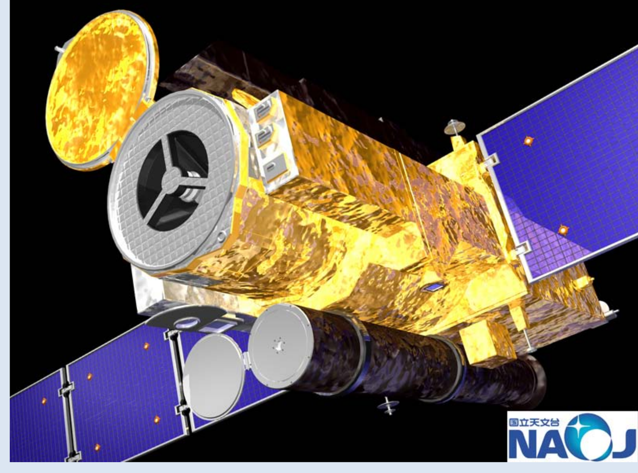
Reports of Cooperative Observations between Hida Observatory & Hinode Satellite (HOP 0012, 0075, 0128)



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Abstract:

Chromospheric active phenomena, reconnections, coronal heating process, prominence activities and sunspot evolution that are all related with the solar magnetic field have become more clear by recent MHD simulations and high-resolution observations with the HINODE satellite.
In order to quantitatively verify the present models of such phenomena, we have continued simultaneous and high-cadence observations of diversified observation from the photosphere to the corona with the HINODE satellite and spectrum observation at the Hida Obs.
In this poster, we introduce some typical results of cooperative observations between Hida Observatory & Hinode Satellite for above-mentioned themes (HOP 0012, 0075, 0128) during these several years.

1. Purposes of HOP 0012 (2007)

1. Emerging Flux Regions (EFR)
- 1a. Rise velocity of emerging loops
- 1b. Shock waves just below the arch filaments in EFR
- 1c. Evolution of magnetic element at the footpoint of EFR

2. Cool Jets
Detection of Alfven wave generation

3. Ellerman Bombs
Observation of reconnection jets and X-ray signatures in the corona

2. Purposes of HOP 0075 (2008)

1. Flare kernels
2. Sunspots
- 2a. Penumbral jets
- 2b. Heating process on sunspots (wave propagation and coronal responses)
- 2c. Ellerman bombs around sunspots
- 2d. Chromospheric jets around sunspots

3. Emerging flux regions
- 3a. Rise velocity of emerging loops and coronal response
- 3b. Evolution of magnetic element at the footpoint of EFR
- 3c. Ellerman bombs under AFS
- 3d. Chromospheric jets around EFR
- 3e. Shock waves just below the arch filaments in EFR

4. Oscillations of prominences & dark-filaments
5. Chromospheric jets
- 5a. Plage jets (high cadence spectrum measurement)
- 5b. Jets in the quiet region

6. Limb spicules
- 6a. Difference between polar region and equatorial region
- 6b. Difference between coronal hole region and other regions

7. Relation between XBPs and supergranulation boundary
8. Polar X-ray jets

3. Purposes of HOP 0128 (2009 – 2013)

1. Active Region
- 1a. Low Cadence (Emerging Flux Region)
- 1b. High Cadence (Sunspot Dynamics)
- 1c. High Cadence (Flare Gas Dynamics)

2. Chromospheric jets
Distributions & evolutions of the velocity field, temperature, density and magnetic field

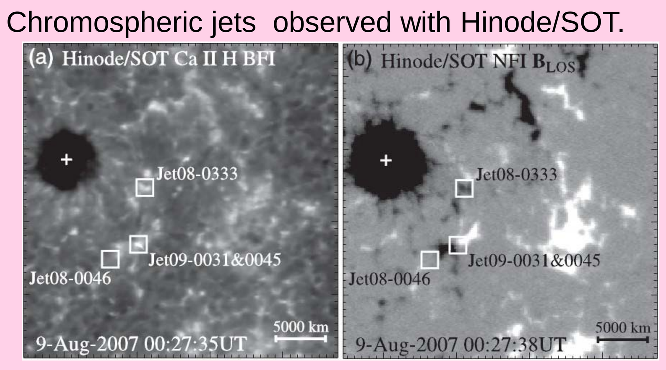
3. Dark Filament & Prominences
Wave-like phenomena and its relation with coronal heating

4. Chromospheric Jets

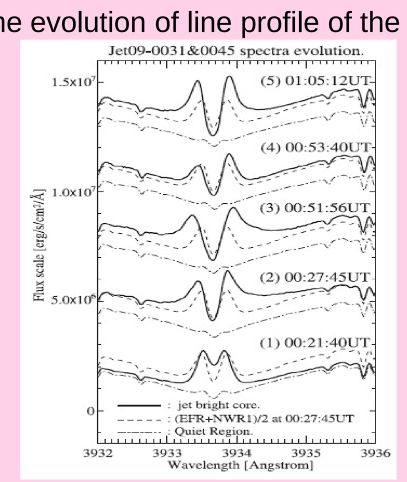
4.1 Energy source of chromospheric anemone Jets

Morita et al. 2010, PASJ, 62, 901

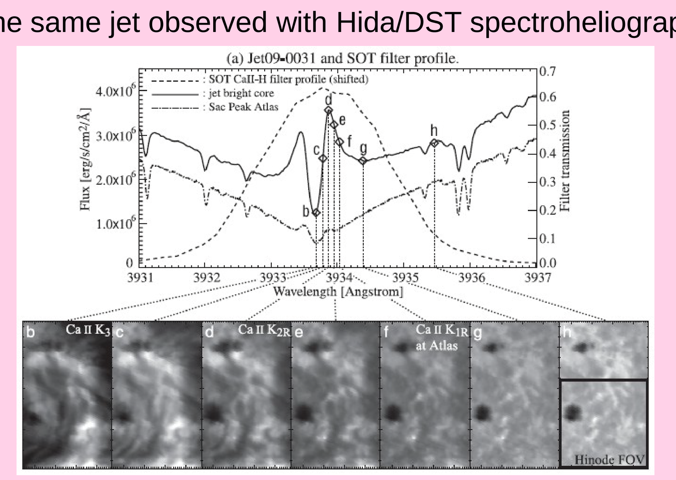
Chromospheric jets observed with Hinode/SOT.



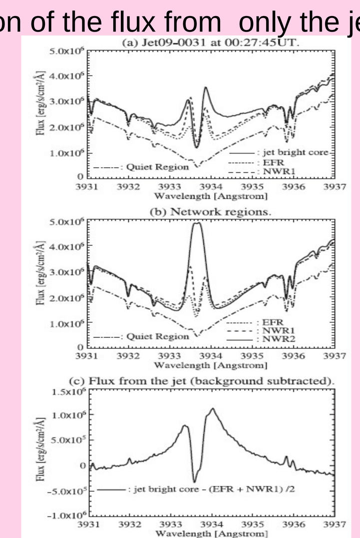
Time evolution of line profile of the jet.



The same jet observed with Hida/DST spectroheliograph.



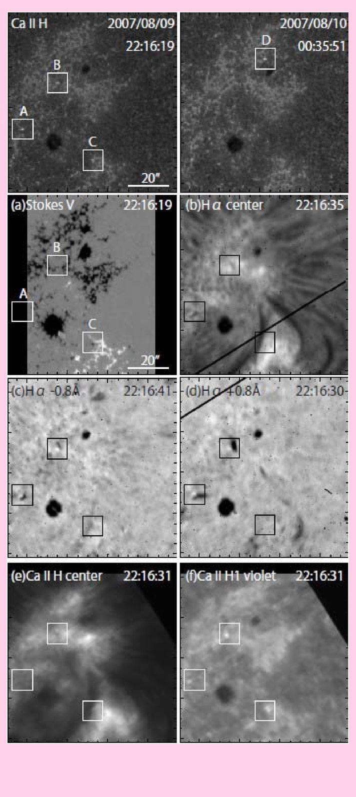
Estimation of the flux from only the jet.



We 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.

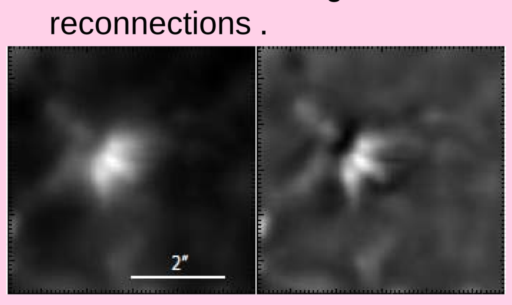
4.2 Fine Structure of Ellerman Bombs

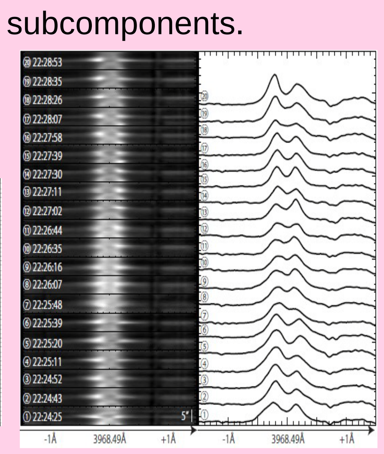
Hashimoto et al. 2010, PASJ, 62, 879



We found that Ellerman bombs are composed of a few of fine subcomponents whose characteristics are as follows:

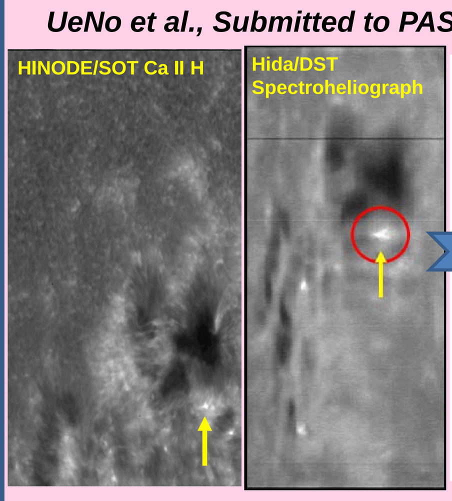
- The mean duration, the mean width, the mean length, and the mean aspect ratio of the subcomponents were 390 s, 170 km, 450 km, and 2.7, respectively.
- Subcomponents started to appear on the magnetic neutral lines, and extended their lengths from the original locations.
- When the Ca II H line of EBs showed the characteristic blue asymmetry, they are associated with the appearance or re-brightening of subcomponents.
- They correspond to successive and intermittent magnetic reconnections .

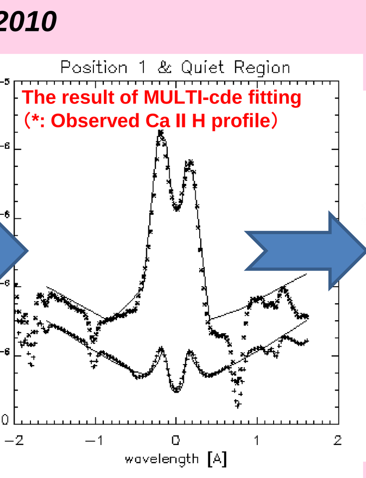




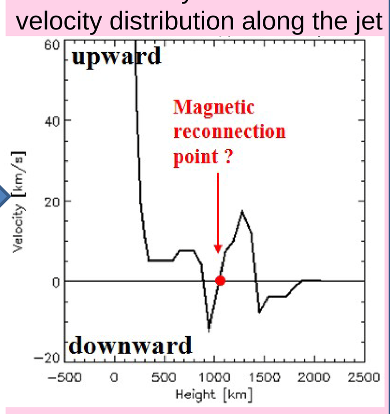
4.3 Model Atmosphere of Jets

UeNo et al., Submitted to PASJ in 2010

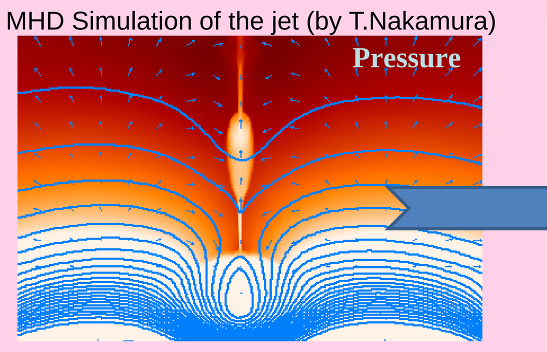




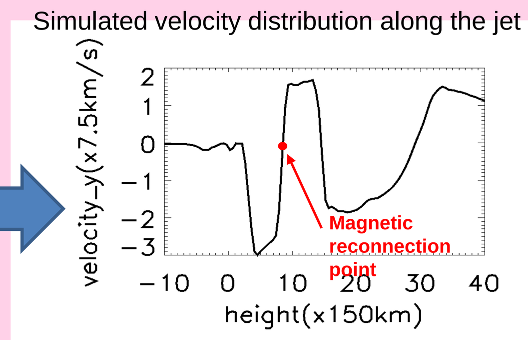
Observationally estimated velocity distribution along the jet



MHD Simulation of the jet (by T.Nakamura)



Simulated velocity distribution along the jet

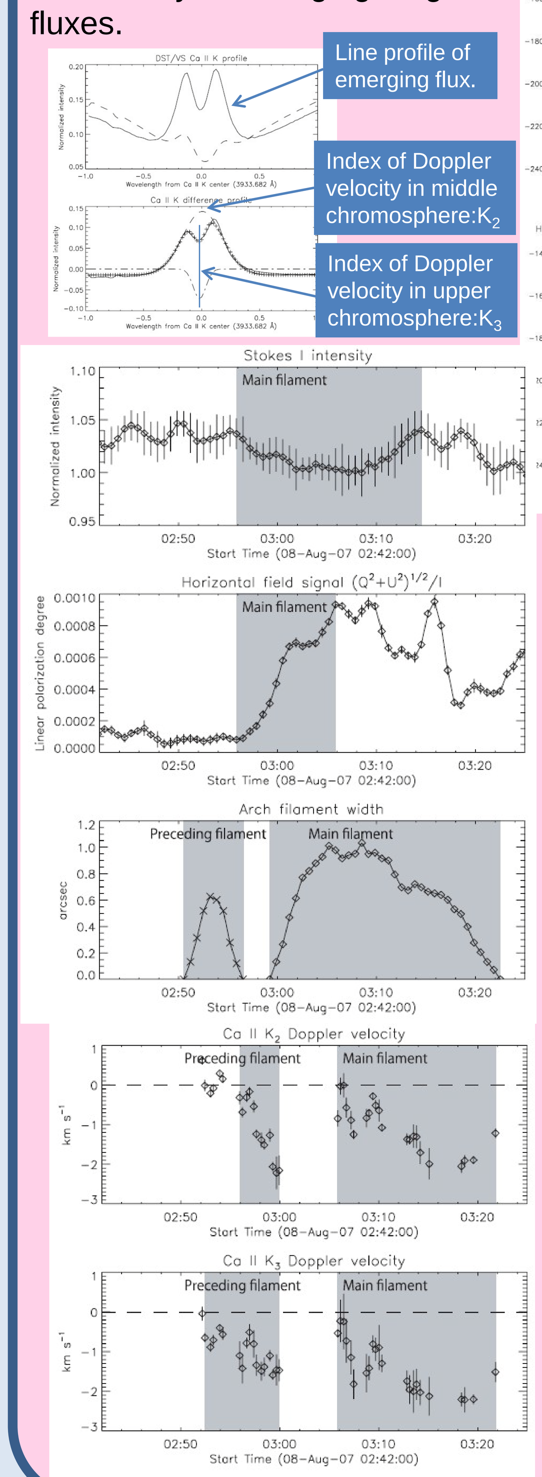


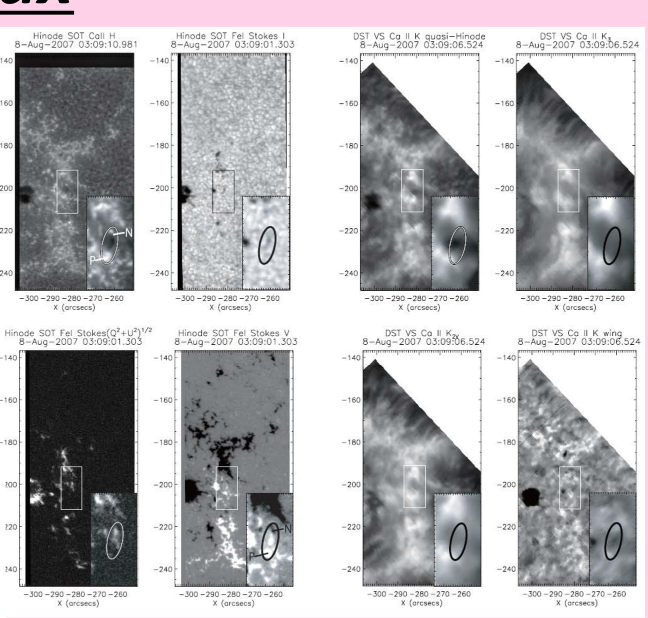
We observationally confirmed the magnetic reconnection point and bidirectional flow in the chromosphere.

5. Emerging Flux

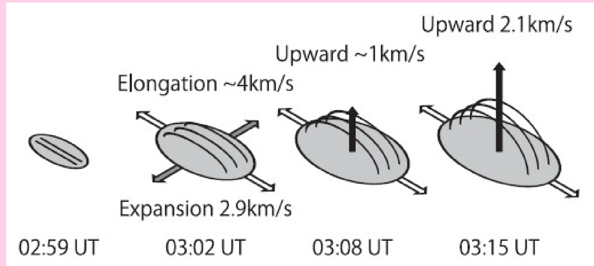
Otsuji et al. 2010, PASJ, 62, 893

Case study of emerging magnetic fluxes.





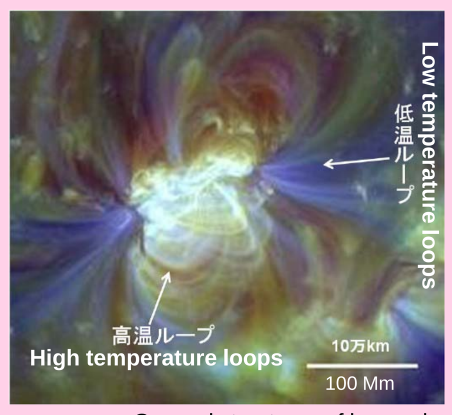
1. The small preceding Ca filament appeared in the SOT filtergram at 02:50 UT without any Stokes I darkening or horizontal field increase. The width of the preceding Ca filament reached a maximum of 0."62 at 02:53 UT with a lateral expansion speed of 2.7 km/s.
2. The Doppler shift of Ca II K2 showed a blue shift from 02:56 UT with an acceleration of -8x10^{-3}km/s^2. The observed maximum velocity for the preceding filament was -2.2 km/s at 03:00 UT.
3. The horizontal field increased at 02:56 UT and lasted until 03:18UT, associated with the main Ca filament. Just simultaneously, the dark granular lane in the Stokes I image started to appear.
4. The main Ca filament appeared in the SOT filtergram at 02:59 UT, 3 minutes after the horizontal field emergence. The filament grew with an elongation speed of ~4 km/s and an expansion speed of 2.9 km/s. The main filament reached its maximum width of 1."03 at 03:08 UT. The K2 Doppler velocity was about -1.0 km/s for this 4-minute period. The Ca II K3 image did not show a prominent darkening.
5. Then, the Doppler shift in Ca II K2 corresponding to the main filament exhibited an acceleration of -3x10^{-3}km/s^2 from 03:10 UT. A maximum velocity of -2.1 km/s was observed at 03:15 UT for the main filament.



6. Coronal Heating

Yoshida, Master's thesis, 2013

In order to investigate the difference of heating mechanism of low-temperature coronal loops (1 – 1.5 MK) and high temperature loops (> 2 MK), we observed chromosphric and photospheric brightness, velocity and magnetic fields etc.



General structures of low and high temperature coronal loops.

Chromospheric brightness:
[Quiet region] < [Low T loops] < [High T loops]

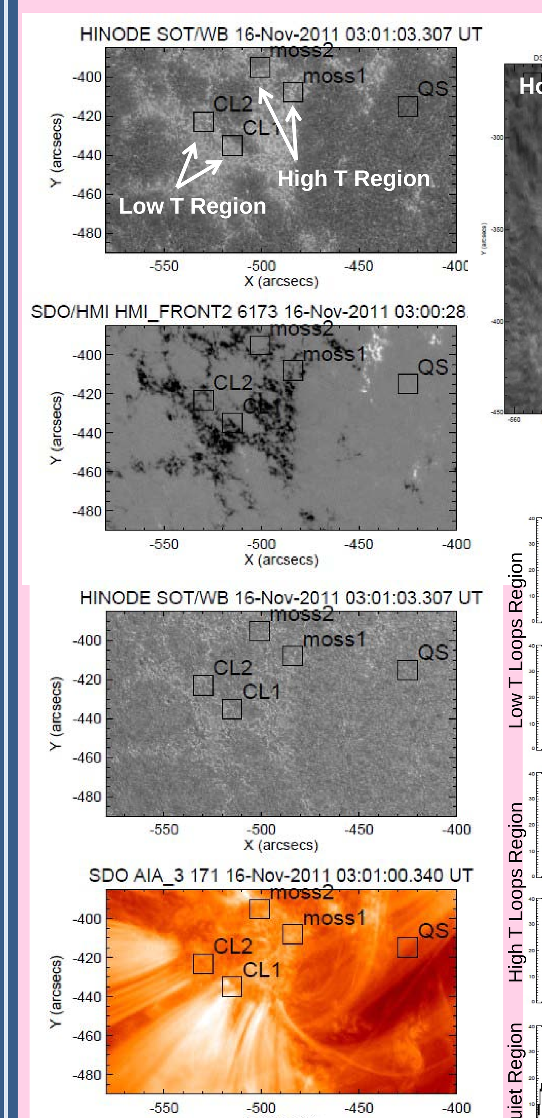
Chromospheric Line Width (Temperature):
[Quiet region] < [Low T loops] ≲ [High T loops]

Chromospheric Doppler Red-shift:
[Quiet region] < [Low T loops] ~ [High T loops]

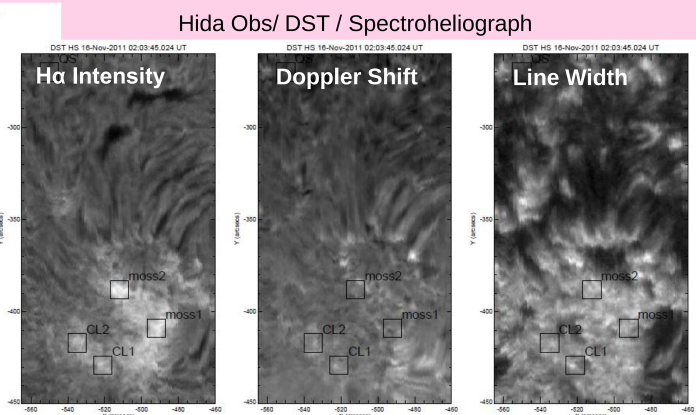
Photospheric brightness:
[Quiet region] < [High T loops] < [Low T loops]

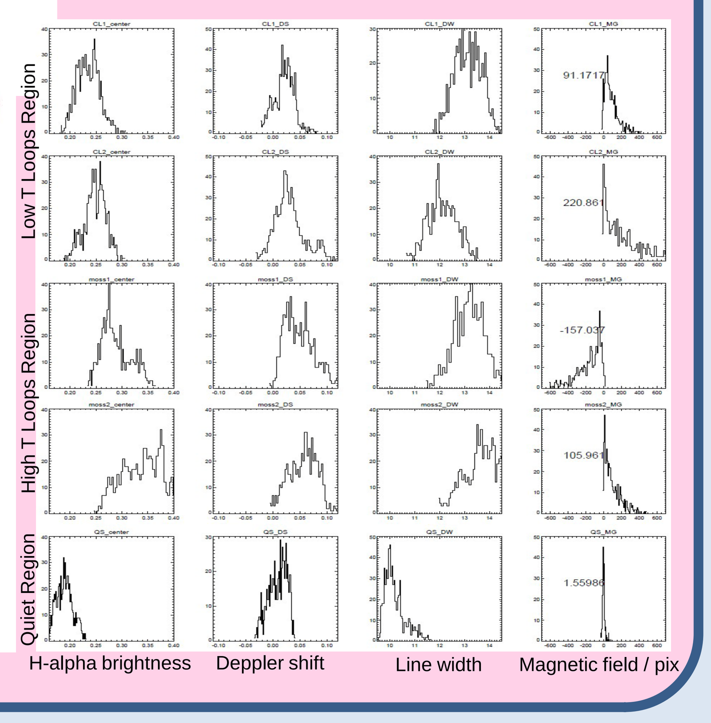
Photospheric magnetic field:
[Quiet region] < [High T loops] < [Low T loops]

Therefore, Photospheric oscillation of magnetic field => Coronal heating => Chromospheric heating ?



Hida Obs/ DST / Spectroheliograph

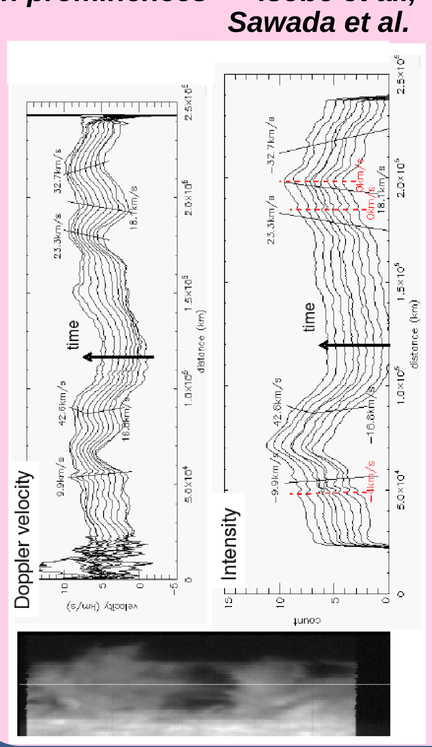




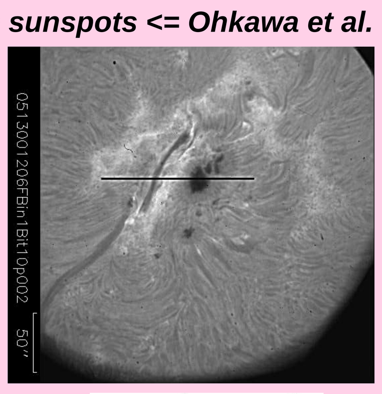
7. Wave Propagation in the chromosphere

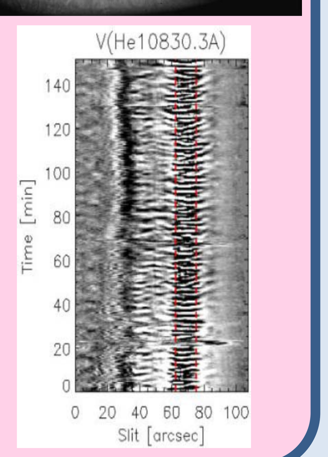
(Ongoing analysis)

In prominences <= Isobe et al., Sawada et al.



In sunspots <= Ohkawa et al.





8. Educational Effects of these cooperative observations

Achieved effects:

K. Yoshida => **Master's thesis (2013)**
Theme: Relation between coronal temperature and chromospheric characteristics

S. Sawada => **Graduation thesis (2013)**
Theme: Oscillation of magnetic fields and plasma in prominences and dark filaments

K. Otsuji => **Doctoral thesis (2011)**
Theme: Observational studies of emerging flux regions

Y. Hashimoto => **Master's thesis (2010)**
Theme: Dynamic phenomena in the chromosphere

T. Anan => **Master's thesis (2010)**
Theme: Wide-range wavelength spectro-polarimetry of chromospheric jets

T. Nakamura => **Master's thesis (2009)**
Theme: Observation and Simulation of chromospheric jets.

Ongoing effects:

T. Anan => **Doctoral thesis**
Theme: Magnetic field and electric field around solar jets

A. Oi => **Doctoral thesis**
Theme: Magnetic field and gas dynamics in the super-penumbra

A. Ohkawa => **Master's thesis**
Theme: Oscillation of the magnetic field and plasma on the sunspot

S. Sawada => **Master's thesis**
Theme: Oscillation of the magnetic field and plasma in prominences and dark filaments

Y. Kato => **Graduation thesis**
Theme: Three dimensional structure and evidences of magnetic reconnection at chromospheric jets (Ellerman bombs)

N. Mohri => **Graduation thesis**
Theme: Three dimensional structure and evidences of magnetic reconnection at solar flares