Continuous H-alpha Imaging Network Project (CHAIN) with Ground-based Solar Telescopes for Space Weather Research

S.UeNo[*], K. SHIBATA[+], K. ICHIMOTO, R. KITAI, S. NAGATA, G. KIMURA, Y. NAKATANI

Kwasan & Hida Observatories, Kyoto University
Kamitakara, Takayama, Gifu 506-1314, Japan
(*) ueno@kwasan.kyoto-u.ac.jp, (+) shibata@kwasan.kyoto-u.ac.jp

Abstract. It is very important for understanding and prediction of the space weather situation to accurately observe erupting phenomena on the solar surface that are initial boundary conditions of all processes. Therefore, we are preparing to create a world-wide observational network with ground-based solar telescopes that is called as "Continuous H-alpha Imaging Network (CHAIN) project". The aim of this project is 24-hour continuous observation of the three-dimensional velocity fields of filament eruptions and shock-wave structures on the whole solar surface. The Flare Monitoring Telescope (FMT) that was constructed in 1992 at Hida observatory can simultaneously observe the full-disk Sun at different wavelengths around H-alpha absorption line, so we can measure the three-dimensional velocity field of the chromospheric gas motion on the full-disk Sun. We plan to use the FMT-type telescopes for the CHAIN-project. We already selected Peru as the country where the 1st oversea FMT will be installed, and we are preparing the installation aiming to start the operation of the FMT in Peru by the end of 2009 before the maximum phase of the solar cycle 24. On the other hand, we have received several informal offers to participate in the CHAIN project from other countries or institutes. In those countries, Algeria is located in the most suitable longitude in the meaning that it can cover the period between the evening of Japan and the morning of Peru. Then, we intend to actually visit and investigate possible sites in Algeria (Aures area, Tamanrasset area) in May 2008 with being supported by CRAAG of Algeria. Such international cooperation will also promote worldwide spread of the solar physics and space weather research.

Introduction

Hida Observatory of Kyoto University has five kinds of telescopes (fig.1). Two telescopes are used for night astronomy: the 60cm reflector and the 65cm refractor, and other three telescopes are used for solar observations: the Domeless Solar Telescope (DST), the Solar Magnetic Activity Research Telescope (SMART) and the Flare Monitoring Telescope (FMT). By using these telescopes, we have studied mainly on the following four kinds of themes;

- Solar physics
- Solar-astro plasma physics
- Solar-stellar physics
- Solar-system physics

In the former two themes, we recently consider that studying of variation of the solar-terrestrial environment (the space weather) is very important subject in recent information society. The space-weather environment around the earth greatly depends on three-dimensional structures and velocities of the CME, shockwave and solar-wind disturbance around the magnetosphere. For the purpose of accurate understanding or prediction of the structures and velocities of the CMEs in the solar-terrestrial space, it is very important to accurately observe erupting phenomena on the solar surface that are initial boundary conditions of them. Therefore, we are preparing to create a worldwide observational network with ground-based solar telescopes that is called as "Continuous H-alpha Imaging Network (CHAIN)-project[1]". In this project, we especially focus on 24-hour continuous observation of the three-dimensional velocity fields of filament eruptions and shock-wave structures on the whole solar surface.

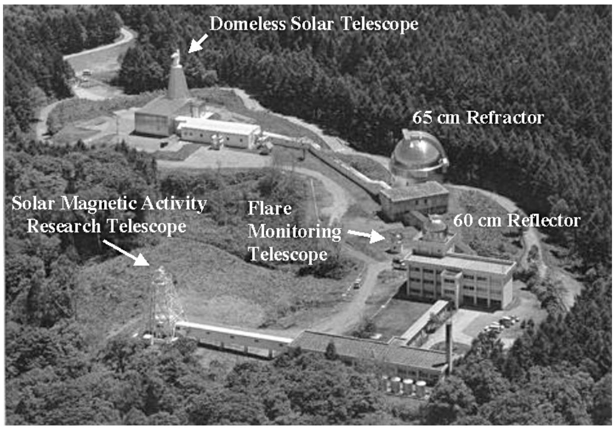

Fig.1. Picture of the Hida Observatory

The FMT that was constructed in 1992 at Hida observatory to investigate the long-term variation of solar activity and explosive events (Kurokawa et al. 1995)[2] is very suitable for the three-dimensional velocity measurement of eruptive phenomena on the whole solar surface. Therefore, we plan to use FMT-type telescopes in this project.

In this paper, we introduce characteristics of our instrument, examples of data analysis by using the FMT data, international cooperation under the CHAIN-project and its future prospect.

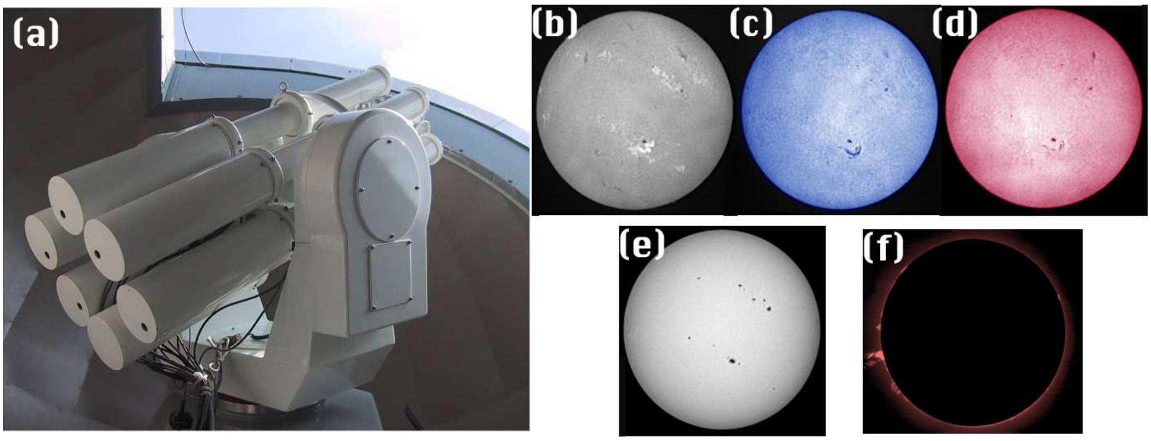

Fig.2. (a) Picture of the FMT at Hida Obs. (b) H-alpha line center image, (c) H-alpha – 0.8Å image, (d) H-alpha+0.8Å image, (e) continuum-light image, (f) prominence-mode image

Instruments for the CHAIN Project

We use FMT-type telescopes in the CHAIN project. The original FMT in Hida Observatory consists of six small telescopes (fig.2 (a)). The optical system of the FMT is also simple (fig. 3). Table 1 shows specifications of the FMT at Hida Obs. The one of six telescopes is used as a photoelectric guider. The others simultaneously observe the full-disk Sun at different wavelengths or in different modes without time lag (fig.2 (b), (c), (d), (e), (f)). Therefore, we can measure the Doppler velocity of the chromospheric gas without effects of temporal variation of atmospheric seeing from multi-wavelength images. Moreover, we can also obtain 3D velocity field by combining Doppler velocity fields with transversal velocity fields. Therefore, the FMT-type telescope is very suitable for the CHAIN-project.

The digital images of each telescope are obtained with CCD cameras at intervals of 20 seconds, the exposure time are 1 – 4 ms, the speed of frame-transfer is 15 f/s. These cameras are connected to five computers through a 80 m optical fiber cable of G-bit Eather-net (fig. 4). Images are smoothly transferred and stored in the computers.

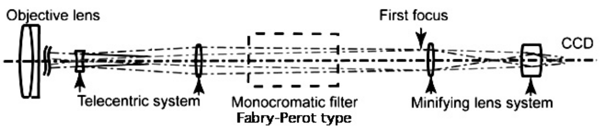

Fig.3. Schematic of the optical system of a telescope in the FMT[2]. Every five telescopes have almost the same structure.

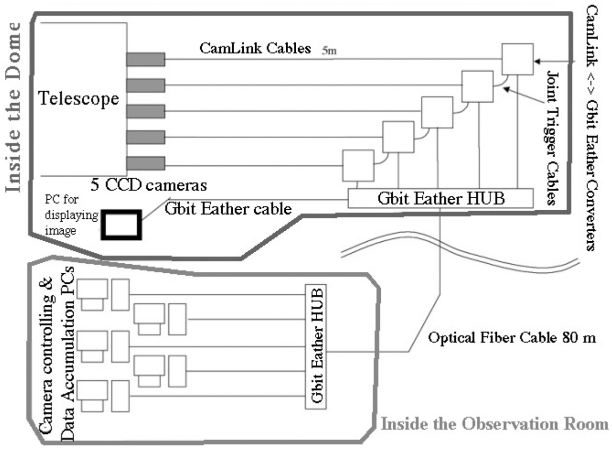

Fig.4. Schematic of data acquisition system of the FMT (after May 2006)

Table 1. Specifications of the FMT in Hida Obs.[2]

Optics		
Diameter 64 mm		
F-ratio 30		
Focal length 1920 mm		
Spatial resolution 1.8 arcsec		
Filters		
Telescope-name	Center-wavelength	Passband
H-alpha center	6562.8 A	0.42 A
H-alpha +0.8 A	6563.6 A	0.5 A
H-alpha –0.8 A	6562.0 A	0.5 A
Continuum	6100 A	60 A
Prominence	6562.8 A	3 A

We are considering two groups of telescopes as the members of CHAIN. The first group is made up of the existing foreign H-alpha solar full-disk telescopes that will be modified for multi-wavelength observation. The second group is formed by newly installed FMT-type telescopes at foreign appropriate places. As for the latter group, we have examined the possibility of installations of the telescopes in developing countries.

Examples of Data Analysis

We introduce examples of data analysis with the FMT data.

In the process of measuring the Doppler velocity of chromospheric filament structures, we apply the "cloud model fitting" to multi-wavelength images (fig. 5). The transversal velocity field is directly measured from solar images. Then, we can obtain three-dimensional velocity field (fig. 6). Morimoto & Kurokawa[4] investigated 35 typical disappearing filaments that were detected from 1992 to 2000, and they distinguished whether each active filament really erupted or not by analyzing its time-variation of the radial upward velocity, and investigated the relation with coronal structure and CME. As the result, all really erupting filaments correspond to appearances of coronal arcade structures and CMEs. In other words, sources of all CMEs are chromospheric H-alpha filaments.

On the other hand, the FMT is competent for detection of wave-like phenomena on the chromosphere (fig.7). We call such wave-like phenomena as the "Moreton wave". More than half the number of Moreton waves that were found over the world in the past have been discovered with the FMT. Theoretically Moreton wave has been considered to show the cross-section in the chromosphere of a shockwave generated by a strong solar flare. Narukage et al.[5] actually investigated their characteristics and compared with X-ray waves in the corona. As the result, these two kinds of waves are very similar in the speed, timing and propagating direction. Moreover, their speeds correspond to the expected MHD shockwave. Therefore, we can know an aspect of the shockwave that spread in the interstellar space by observing chromospheric wave.

Our main subject of the CHAIN project will be investigation of the correlation between "the velocity strength and direction of the erupting phenomena" and "the strength of effects of the corresponding CMEs on the earth".

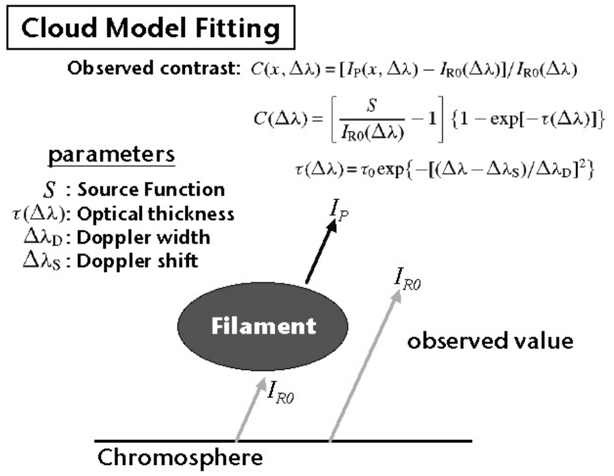

Fig.5. Principle of the cloud model fitting

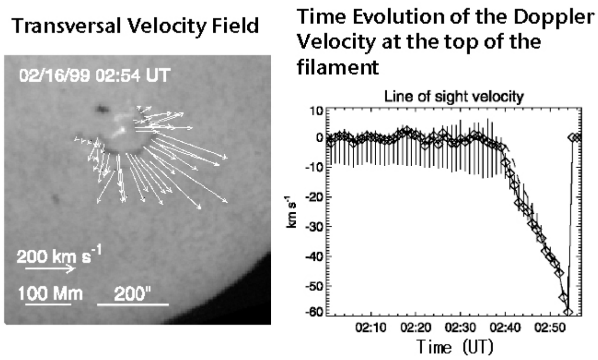

Fig.6. Sample figures of three dimensional velocity field measurement (Morimoto & Kurokawa 2003)[3]

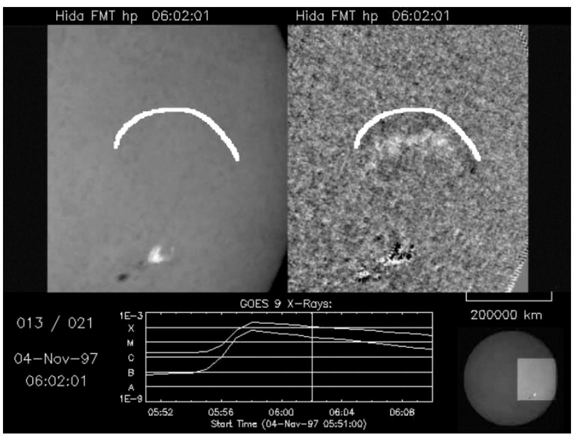

Fig.7. Sample figures of the shock-wave observation (Narukage et al. 2002)[5]

The 1st Oversea FMT in Peru

We already selected Peru as the country where the 1st oversea FMT will be installed, and decided the campus of Ica University as the installation-site (fig. 8 (a)). Fortunately, this wide campus ground will be developed and provided as the "Solar Station[6]" by Ica Univ. in 2008 and another instrument for measuring solar spectra will also be installed here with being supported by National Astronomical Observatory of Japan (fig. 8 (b)). Therefore, the infrastructure and the educational environment of this site are excellent. We are preparing various items, aiming to start the operation of the FMT in Peru by the end of 2009, before the next maximum phase of the solar cycle 24. For example, we will improve filter combination for the FMT in Peru as shown in table 2, so that the observable range of the Doppler velocity will be enlarged.

Fig.8. (a) Picture of the campus of Ica Univ.
(b) Pictures of coelostat and spectroscope that will be also installed in Ica Univ.

Table 2. Improvement of Filter Combination

At present:		CHAIN version:
・H α center	→	H α center
・H α +0.8 Å	→	H α +0.8 Å
・H α −0.8 Å	→	H α −0.8 Å
・H α Prominence	→	H α +3.2 Å
・Red Continuum	→	H α −3.2 Å
Observable range of the Doppler velocity		
0 〜 80 km/s		0 〜 130 km/s

Cooperation with Algeria

We have received several informal offers to participate in the CHAIN project from other countries or institutes. In those countries, Algeria is located in the most suitable longitude (fig. 9) in the meaning that it can cover the period between the evening of Japan and the morning of Peru (fig. 10). Moreover, in Algeria, there is a plan of construction of a new astronomical observatory by CRAAG (see Dr. Seghouani's thesis) and they also hope to install some solar telescope in the new observatory. CRAAG people have already started investigation of the possible sites. We consider that the installation of the FMT in the Algerian new observatory will give merit to both Japan and Algeria. Therefore, we also intend to actually visit and investigate possible sites in Algeria (around Aures area and Tamanrasset area as shown in fig. 11) in May 2008. In this time, we will investigate the following points with being supported by CRAAG:

- General climate
- Manpower
- Infrastructure
- Appearances of the atmospheric turbulence

After that, we hope to continue cooperation with Algerian people especially on the continuous measurement of atmospheric turbulences and on studies of solar physics and space-weather.

Summary

Observations of solar flares, filament eruptions and shockwaves are very important for the space weather research. The FMT is a powerful instrument for studying physical properties (especially 3D velocity field) of large-scale eruptive phenomena on the whole solar-disk. We are planning CHAIN project and installation of the FMT in Peru in order to obtain more data continuously with aiming to start the operation of the FMT in Peru by the end of 2009, before the maximum phase of the solar cycle 24. Other several countries or institutes have already hoped for participation in the CHAIN-project. Algeria is good position as the possible site for installing the 2nd oversea FMT, because of the appropriate longitude. We hope to strengthen connections with Peru and Algeria in the field of solar physics and space-weather research in order to realize our conception.

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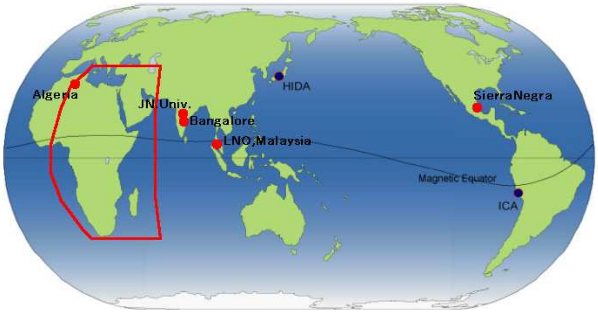

Fig. 9. Positions of possible sites of CHAIN stations on the world map. Blue circles shows Hida Obs. and Ica Univ. Red circles shows the countries or institutes that sent us offers to participate in the CHAIN project. The region surrounded by a red solid line is located around middle between Japan and Peru.

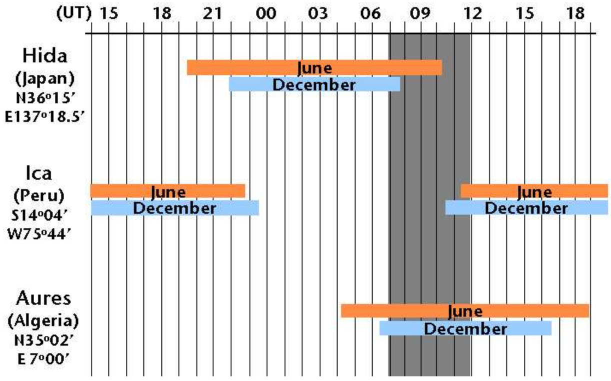

Fig. 10. Maximum and minimum daytime-period of Japan, Peru and Algeria. The gray zone shows a blank period of solar observation between the evening of Japan and the morning of Peru.

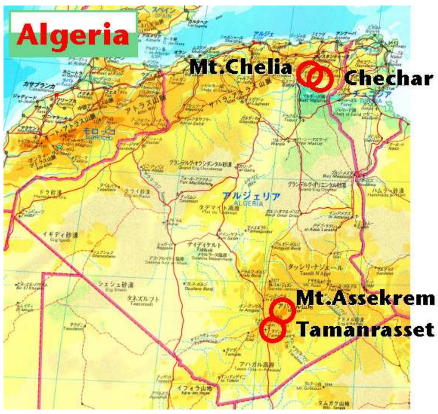

Fig. 11. Positions of possible sites in Algeria

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