Improvement of instruments and capacity-building activities under the CHAIN-project

Purposes of CHAIN Project under the ISWI program (Continuous H-alpha Imaging Network Project)

Reinforcement of multi-wavelength H-alpha observations of the full-disk Sun by formation of an international network of ground-based solar station.

Capacity building:
International spread, academic exchange and promotion of the space-weather research including developing countries.
Observational & Scientific Themes of CHAIN Project

(1) 3D velocity field measurement of eruptive phenomena on the solar surface

(2) Detection of shock waves (Moreton wave) generated by solar explosive phenomena

(3) Estimation of solar UV radiation and comparison with ionospheric variation
Improvement of instruments under the CHAIN-project (2016-2019)
Main three stations at present

Three solar telescopes of the CHAIN project

1) SMART telescope
   (Solar Magnetic Activity Research Telescope)
   at Hida Obs., Japan
   (2003 Oct. □ )

2) FMT telescope
   (Flare Monitoring Telescope)
   at National Ica Univ., Peru
   (2010 Mar. □ )

3) FMT telescope
   at King Saud Univ., Saudi Arabia
   (2015 Oct. ~ )

The largest observational characteristics of the CHAIN:
Multi-wavelength imaging around H-alpha line
SMART telescope at Hida Obs. Japan:

1) 5 wavelength observation / 2 min (2005 Jul – 2011 Feb)

2) 7 wavelength observation / 2 min (2011 Mar – 2014 Oct)
Several wavelengths observation can measure only low velocity field of eruptions. Large Doppler shift cannot be detected.
SMART telescope at Hida Obs. Japan:

1) 5 wavelength observation / 2 min (2005 Jul – 2011 Feb)

2) 7 wavelength observation / 2 min (2011 Mar – 2014 Oct)

3) 73 wavelength observation (-9.0 to +9.0 A) / 15 s (2016 May – present)

By using a liquid-crystal Lyot filter
At present, 3 wavelength observation (H-alpha center, +0.8, -0.8 A / 20 s) is being performed by Peruvian FMT. => ~ 40km/s
The completed FMT that started daily solar observation from 2015-10-31 at King Saud University.

At present, 5 wavelength observation (H-alpha center, +0.6, +1.2 Å /20 s) is being performed. => ~ 60 km/s
Supporting Program for Interaction-based Initiative Team Studies

As part of the MEXT-sponsored Program for Promoting the Enhancement of Research Universities, Kyoto University made the fund of 'SPIRITS' that is a trans-border program consisting of interdisciplinary, international, and interpersonal areas, aiming to accelerate the internationalization of Kyoto University by creating an environment that encourages pushing the boundaries of frontier research and protosciences, and promotes the creation of innovative practices.

Our theme is

Japan-Peru-Saudi Arabia High-speed Solar explosions Monitoring System
Japan-Peru-Saudi Arabia High-speed Solar explosions Monitoring System

**JAPAN**
Hida Obs. Kyoto Univ.

Solar Magnetic Activity Research Telescope (SMART)
New-type Filtergraph (SDDI)

After 2016 May, high-speed eruptions (400 km/s) can be detected over the full-disk Sun.

Flare Monitoring Telescope (FMT)
Multi-wavelength Filtergraph

Measure the eruption velocity up to about **60 km/s** over the full-disk Sun.

Heliostat Spectroscope
Measure the velocity up to **400 km/s** only around eruption regions.

安装双高精度平面镜
安装 slit-scan 系统

**SAUDI ARABIA**
King Saud Univ.

Flare Monitoring Telescope (FMT)
Multi-wavelength Filtergraph

24 hours continuous relay observation

**PERU**
National Ica Univ.

Flare Monitoring Telescope (FMT)
Multi-wavelength Filtergraph

Measure the eruption velocity up to about **40 km/s** over the full-disk Sun.

Coelostat Spectroscope
Measure the velocity up to **400 km/s** only around eruption regions.

安装 slit-scan 系统
Spectroscopes at Peru & Saudi Arabia

We are equipping spectroheliograph using existing heliostat (Coelostat) and spectroscope of Ica Univ or King Saud Univ., so that filament eruptions that have very high speed (very large Doppler shift) can be tracked.

Coelostat & Spectroscope at Ica Univ., Peru

Heliostat & Spectroscope at King Saud Univ., Saudi Arabia
Replace of the 2 flat mirrors of the Coelostat at Ica Univ, Peru:

1) 2018-Jan-24
2) 2018-Dec-18

Highly accurate flatness mirror
Installation of the high speed slit-scan system (rotation glass-cube etc.) in front of the slit.
Spectroheliogram at around prominence 2018-01-27 16:11UT with the Spectro-heliograph of National Ica University, Peru (required time: ~ 10 s)
On the other hand, in King Saud University (KSU), the drive-system of the heliostat is broken.

The repair of it by KSU has not been achieved yet.

So, as for the KSU, the solar observation will be done using only their FMT telescope for a moment.
Capacity-building Activities under the CHAIN-project (2017 – 2019)
Receiving an exchange student from Peru

An Peruvian young researcher Mr. Denis Cabezas, who became a solar physicist through the CHAIN project, entered the doctoral course of Kyoto University in April 2017 as a government-financed foreign student.
The 4th FMT Data Analysis Workshop

2017 Feb. 13 - 17

at Kwasan Observatory and Kyoto Univ., Japan

Main purpose:
To promote data analysis using Saudi Arabian FMT data.
Workshop Celebrating the 60 Years of Dr. Mutsumi Ishitsuka in Peru: Achievements on Solar Physics and Astrophysics

2018 Jan. 29

at National Ica University, Ica, Peru

Main purpose:
To discuss about recent new results obtained from the FMT data.
The 5th CHAIN / FMT & SMART International Data Analysis Workshop

2019 Feb. 05 – 12

at Kyoto University, Japan

Main purpose:
To promote data analysis of FMT&SMART data, scientific discussion and writing papers.
Summary

• CHAIN project has promoted ground-based solar observations, researches of solar physics and space weather, mainly by using three solar imaging telescopes in Japan, Peru and Saudi Arabia.

• For the purpose of improving ability to measurement of physical quantities of solar active phenomena, we are adding solar spectroscopes to our CHAIN’s instruments.

• Regarding the Peruvian solar station, the improvement of Coelostat and spectroheliograph was already finished successfully. => Further higher speed solar explosive phenomena will be treated in our space weather researches.

• As for the Saudi Arabian solar station, the improvement has not achieved yet. => In cooperation with King Saud University, we are going to improve the heliostat spectroscope in order to utilize it for space weather researches.

• For recent three years, we have also performed capacity-building activities under the CHAIN project, such as receiving a foreign student, holding data analysis workshops and a symposium in Japan and Peru. => After this also, we continue to promote such international education and researches by using our solar data, with adding new spectroscopic data.
Other CHAIN cooperation countries.

Where is the data?

http://www.hida.kyoto-u.ac.jp/FMT/daily_b2/
Dynamic eruption!

Hα spectra by DST (2014.11.11)

Previous $\pm 1.2A = \pm 50\text{km/s}$

$\pm 400\text{km/s}$

Velocity of erupting prominence on the limb by NoRH (Nobeyama Radio Heliograph)

1993-2013 $\Rightarrow$ max $\sim 400\text{km/s}$, average $\sim 100\text{km/s}$ (Shimojo 2014)

Solar Dynamics Doppler Imager (SDDI)

<table>
<thead>
<tr>
<th>Wavelength scan range</th>
<th>Previous</th>
<th>SDDI</th>
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<tbody>
<tr>
<td></td>
<td>Hα -1.2 $\sim$ +1.2 A</td>
<td>Hα -9 $\sim$ +9 A</td>
</tr>
<tr>
<td>Spectral resolution</td>
<td>$\sim 0.4A$ (7 positions)</td>
<td>0.25A (73 positions)</td>
</tr>
<tr>
<td>Field of view (FOV)</td>
<td>$\phi 2300^\circ$</td>
<td>$\sim 2460^\circ \times 2460^\circ$</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>0.56$^\prime$</td>
<td>1.23$^\prime$ [cf: resolution limit=0.83$^\prime$]</td>
</tr>
<tr>
<td>Time resolution</td>
<td>60 sec</td>
<td>15 sec $\rightarrow$ 12 sec</td>
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