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Observations of Solar Hα Filament Disappearances with a New Solar Flare-Monitoring-Telescope at Hida Observatory

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The outine of a new solar Flare-Monitoring-Telescope is given, which was built at the Hida Observatory of Faculty of Science, Kyoto University, in the first financial year of the Japan's STEP project. The telescope is unique among currently-operating solar flare-patrol-telescopes, because it can simultaneously observe five solar images, which are four full disc images in Hα center, Hα + 0.8 Å, Hα − 0.8 Å and continuum, and one solar limb image in Hα center. After its start of operation it was confirmed that this telescope system is very useful to study the dynamical features of Hα filament disappearance, because it can, for the first time, continuously record the full solar disc simultaneously in three wavelengths of the Hα line. Two typical examples of Hα filament disappearance observed with the telescope are demonstrated and are comparatively studied. It is found that the more dynamical and more energetic Hα filament eruption causes the larger enhancement of soft X-ray bright arcade structure observed with the Soft X-ray Telscope of Yohkoh.

1. Introduction

We have been studying the energy build-up and release processes of solar flares and eruptive prominences (Kurokawa *et al.*, 1987; Kurokawa, 1989) by using the 60 cm Domeless Solar Telescope (Nakai and Hattori, 1985) at the Hida Observatory of Kyoto University. This subject is important not only in the study of solar physics itself, but also for the study of the solar-terrestrial energy transport, because solar flares and eruptive prominences are considered as the sources of interplanetary and geomagnetic storms (Wright and McNamara, 1983). In order to make further progress in this study during the STEP period, we constructed a new Flare-Monitoring Telescope (FMT). The FMT supplies four full solar disc images in four different wavelengths and one solar limb image with an occulted solar disk.

After its operation, it was confirmed that the FMT system is very effective to record and to study the dynamical features of various types of prominence activities as well as flares. Many limb events, which provide us with detailed information of the vertical structures of prominence disruptions, sprays, surges and post-flare-loops, were observed with the FMT. The prominence eruption of 31 July, 1992 was one of the largest events on the limb. The detailed analysis of this event was done by comparing the FMT Hα, Nobeyama 17 GHz, and Yohkoh soft X-ray images by Hanaoka *et al.* (1994).

The Hα − 0.8 Å and Hα + 0.8 Å images are especially useful for detecting the motions of activating prominences on the solar disc. They enable us to discriminate the dynamical disappearance from the thermal one of Hα filaments, and to examine whether the disappearing filament has been ejected into the interplanetary space or not. This examination is crucially important to study the causal relation between the filament disappearance and geomagnetic disturbances.

In this paper, we give the outline of the new FMT system, and present two typical examples of Hα filament disappearances observed with the system. We also compared their images with soft X-ray bright structures observed with the Soft X-ray Telescope aboard Yohkoh.

2. Outline of the Flare-Monitoring-Telescope

The Flare-Monitoring-Telescope (FMT) consists of six small telescopes, namely, four full-disk-telescopes, one prominence-telescope and one photoelectric-guiding-telescope. They are assembled in a large common fork arm which is driven with a telescope control unit. The objective lens of each telescope is 64 mm in diameter. The overall structure and outlook of the telescope and the dome are shown in Figs. 1 (a) and (b). The FMT was constructed by Nishimura Factory.

2.1 Full-disk telescopes

Four full-disk-telescopes observe full solar images in four different wavelengths. They have the same lens system but different optical filters transmitting different wavelengths. Each telescope has a front filter, an objective lens, a neutral density filter, a telecentric lens system, a monochromatic filter, a minifying lens system and a CCD camera. The alignment of these optical parts in a telescope is shown in Fig. 2. Fabry-Perot filters of DayStar Company are used to obtain the Hα monochromatic images. The telecentric lens system consists of two lenses, the first one is concave and the second, convex. These two lenses are positioned so that the front focal point of the second lens coincides with the location of the virtual image of the objective lens produced by the first lens. By this lens system, every principal ray is made parallel to the optical axis of the system, so that the central wavelength transmitted through the Fabry-Perot filter is strictly homogeneous all over the field of view. The F-30 beam fed to the monochromatic filter increases the effective passbands of the Fabry-Perot filters by about 0.1 Å over the values specified in

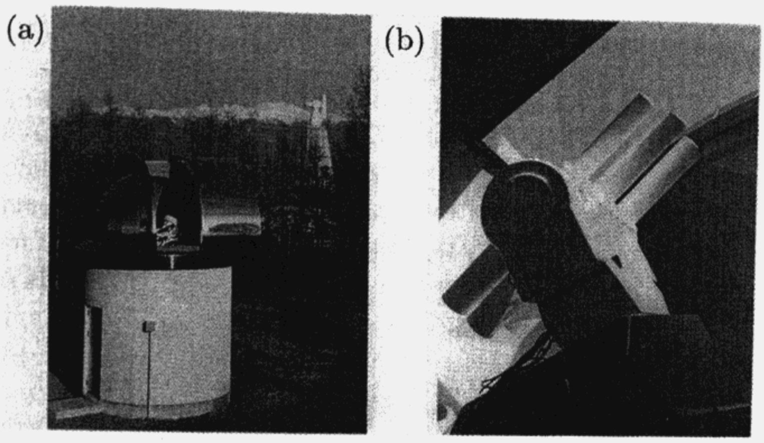

Fig. 1. (a) An outlook of the Dome of the New Flare-Monitoring Telescope. The 60 cm Domeless Solar Telescope Tower is also seen to stand on the right. (b) Outlook of the Flare-Monitoring Telescope.

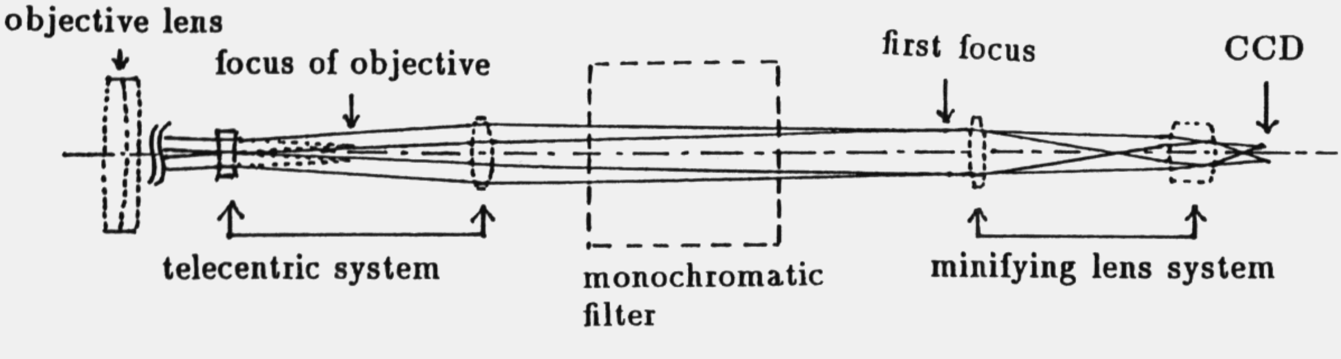

Fig. 2. Optical configuration of the Full Disk Telescope.

Table 1. Filler parameters of the Hida Flare Monitoring Telescope.

Telescope name	Monochromatic filter		
	Central wavelength	Passband	Filter type
Hα center Tele.	6562.8 Å	0.42 Å	Fabry-Perot (DayStar)
Hα + 0.8 Å Tele.	6563.6 Å	0.5 Å	Fabry-Perot (DayStar)
Hα − 0.8 Å Tele.	6562.0 Å	0.5 Å	Fabry-Perot (DayStar)
Continuum Tele.	6100 Å	60 Å	multi-layer coating
Prominence Tele.	6562.8 Å	3 Å	Fabry-Perot (DayStar)

Table 1. The minifying lens system reduces the solar image of 1956 seconds of arc diameter to 6 mm at the second focus or on the CCD video camera (SONY AVC-D7). The combination of the lens pairs in the telecentric system and the minifying system was optimized by the Technical Center of Minolta Camera Co., Ltd. The Kenko R64 and the Kenko N8 (reduced rate of transmission: 1/8) have been adopted for the front filter and the neutral density filter, respectively. The central wavelengths, passbands, and types of the monochromatic filters are summarized in Table 1. The 6100 Å interference filter is currently replaced by a neutral density filter (reduced rate of transmission: 1/400), because the former was found to cause a ghost light. An infrared-cut filter has been added in front of the R64 filter in the continuum-image-telescope. Consequently, the effective central wavelength of the continuum-image-telescope is currently about 6500 Å with a passband of about 200 Å.

2.2 *Prominence telescope*

The prominence telescope was designed to observe solar prominences outside the solar limb. Its optical configuration is nearly the same as that of the full disk telescopes. The minifying lens system is optimized to give a little larger minification rate than for the full-disk-telescopes: it reduces 1.18 times the solar disc or 2306 seconds of arc to 6 mm on the CCD focal plane in the prominence-telescope. A DayStar Hα filter of 3 Å passband is used as the monochromatic filter. Two occulting cones reflect the light of the solar disc to increase the visibility of prominences outside the solar limb. The first cone roughly occults most of the solar disc in front of the Hα filter, and the second one occults exactly the whole solar disc at the primary focus behind the Hα filter.

2.3 *Video recording system*

The five solar images taken by the FMT are transmitted to an observing room in a separated building by five coaxial cables of 40 m long. They are displayed and recorded with five time-lapse video-tape-recorders (Panasonic AG-6570A) as shown in a sketch of the FMT system in Fig. 3. Figure 4 shows a photograph of monitors and video-tape-recorders. The solar images can also be recorded in digital form by a personal computer NEC PC-9821 with an image digitizer PHOTRON FRM2-512.

The five solar images are also transmitted to the 60 cm Domeless Solar Telescope (DST) building by coaxial cables of 250 m long, and are displayed in the DST observing room to help the selection and quick change of target regions in the high resolution observation with DST.

3. Observations of Disappearing Hα Filaments

The FMT system recorded many flares, surges, filament disappearances, and prominence eruptions since May, 1992. The Hα − 0.8 Å and Hα + 0.8 Å images are especially useful to study the dynamical features of filament disappearances. Among them two Hα filament disappearances are selected, and their different characteristics are discussed by comparing them with their soft X-ray images obtained by Yohkoh.

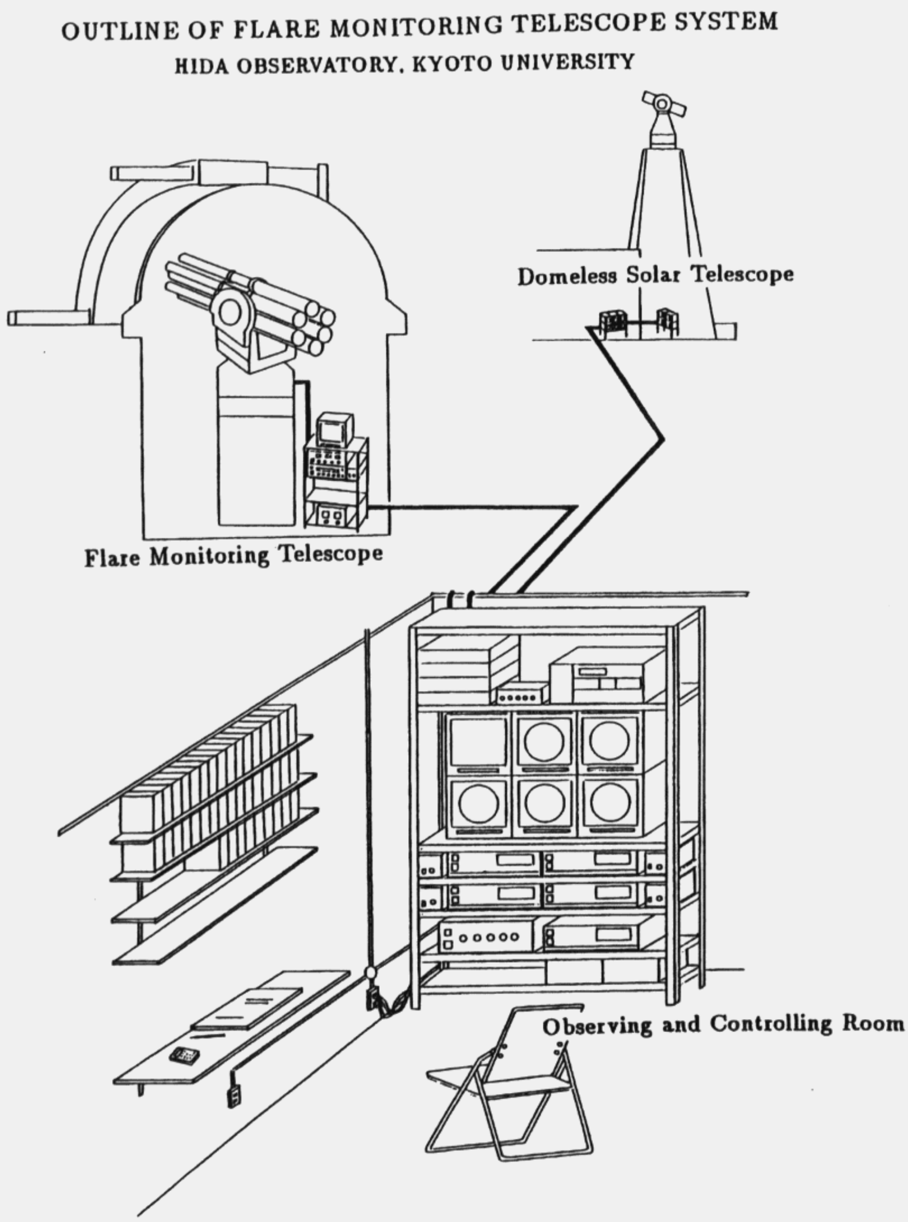

Fig. 3. Sketch of the Flare-Monitoring-Telescope System.

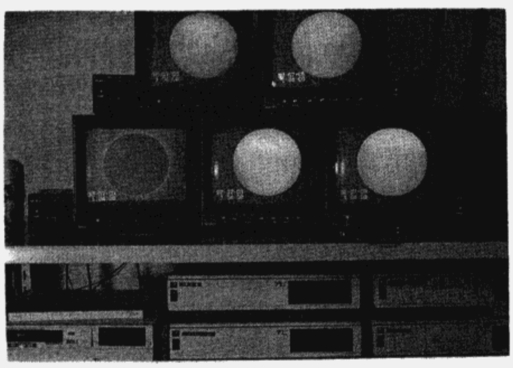

Fig. 4. Five video monitors and five video-tape-recorders.

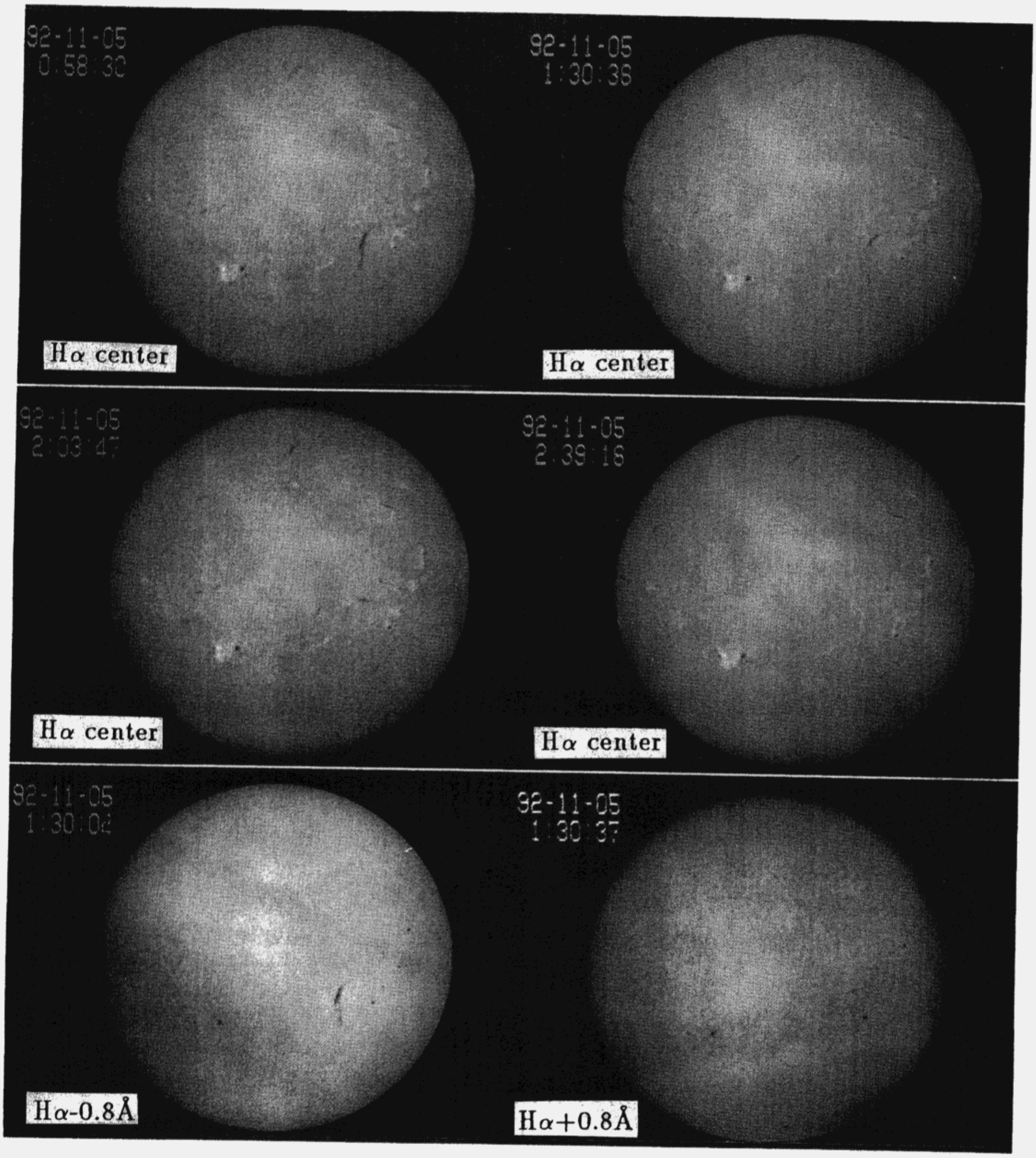

Fig. 5. Full disk Hα images showing the filament disappearance of 5 Nov., 1992.

3.1 5 November 1992 event

Figure 5 shows the Hα filament disappearance of 5 Nov. 1992 by four Hα center and one Hα – 0.8 Å and one Hα + 0.8 Å images. The filament, which was seen at the southwest (the lower-right) of the disc center at 005830 UT, nearly disappeared at 020347 UT in Hα center. A dark filament seen in the Hα – 0.8 Å image indicates a rising motion of the filament at 0130 UT. The Hα + 0.8 Å image at 013035 UT only shows a small dark knot indicating a downward motion at the north (upper) footpoint of the erupting filament. After the filament eruption (at 023916 UT), two faint but bright strands, or one long and one very short strand appeared in Hα line center at the position where the filament was located.

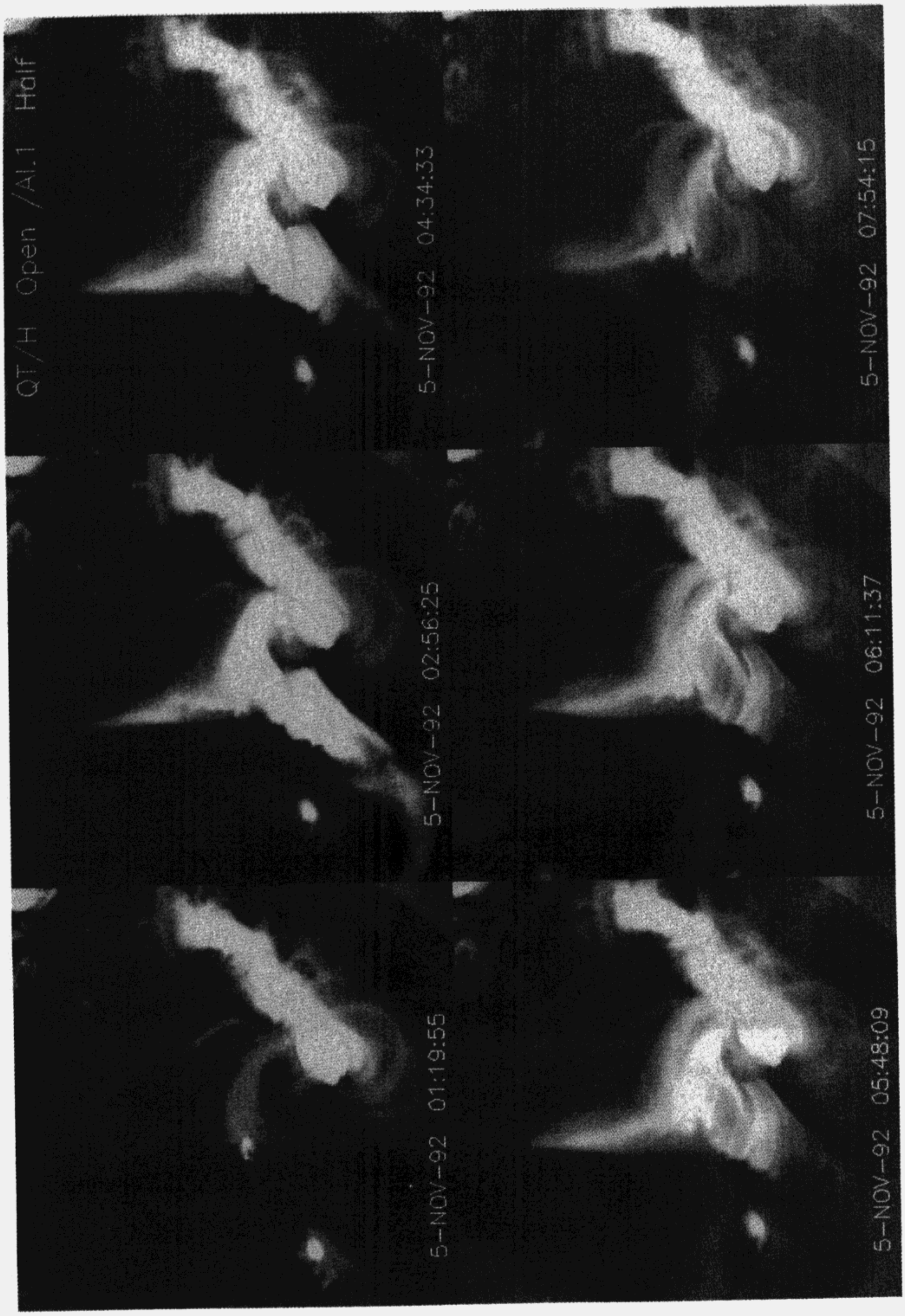

Fig. 6. Yohkoh soft X-ray images of the 5 Nov. 1992 event.

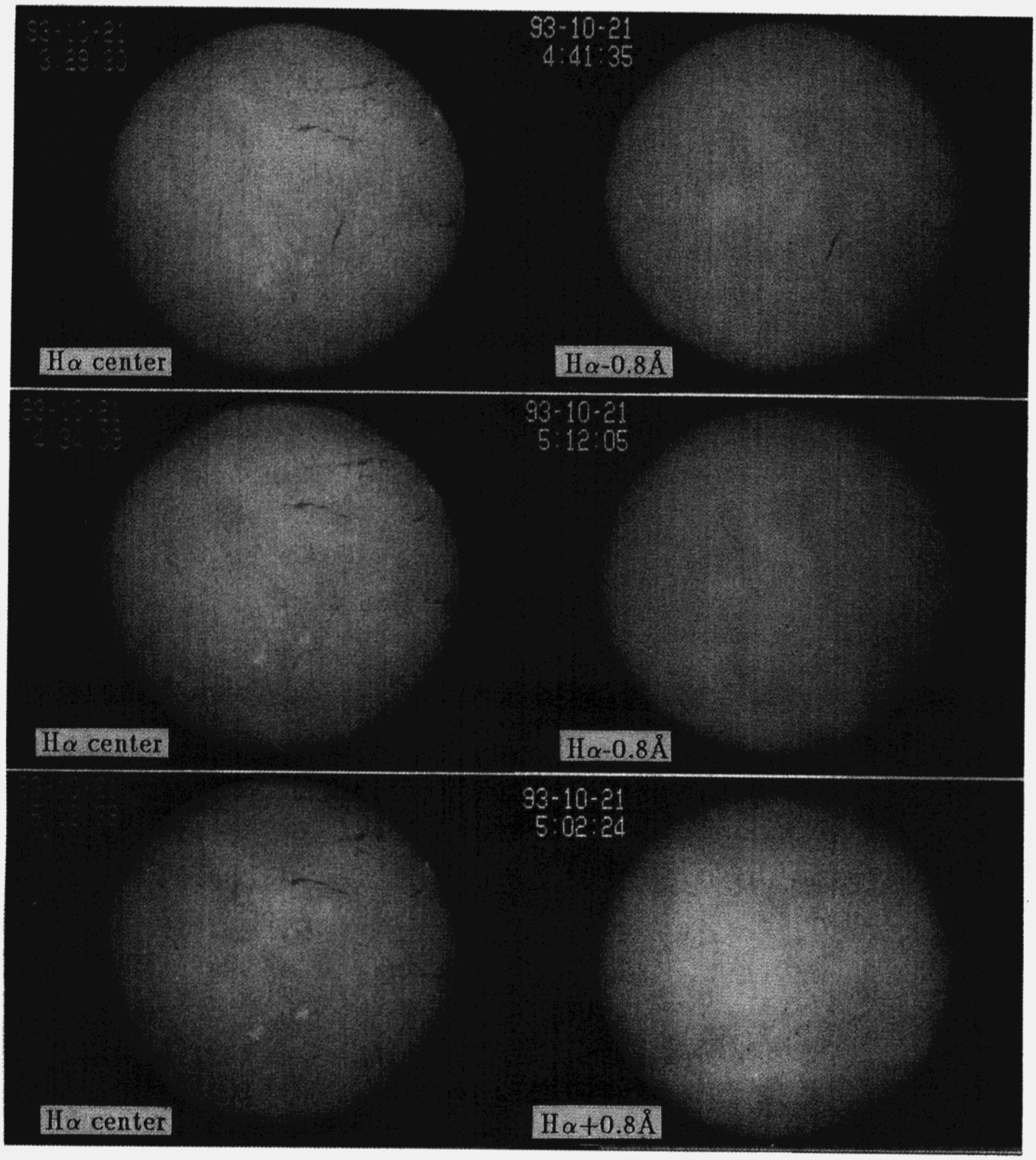

Fig. 7. Full disk Hα images showing the filament disappearance of 21 October, 1993.

Yohkoh soft X-ray images show a bright arcade structure of soft X-ray loops developing at the location where the filament erupted (Fig. 6). The bright Hα ribbons well coincide in space with the footpoints of the bright X-ray loops. The detailed study of this event was done by McAllister *et al.* (1995).

3.2 *21-October-1993 event*

The temporal variation of the disappearing filament observed on 21 October, 1993 is shown in Fig. 7. The filament, which was seen at the southwest (lower-right) of the solar disc at 032930 UT, became faint as a whole and nearly disappeared in Hα line center around 043407 UT, when it became gradually visible

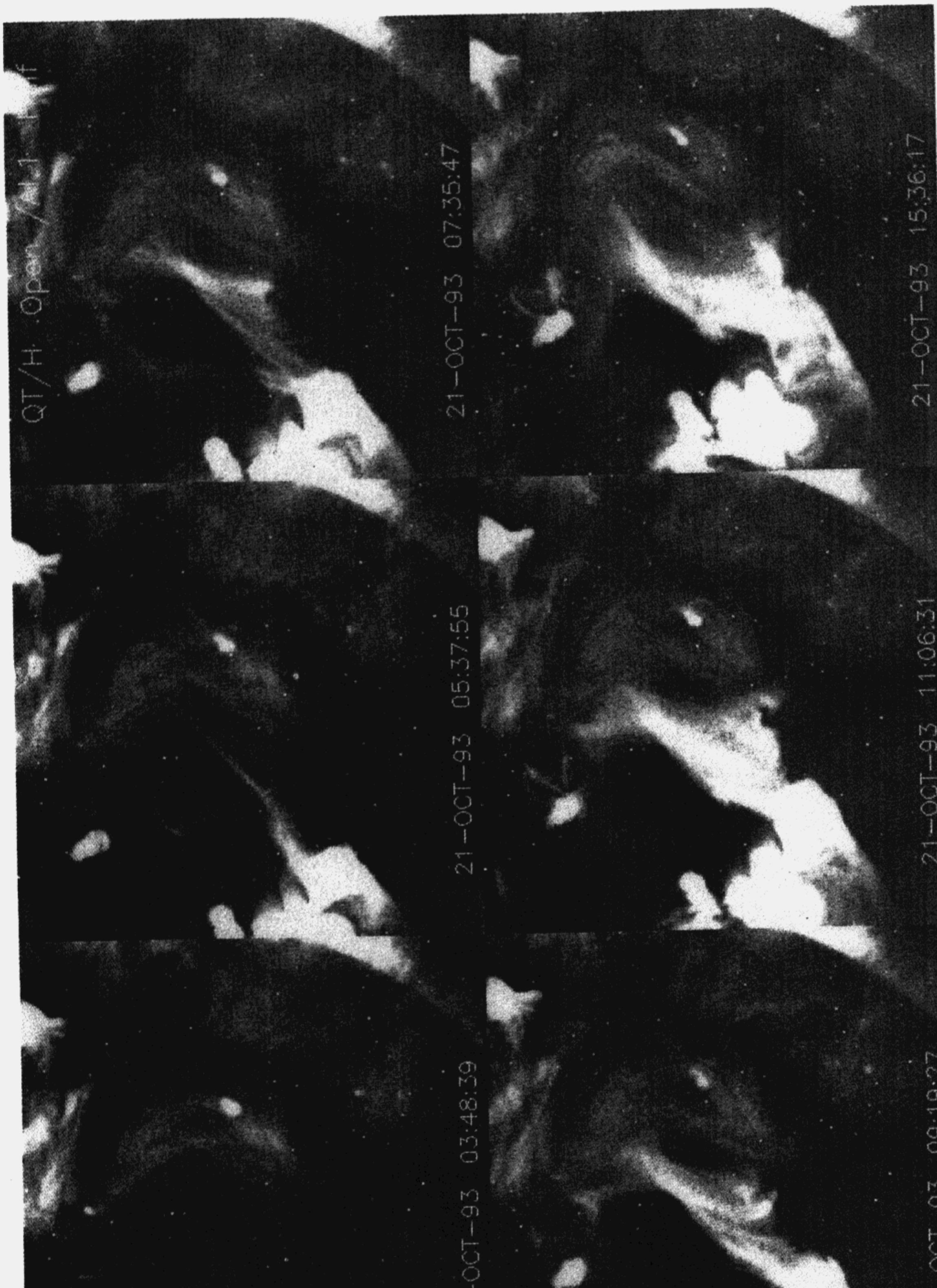

Fig. 8. Yohkoh soft X-ray images of 21-Oct.-1993 event. An arrow in the frame of 091927 UT indicates a small corona hole developing after the filament disappearance.

in Hα – 0.8 Å. The rising motion of the filament is seen most clearly in Hα – 0.8 Å around 044135 UT. The dark part in Hα – 0.8 Å or rising part of the filament gradually shifted to the southeast along the filament axis. The southernmost part of the erupting filament was slightly visible in Hα – 0.8 Å at 051205 UT. No Hα bright emission was found after the filament disappearance for this event (see the Hα image of 051238 UT).

The Yohkoh soft X-ray images of the 21-October-1993 event are shown in Fig. 8. No conspicuous X-ray arcade structure is found, and instead several bright X-ray loops along the filament axis developed very slowly from 0537 through 1536 UT at the position where the main body of the filament was located. This is consistent with the fact that no bright Hα emission was found after the filament disappearance for the 21-October-1993 event. Another interesting feature found in the soft X-ray images is a small coronal hole which developed at the east of the brightening X-ray loops after the filament disappearance. Notice the close time correlation between the brightening of the X-ray loops and the darkening and developing of the coronal hole from 0537 through 1106 UT in Fig. 8.

4. Discussion and Conclusion

A new Flare-Monitoring-Telescope was installed at Hida Observatory. The telescope is unique among currently-operating flare-patrol-telescopes in the world, because it simultaneously records four full-solar-disc images in Hα line center, Hα + 0.8 A, Hα – 0.8 Å and continuum, and one solar limb (prominence) image in Hα line center with five time-lapse video-tape-recorders. After its start of operation, it was confirmed that the telescope is very effective to study the dynamical features of various types of prominence activities. The Hα – 0.8 Å and Hα + 0.8 Å images are especially useful for detecting the motions of activitating filaments (prominences) on the solar disc. We presented two typical filament disappearances observed with this telescope in Section 3, and comparatively examined their dynamical characteristics. The 5-Nov.-1992 event is a typical filament eruption of a medium scale. The filament was gradually accelerated upward and main part of the filament matter escaped to the interplanetary space. Only its minor part fell back to the solar surface along the northern leg of the filament. The soft X-ray arcade structure and faint Hα two-ribbon brightenings found after the filament eruption are consistent with the above conclusion. The magnetic field opened by the filament eruption is considered to reconnect and to form the soft X-ray arcade and the Hα brightening according to Hirayama (1974).

The 21-October-1993 event is a less dynamic and rather quiet filament disruption. In this case, neither conspicuous soft X-ray arcade nor Hα brightening was formed after the filament disappearance.

It must be important to study whether we can find any causal relations between these three filament eruptions of different characteristics and corresponding geomagnetic and or interplanetary disturbances, which will be examined in the next paper.

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