of GLE-CMEs is west of E10^0 with the most probable longitude of between W60^0 and W70^0. (3) The CME average speeds are ∼ 1762 km $\cdot s^{-1}$, ∼ 1077 km $\cdot s^{-1}$ and ∼ 887 km $\cdot s^{-1}$ respectively for the GLE-CMEs, the moderate SEP-CMEs and the minor SEP-CMEs. There are 11 (92%) GLE-CMEs whose speed exceeding 1000 km $\cdot s^{-1}$. (4) Of the 13 GLE related flares, 11 (85%) were class x level. SEP fluxes exceeded several hundreds

Table 1. Properties of CMEs and flares correlated with 13 GLEs

GLE date	X time (UT)	Bright	flux (pfu*)	Time (UT)	AW (deg.)	V (km$\cdot s^{-1}$)	Location	AR	II
1997.11.06	11:55	X9/2B	490	12:10	h	1556	S18W63	8100	y
1998.05.02	13:42	X1/3B	150	14:06	h	938	S15W15	8210	y
1998.05.06	8:9	X2/1N	210	8:29	190	1099	S11W65	8210	y
1998.08.24	22:12	X1/3B	670	-	-	-	N35E09	8307	y
2000.07.14	10:24	X5.7/3B	24000	10:54	h	1647	N22W07	9077	y
2001.04.15	13:50	X14/2B	951	14:06	167	1199	S20W85	9415	y
2001.04.18	2:14	C2/2B	321	2:30	h	2465	S20Wlimb	9415	y
2001.11.04	16:20	X1/3B	31700	16:35	h	1810	N06W18	9684	y
2001.12.26	5:40	M7/1B	779	5:30	212	1446	N08W54	9742	y
2002.08.24	1:12	X3/1F	317	1:27	h	1878	S02W81	10069	y
2003.10.28	11:10	X17/4B	29500	11:30	h	2459	S16E08	10486	y
2003.10.29	20:49	X10/2B	3300	20:54	h	2029	S15W02	10486	y
2003.11.02	17:25	X8.3/2B	1570	17:30	h	2598	S14W56	1o486	y

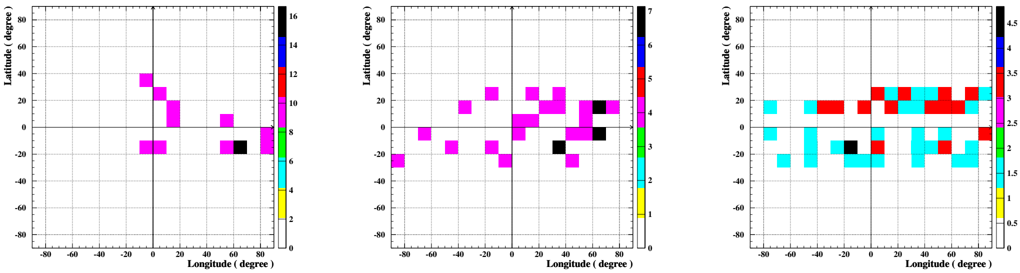

Figure 1. Distribution of heliocentric coordinates of solar surface source region of CMEs. left panel for GLE-CMEs, middle panel for moderate SEP-CMEs and right panel for minor SEP-CMEs. The numbers on the right color bar indicate appearance probability. Black represents the most probable region.

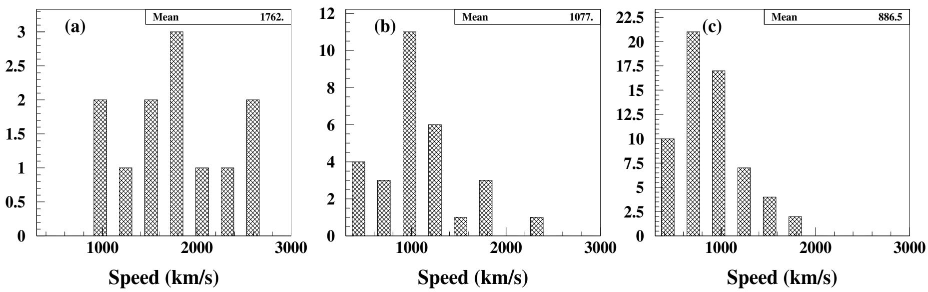

Figure 2. Distribution of CME speed. left panel for GLE-CMEs, middle panel for moderate SEP-CMEs and right panel for minor SEP-CMEs.

pfu and the highest intensity was 31,700 pfu. (5) All GLE-CMEs were associated with DH type II bursts.

Acknowledgements

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References

Reams, D.V. 1999, *Space Sci. Rev.*, 90, 413.
Kahler, S.W. 2001, *J. Geophys. Res.*, 106, 20947.

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