CORRESPONDENCE OF COLD MASS MOTION AND RADIO SIGNATURES IN THE EVENTS OF 9 MARCH 1979 AND 9 JULY 1982

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ABSTRACT. A study of characteristic stages of flare development in H_α and radio was made for two complex limb events. By means of coronograph observations (Wroclaw) and radio observations (Tremsdorf) general conclusions were drawn on the temporal correspondence of signatures of optically visible mass ejections and radiation from hot flare matter. Three major stages characterizing associated H and radio features of complex flare events have been defined. Spray and bright flare loops appear to form two most prominent possible signatures of main phase "explosive" radio burst phenomena. Interactions with prominences seem to be a characteristic of complex flare events. Finally a remarkable association between characteristic stages of post flare loop development and dm-burst activity ha been detected.

ВЗАИМОСВЯЗЬ ВЫБРОСОВ В H_α И РАДИОИЗЛУЧЕНИЯ В РАЗВИТИИ СОБЫТИЙ 9-ОГО МАРТА 1979 И 9-ОГО ИЮЛЯ 1982: Приведены результаты изучения характерных стадий развития двух сложных лимбовых событий в H и радиодиапазоне. Анализ лимбовых фильтрограмм в H (Вроцлав) и радиоизлучения (Тремсдорф) приводит к общему заключению о взаимосвязи между движением выбросов в H и излучением горячей вспышечной плазмы. Определены три основные стадии, характеризующие взаимосвязь явлений в H и радиодиапазоне дья сложных вспышечных событий. Выбросы и яркие вспышечные петли по-видимому являются двумя доминирующими явлениями в главной фазе "взрывных" радиовсплесков. Взаимодействие с протуберанцами оказывается характерным для сложных вспышечных процессов. Наконец, обнарушена связь характерных стадий развития послевспышечных петель с дециметровыми всплесками.

SÚVIS H-ALFA EJEKCIÍ A RÁDIOVÉHO ŽIARENIA POČAS VÝVOJA DVOCH OKRAJOVÝCH ERUPCIÍ: 9. MÁJA 1979 A 9. JÚLA 1982. Uvedené sú výsledky štúdia charakteristických stupňov vývoja dvoch zložitých okrajových erupcií v rádiovom žiarení a v H-alfa. Analýza filtergramov v H-alfa (Wroclaw) a rádiového žiarenia (Tremsdorf) viedla k všeobecnému poznatku o časovej zhode prejavov opticky viditeľných ejekcií hmoty a žiarenia z horúcej látky erupcie. Boli definované tri hlavné stupne, chakterizujúce vzájomný súvis H-alfa a rádiových prejavov. Protuberancie typu sprej a jasné erupčné slučky sú najvýznamnejšie znaky hlavnej fázy "explozívneho" rádiového pulzu. Pre zložité erupcie je výskyt aktívnych protuberancií charakteristický. Zistený bol súvis medzi vývojom poerupčných slučiek a emisiou na dm-vlnách.

1. INTRODUCTION

In recent years the complex study of the dynamical processes displayed by optical (coronographic) and radio/X-ray observations found a renewed interest by the exploration of solar flare processes and coronal mass ejections (DULK, 1980; STEWART et. al., 1982; Wagner 1984). In particular flare sprays and eruptive prominences were recognized to be similar in nature and directly related to coronal mass ejections (CME) (Rust et al., 1980). A large part of CME's ($\geq$30 %) appeared not to be associated with H_α flare events.

On the other hand, almost all major flares are accompanied by sprays and the major spray events exhibit radio responses in type IV and/or type II radio bursts. Up to now one open point is the question of an exact timing of these phenomena occurring in different spectral regions which provides a key for the understanding of the physics of the sequence of the underlying flare processes.

It is the aim of the present contribution to study the characteristic stages of the flare development in H_α and in radio (cm-dm-m-Dm ranges) simultaneously for the two compex limb events of 9 March 1979 an 9 July 1982. A detailed comparison of both events and of the different wavelength regions will allow general conclusions on the temporal correspondence of signatures of the occurrence of hot flare matter and cool mass ejections.

2. OBSERVATIONS

The optical observations were made by means of the coronograph of the Astronomical Observatory of the Wroclaw University. The coronograph is designed in particular for observations of active prominences and is equipped with H_α birefringent filter of 8 Å bandpass wich can be shifted in the range $\pm$5 Å from the theoretical line center choosing the best contrast of the H_α-picture.

The radio observations have been taken from the single frequency patrol program of the Observatory for Solar Astronomy at Tremsdorf near Potsdam cove-

Table 1

Characteristic flare stages and signatures of H_α and radio emission

Stage	H_α signatures, mass motions	Radiosignatures	Onset time (UT) in the events of 9 March 1979	9 July 1982 UT
Preflare stage	brightening (expansion) flare loops - and/or rise of prominences	preburst increase, (μ) begin of gradual burst	10.05	07.00
Main flare phase	sometimes bulge of flare loops; formation of sprays or "loop eruptions"	a/ impulsive burst onset (μ, III)	10.17	
		b/ explosive burst onset (IVμ, mA_1)	10.21	07.34.10; 08,17
Subsequent coronal activity	invisible	IV m A_2, B; II	10.27	07.43.30; 08.47
Intermitting	further strays and spray blobs, surges, quiet prominence activation	complex μ, III, II, IV-burst activity	10.30	08.47
			10.48	08.33
Post flare activity	formation and rise of post flare loops outflow of H knots	dm-activity	10.40	between 08.33 and 09.22
			11.57	

ring the whole cm-dm-m-Dm-range at ten widely spaced wavelengths with a time resolution <10 sec. Additional information on spectral features (e.g. drift bursts) were obtained from records of the IZMIRAN- and Weissenau- radio spectrographs (Courtesy Drs. V.V. Fomichev and H. Urbarz).

A summary of the most important stages and related phenomena displayed by the optical and radio observations is compiled in Table 1.

3. DISCUSSION

It is shown in Table 1 that, apart from various types of coronal activity which is invisible in H and a series of intermitting processes differing for each particular event, three stages can be defined which characterize large flare events, viz. (1) the preflare stage, (2) the main flare phase, and (3) the post flare activity. The preflare stage is characterized by a gradual preburst increase at microwaves associated with the start of the brightening or expansion (rise) of flare loops and/or prominences (flare loops and active region prominences are often difficul to discriminate at solar limb observations !) Next follows the main flare phase (cf. Priest, 1982) which sometimes allows to distinguish an impulsive burst onset from an explosive one. The label "impulsive" phase here means "not too long" duration (<5 - 10 min), "not to high" particle energy (<10 ... 30 keV), and "not too steep" onset (rise time ~1 ... 3 min) in contrast to the "explosive" phase (cf. Křivský et al., 1976). The event of 9 March 1979 shows that both the preflare stage and the impulsive phase, may correspond to the appearance of closed loop phenomena. An "explosive" burst onset, however, may be related to processes leading either to disruptions of prominences which is especially indicated by the ocurrence of sprays (9 March 1979) or to the appearance of bright flare loop eruption (9 July 1982). A peculiarity of the latter event is the relatively short duration of its main phase.

Active region prominences seem to play an important role for the generation of large flares which can be understood in the frame of an extended Svestka- or Kaastra-model (Svestka et al., 1982; Kaastra, 1985). It can be learned from optical limb observations that often there is a contribution of activity due to an interaction from more or less distant parts of the Sun, e.g. neighbouring prominences, active regions, or parts of them. During periods of high activity the flare events are typically influenced or triggered by an overlapping in time with former or newly excited flare activity. For such a behaviour the flare of 9 July 1982 is a good example.

Finally, the considered events allow to detect a remarkable association between dm-burst activity and a peculiar phase of post flare loop formation, as already mentioned in the context of another event by Karlicky et al. (1985). More detailed analyses of the presented events will be published elsewhere.

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