Statistical Study of Filament Eruptions and Moreton Waves Observed by the Flare Monitoring Telescope at Hida Observatory, Kyoto University

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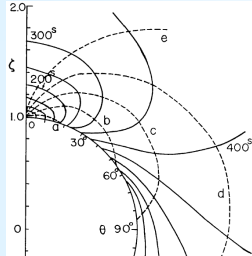
INTRODUCTION

What is Moreton wave?
• Flare related wave-like phenomena in Hα
• V ~1000km/s, limited opening angle
• Interface between MHD fast mode shock (traveling in the corona) and the chromosphere (Uchida model)
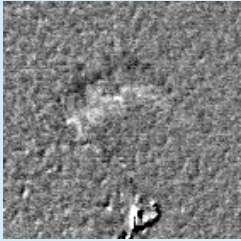
Moreton wave with flare in November 4, 1997

Uchida Model

Conditions of Moreton Wave
• Moreton waves are rare!
  – tend to be associated with large flares
  – always associated with filament eruptions
  (the direction of a Moreton waves is the same as that of the associated filament eruption)

[idea]
• Fast mode shock that generated Moreton waevs are "piston-drive"?
• The shock front must be horizontal to intersect with the chromosphere (and to generate a Moreton wave) ?
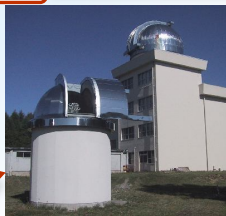
motivation
To confirm the idea, we investigated elevation angles of filament eruptions statistically observed with Hida/FMT

OBSERVATION

Instrument
• Flare Monitoring Telescope(FMT)
  – five refractors diameter 64mm
  – focal length 1920mm
  – wavelength
    Hα center
    +0.8A
    -0.8A
    continuum
    Hα for limb prominence

FMT

1992~2006, 2010 move to Peru

DATA

Table 3.1: Event list of Moreton waves observed with the FMT.

date	peak time	position	NOAA AR	class	Moreton wave and/or winking filament[a]
1997/11/03	04:38	S20 W13	8100	C8.6	MW
1997/11/04	06:02	S14 W33	8100	X2.1	MW & WF
1998/08/08	03:17	N17 E74	8299	M3.0	MW
1999/02/16	03:12	S23 W14	8458	M3.2	MW & WF
2000/03/03	02:14	S15 W60	8882	M3.8	MW
2000/06/04	22:10	N21 E37	9026	M3.2	WF
2000/06/15	23:43	N19 E19	9040	M2.0	MW
2000/07/16	06:14	S08 W25	9082	C3.8	MW
2001/04/10	05:26	S23 W09	9415	X2.3	WF
2001/05/12	23:35	S17 E00	9455	M3.0	MW
2001/05/13	03:04	S18 W01	9455	M3.6	MW
2001/05/13	03:09	S15 W13	9455	C1.1	WF
2001/05/21	03:20	N22 E08	9461	C9.0	WF
2001/12/19	02:32	N09 E37	9742	C4.9	MW
2002/07/18	07:44	N19 W30	0030	X1.8	WF
2002/08/22	01:57	S07 W62	0069	M5.4	MW
2002/10/04	22:43	N13 E43	0139	M2.7	MW
2003/05/27	23:07	S07 W17	0365	X1.3	MW
2004/11/03	03:35	N09 E45	0696	M1.6	MW
2005/08/03	05:06	S13 E45	0794	M3.4	MW

We analysis 14 events from all 20 events
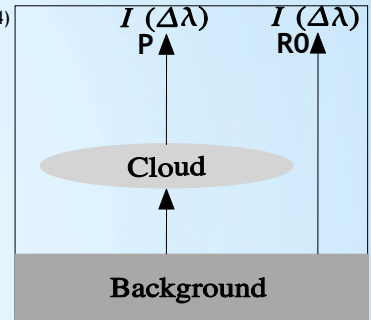(There are 374 X & M class flare in cycle 23(1996-2008))

ANALYSIS

Analysis Method
• Beckers' Cloud Model (Beckers 1964)
• Contrast function C (x, Δλ)

$$C(x, \Delta\lambda) = \frac{I_P(x, \Delta\lambda) - I_{R0}(\Delta\lambda)}{I_{R0}(\Delta\lambda)}$$

I_p : Cloud intensity
I_{R0}: Background intensity

From the contrast function, physical parameters of erupting filaments such as source function and doppler shift are determined

Obtained parameter
• the velocity perpendicular to line of sight
• the velocity along line of sight
  →absolute velocity of filament eruption
  →inclinations angle to the normal direction
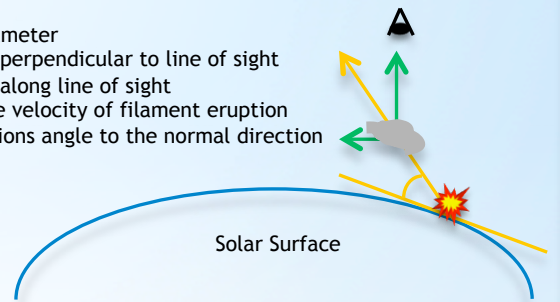
RESULT

Date	Peak time	Position	NOAA AR	Class	Moreton wave and/or winking filament[a]	Elevation angle	Absolute Speed	Doppler Velocity	Transversal Velocity
1997/11/3	4:38	S20 W13	8100	C8.6	MW	-14	170	27	170
1997/11/4	5:58	S14 W33	8100	X2.1	MW & WF	11	200	19	200
1998/8/8	3:17	N17 E74	8299	M3.0	MW	9	50	26	50
1999/2/16	3:12	S23 W14	8458	M3.2	MW & WF	45	100	28	100
2000/3/3	2:14	S15 W60	8882	M3.8	MW	43	140	26	130
2000/6/15	23:43	N19 E19	9040	M2.0	MW	-6	160	25	150
2000/7/16	6:14	S08 W25	9082	C3.8	MW	30	110	8	110
2001/5/12	23:35	S17 E00	9455	M3.0	MW	20	160	6	160
2001/5/13	3:04	S18 W01	9455	M3.6	MW	53	30	17	20
2001/12/19	2:32	N09 E37	9742	C4.9	MW	8	170	26	170
2002/8/22	1:57	S07 W62	69	M5.4	MW	11	150	24	150
2002/10/4	22:43	N13 E43	139	M2.7	MW	-37	170	7	170
2003/5/27	23:07	S07 W17	365	X1.3	MW	25	60	19	60
2005/8/3	5:06	S13 E45	794	M3.4	MW	4	130	22	130

length : absolute velocity
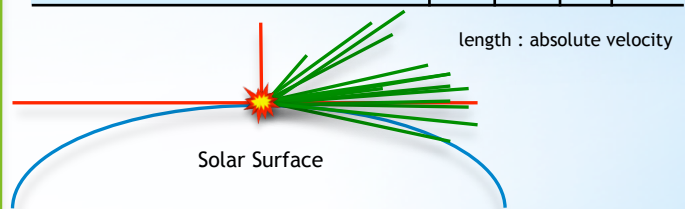
DISCUSSION and SUMMARY

• The average value of absolute velocity summary
  ～130km/s(30-200km/s)
• The direction of eruption is almost horizontal
  (0～30°)
→This is follow the idea horizontal filament eruption drives Moreton wave
• We researched filament eruptions associated with Moreton wave and as the result, filament eruptions tend to be horizontal
• Now, We are studying the filament eruptions not associated with Moreton wave to compare