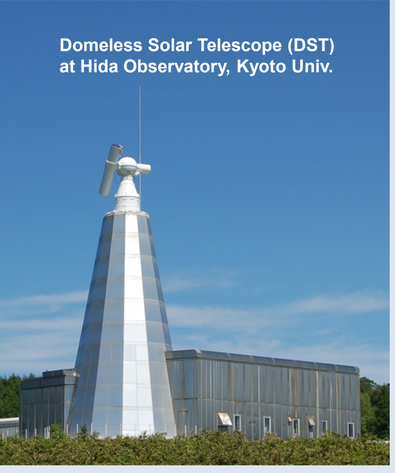

Roles of Ground-based Solar Observations of Hida Observatory toward the Solar-C Era

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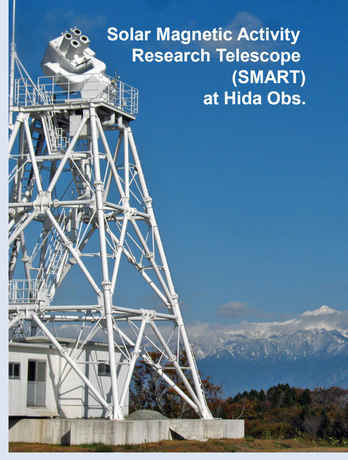
I. Dorotovič, E. Shahamatnia, R.A. Ribeiro, J.M. Fonseca
(CTS-UNINOVA, FCT/UNL, Caparica, Portugal)



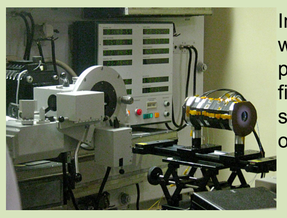
Abstract:

For the realization of the Solar-C satellite, discussions about scientific themes and preliminary observations are internationally carried out now. At **Hida Observatory** of Kyoto University, we will play the following roles toward the Solar-C era by utilizing the **Domeless Solar Telescope** (**DST**) and the international solar chromospherirc full-disk observation network (**CHAIN** project) that includes the **Solar Magnetic Activity Research Telescope** (**SMART**) with international collaborations, for example, such as the development of image-analysis software by **UNINOVA** (Portugal) and so on.

1. Roles before the Solar-C Launch

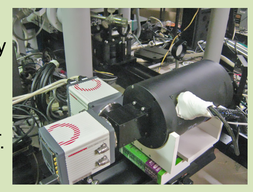
1.1 Development and Test of new detectors and optical instruments

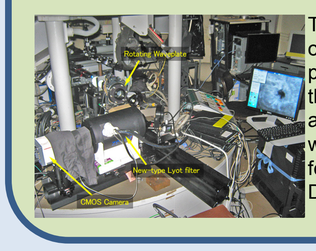
◆ Development of new-type Lyot filters using liquid-crystal retarders by Hagino (NAOJ) et al.
(See the poster of Dr. Hagino)



Investigation of wavelength properties of the filter by using spectroscope of the DST.

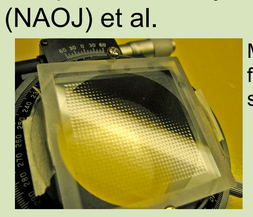
Test observation of simultaneously imaging at two wavelengths at around the focal plane of the DST.





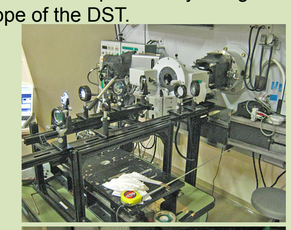
Test observation of imaging-polarimeter using the new Lyot filter and a rotating waveplate at the focal plane of the DST.

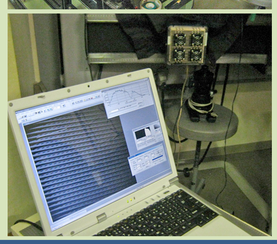
◆ Development of 2-D spectroscopes using Micro Lens Arrays or Optical fibers by Suematsu (NAOJ) et al.



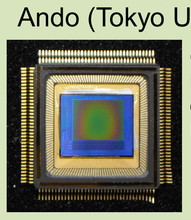
Micro lens array for the 2-D spectroscopy

Experimental observation of 2-D spectroscopy at around H-alpha line by using the spectroscope of the DST.

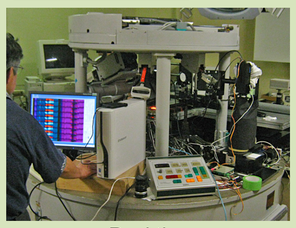


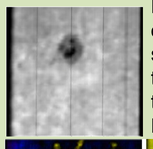


◆ Experimental observation with Correlation imaging sensors for polarimetry by Ando (Tokyo Univ.) et al.

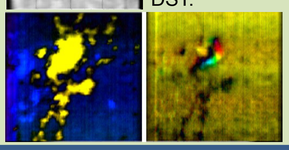


Correlation image sensor developed by Prof. Ando.





Real-time measurement of Stokes profiles of the solar spectrum by using the image sensor and the spectroscope of the DST.

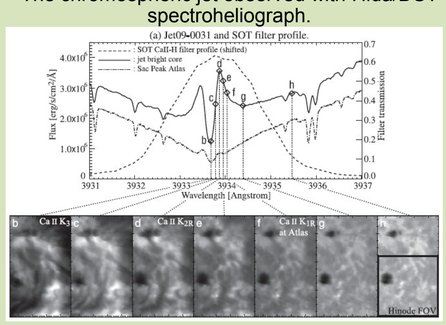


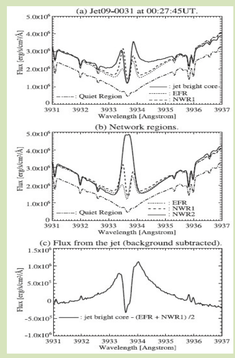
1.2 Revealing unclear points in the solar chromospheric physics

◆ Estimation of released energy by chromospheric activities (jets etc.)

Example: Morita et al. 2010, PASJ, 62, 901

The chromospheric jet observed with Hida/DST spectroheliograph.



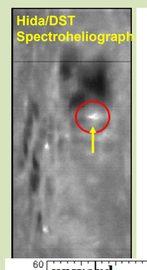


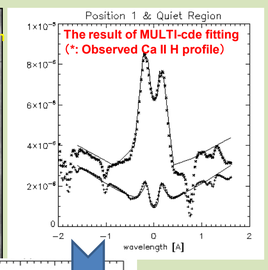
Estimation of the flux from only the jet.

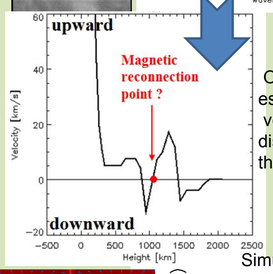
They confirmed that the "**magnetic energy release rate**" by magnetic cancellation around the jet is comparable to **the total energy loss** of the jet estimated from the radiative loss in the Ca II K line.

◆ Mechanism and 3-D structures of chromospheric phenomena

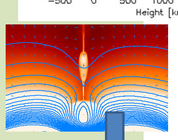
Example: Estimation of atmospheric model of the chromospheric jet by UeNo et al.

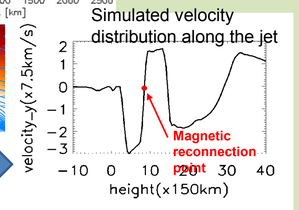






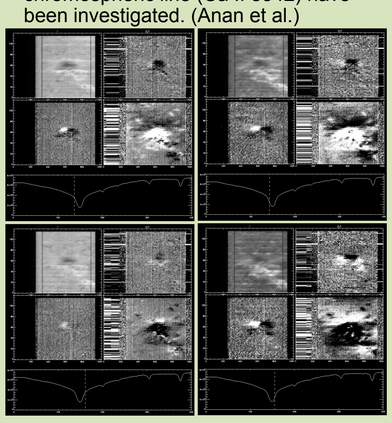
Observationally estimated velocity distribution along the jet





◆ Inversion method of chromospheric magnetic fields by applying Zeeman effect and Hanle effect to various lines

Currently inversion method for chromospheric line (Ca II 8542) have been investigated. (Anan et al.)



Moreover, Mr. Sano (graduate student) Is observing and investigating Hanle effect in the following chromospheric lines of promineces:

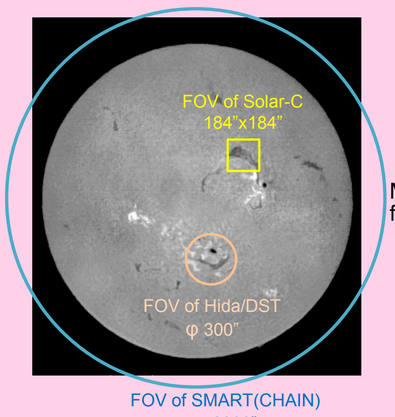
CaII 8662, CaII 8543, CaII 8498,
Hα 6563, Na 5890, Mg 5172,
Hβ 4861, Hγ 4340, CaI 4226,
Hδ 4101, CaII 3968, CaII 3933

etc. ・・・

2. Roles after the Solar-C Launch

2.1 Cooperative Observations with Solar-C

◆ Complimentary observations with satellite's high-spatial-resolution observations that are limited in the spatial FOV and continuous observable time due to the data capacity



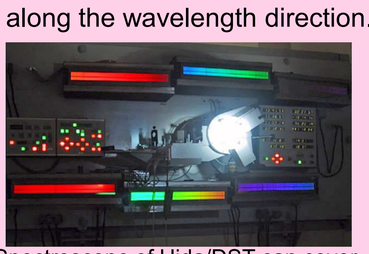
FOV of SMART(CHAIN)
φ 2300"

Data capacity

of Hida/DST :
max: Several TB / day

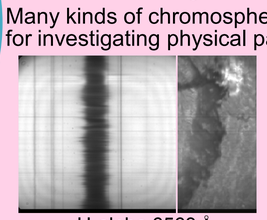
of SMART(CHAIN) :
A few TB / day

◆ Complimentary observations with satellite's spectroscopic observations that are limited in the amount of information along the wavelength direction.

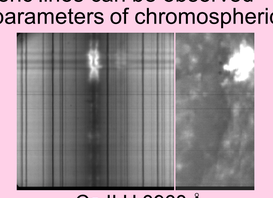


Spectroscope of Hida/DST can cover whole range of visible light and near IR.

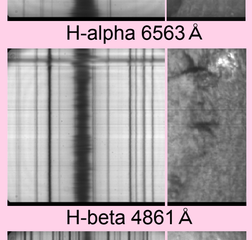
Many kinds of chromospheric lines can be observed for investigating physical parameters of chromospheric gas.



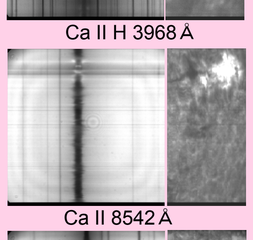
H-alpha 6563 Å



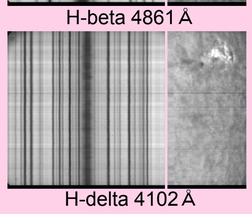
Ca II H 3968 Å



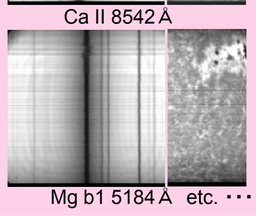
H-beta 4861 Å



Ca II 8542 Å



H-delta 4102 Å

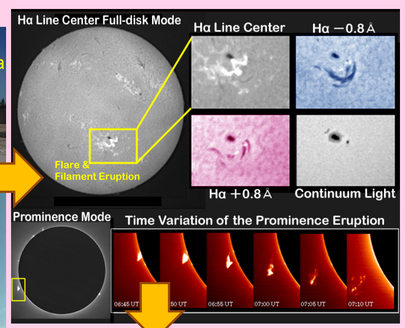


Mg b1 5184 Å etc. ・・・

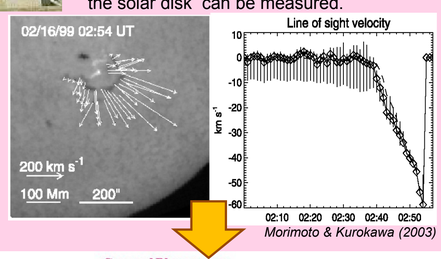
2.2 Expanding and Applying New Knowledge Provided by Solar-C to the Whole of the Sun

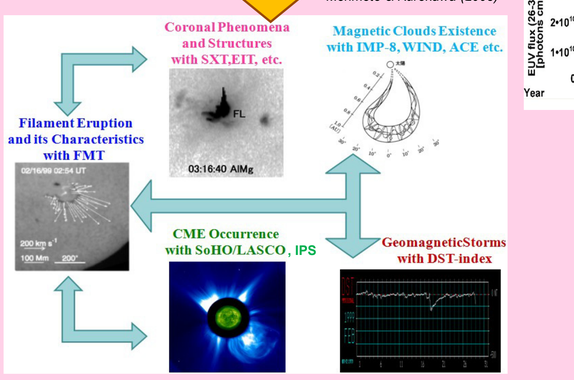
◆ For prediction of the influence of solar active phenomena on variations of space weather environment and climate of the Earth

CHAIN project Network

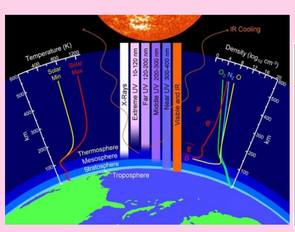


3-D velocity field of all erupted filament on the solar disk can be measured.





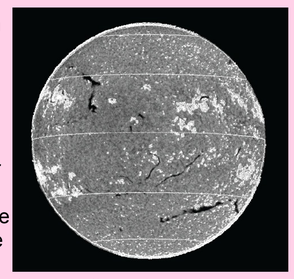
◆ For estimating solar UV variation that affects ionospheric and stratospheric environment

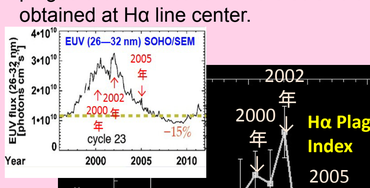


UV wavelengths that affect ionosphere

Element	Ionization	
	Vp(eV)	λ(nm)
N_2	15.58	79.6
O_2	12.08	102.6
O	13.61	91.1
N	14.54	85.3
NO	9.25	134
H	13.59	91.2
He	24.58	50.4

By using H-alpha imaging data for 21 years, we calculated "Hα Plage Index" as a candidate proxy of the solar UV radiations.
It is defined as the percentage of the area covered by plages & active network in the solar disk obtained at Hα line center.

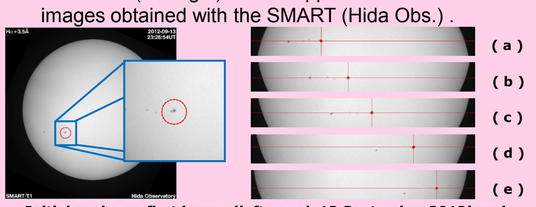




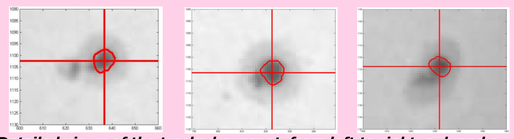
The accuracy of UV-reproduction will be improved by using UV-spectral data of the Solar-C.

◆ For detecting solar global gas-motions and global distributions of physical parameters that are related with Dynamo theory

In order to add accurate information of the **solar differential rotation** to the information of global solar gas-motions, the hybrid Particle Swarm Optimization (PSO) algorithm and Active Contour model developed by UNINOVA (Portugal) will be applied to full-disk solar images obtained with the SMART (Hida Obs.) .

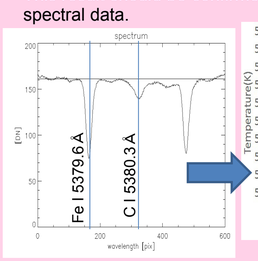


Initial snake on first image (left panel, 13 September 2012) and detection and tracking process of the selected sunspot for 6 days (right panel).



Detailed views of the tracked sunspot, from left to right: a, b and e The red contour delineates the umbra and the center of axes represents the center of sunspot.

Moreover, the information of **temperature distribution of the photosphere** is also important for the Dynamo theory.
We detected the latitudinal dependency of the photospheric temperature by measuring line-depths of two different photospheric absorption lines with high resolution spectroscope of the Hida/DST.
This result should be confirmed by being compared with Solar-C's spectral data.



etc. ・・・

3. Regular Roles

3.1 Providing the Place of Educational-observation, Training for Students and Young Researchers

Educational observation with the spectroscope of the DST for undergraduate students of Kyoto Univ. (2015)

Training of solar observations and data analysis for graduate students of Ibaraki Univ. (2014 at Hida Obs.)

Training about optical instruments for graduate students of Osaka Dentsu Univ. (2013 at Hida Obs.)

Educational solar observation for general citizen (2014 at Hida Obs.)

3.2 Providing the Place of Enforcing Experimental Observations, Classical Scientific Themes, Long-duration and Large-data Observations

For example:

◆ Detection of Gravitational Redshift (Takeda & UeNo 2012, SolPhys) by measuring absolute wavelength shift of photospheric absorption lines

◆ Spectroscopic measurement of the solar differential rotation (Takeda & UeNo 2011, SolPhys) by measuring absolute Doppler shift of photospheric absorption lines
=> Long-term variation also should be investigated in future.

◆ Very High Time-cadence Imaging and Spectroscopic Observations (by Tohmura)

At present, 1000 fps high-speed camera have been experimentally applied to solar observation.

etc. ・・・