New insights from Hinode-VTT **He10830** observation

Ryohko Ishikawa (NAOJ/Univ. Tokyo)

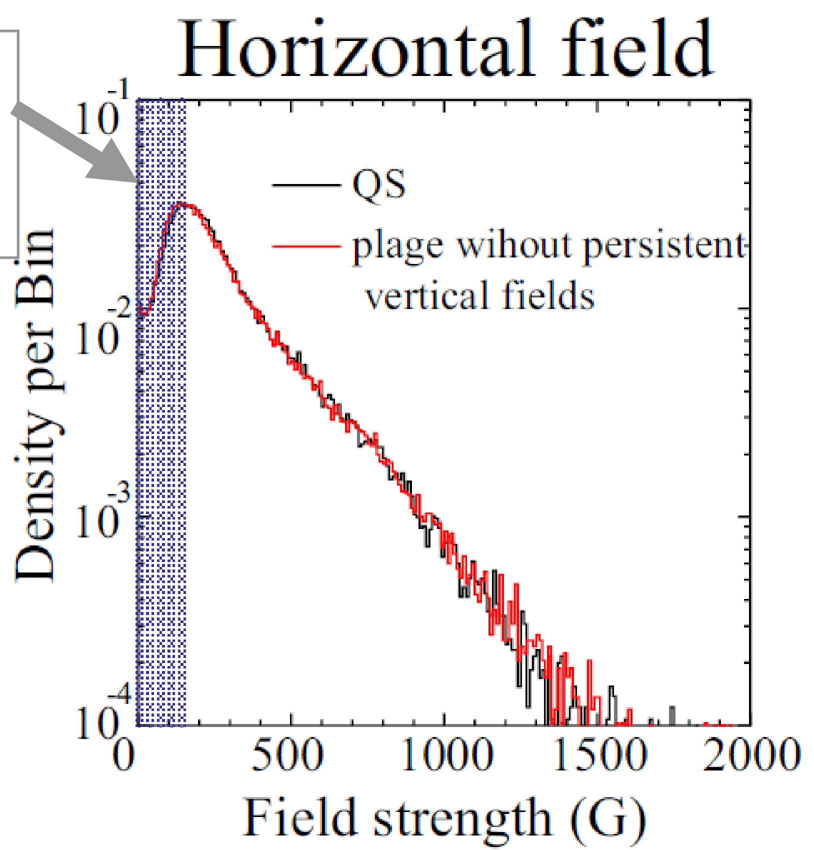
Saku Tsuneta (NAOJ)

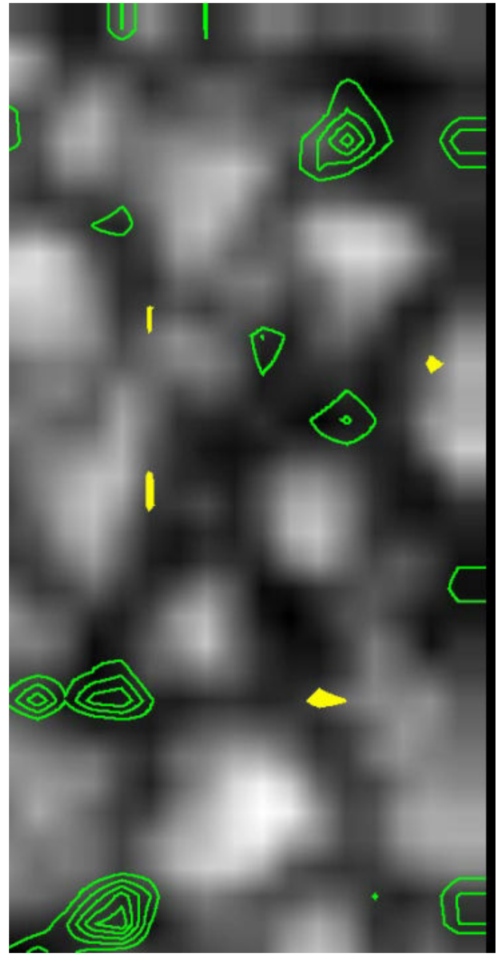
Andreas Lagg (MPS)

Hinode-VTT joint campaign (HOP71)
(2008/04/29-2008/05/12)

Purpose: Finding chromospheric counterparts of THMFs (transient horizontal fields) seen in the photosphere

Green: Vertical field, 13G
Yellow: THMF, 140G





Cutoff due to the threshold and/or the sensitivity issue of Zeeman effect

?

Hidden magnetism as revealed with Hanle effect (Trujillo Bueno et al. Nature 2004)

THMFs reach the chromosphere?

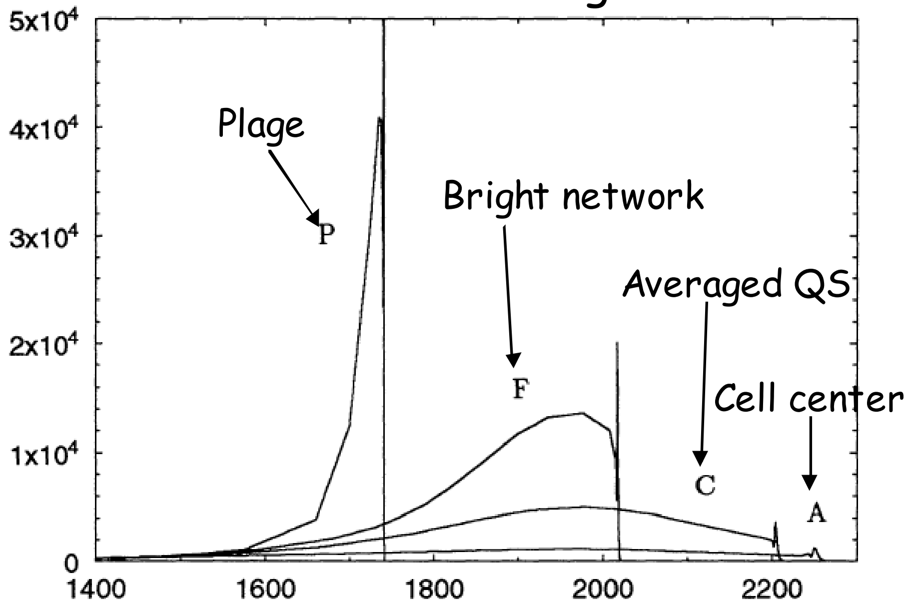
$$\boxed{\frac{B^2}{8\pi} \approx P \qquad B \approx \sqrt{8\pi P}}$$

Pph; Gas pressure @ photosphere
Bph; field strength of THMFs @ photosphere, average: 400 G

Chromosphere: ~10^{6} m = 1000 km = 10 Hp
Pch ~ e^{-10}Pph → Bch ~ e^{-5}Bph = **2.7 G**

The magnetic field would be detected only by Hanle effect

Number density of $2s^3S$ level of He I vs Height



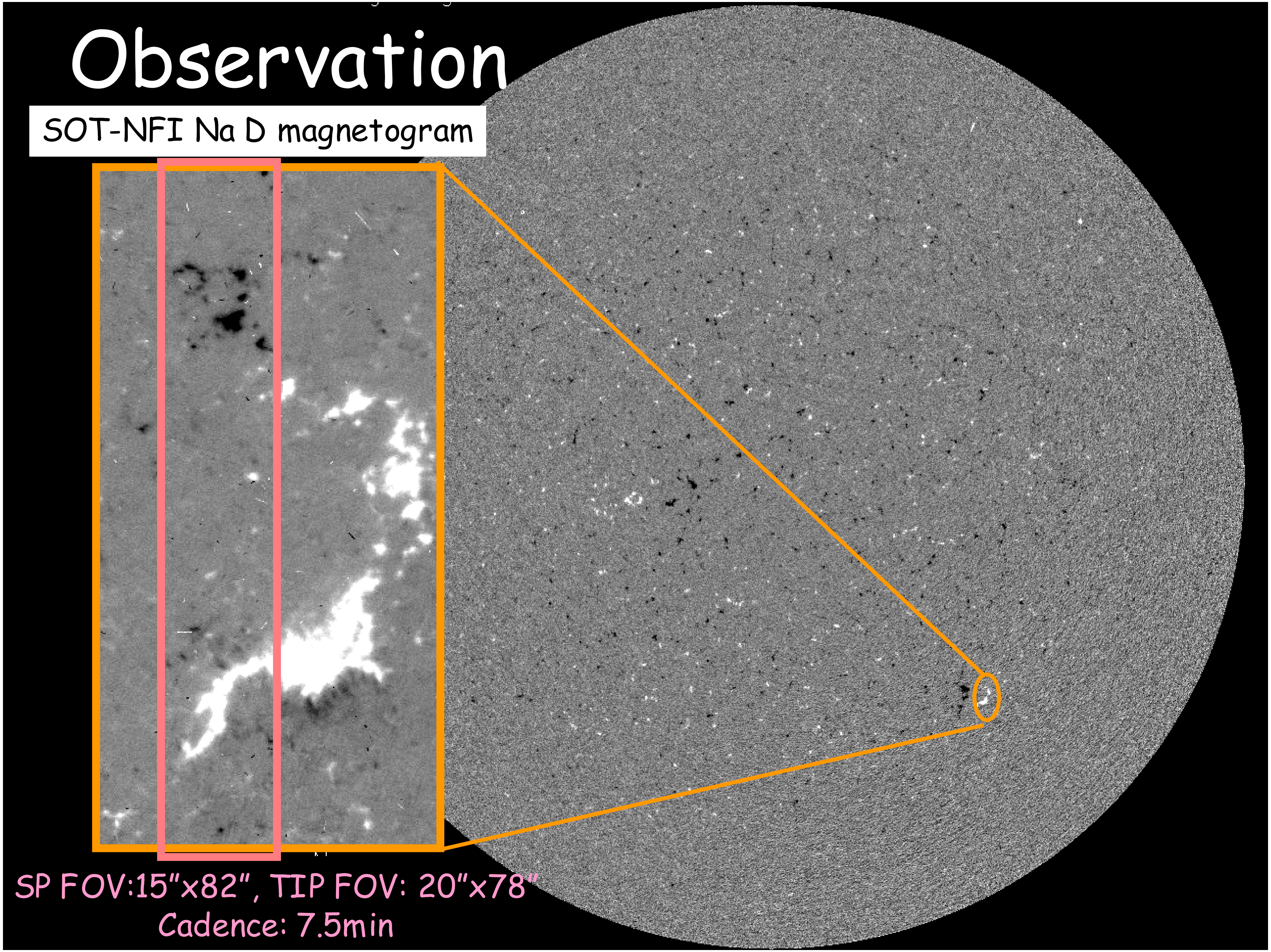
Avrett et al. 1994

VTT-TIP He 1083 nm

+A few G to kG magnetic field can be detected with Hanle and Zeeman effect
+Inversion of Stokes profiles is available (understood)
+Simultaneous observation with photosphere of Si (easy to perform alignment with Hinode/SOT)

1083nm: $2s3S\text{-}2p^3p^0$ absorption

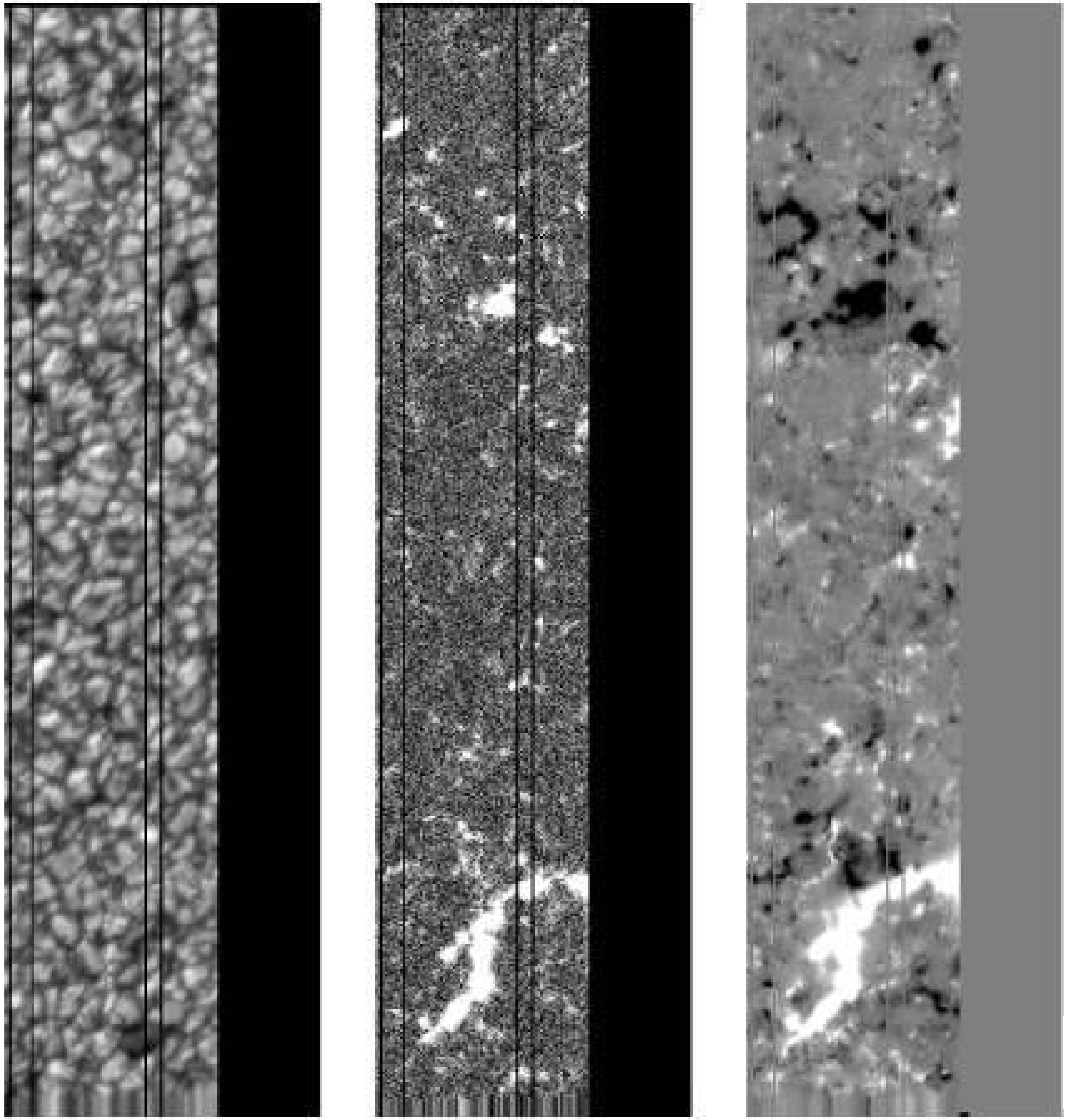
Observation



Photospheric magnetic signals

Hinode/SOT-**SP** FeI 630 nm

Continuum Stokes-I	Linear pol. sqrt(Q^2+U^2)	Circular pol. Stokes-V

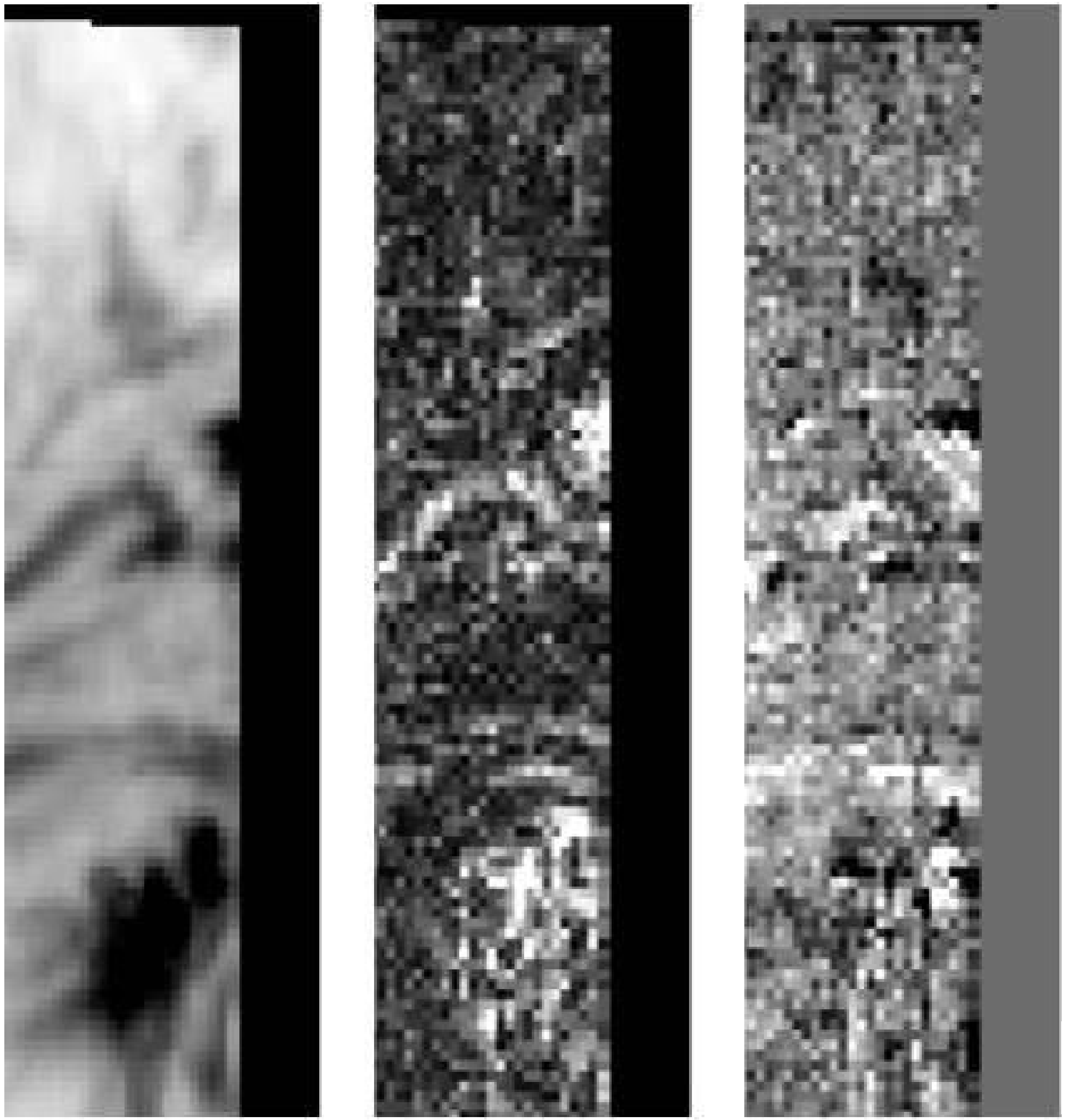


Stokes signals are dominated by **Zeeman** effect.

FOV:15"x82"

Chromospheric magnetic signals

VTT-TIP HeI 1083 nm



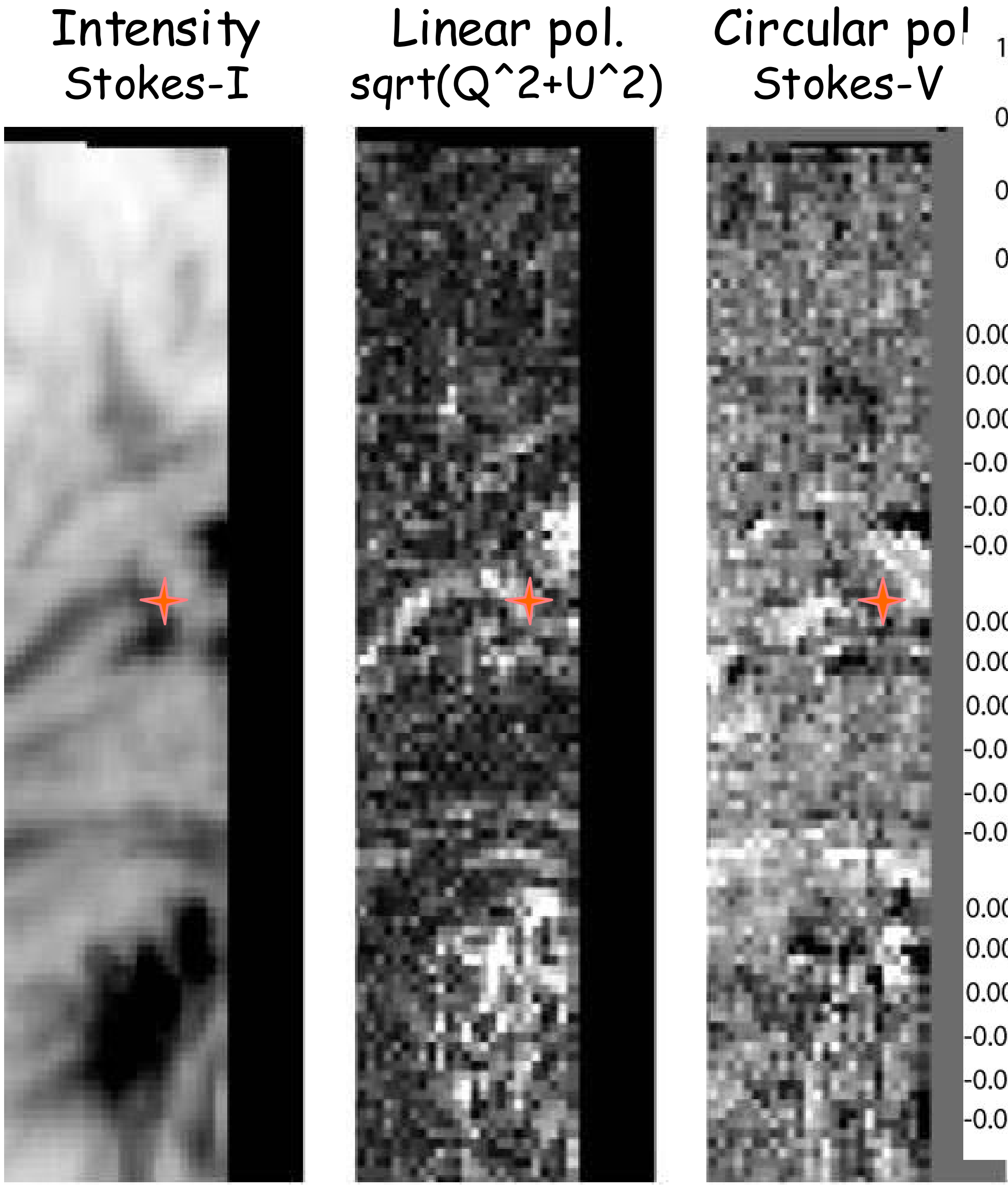
Completely different from photosphere!!!

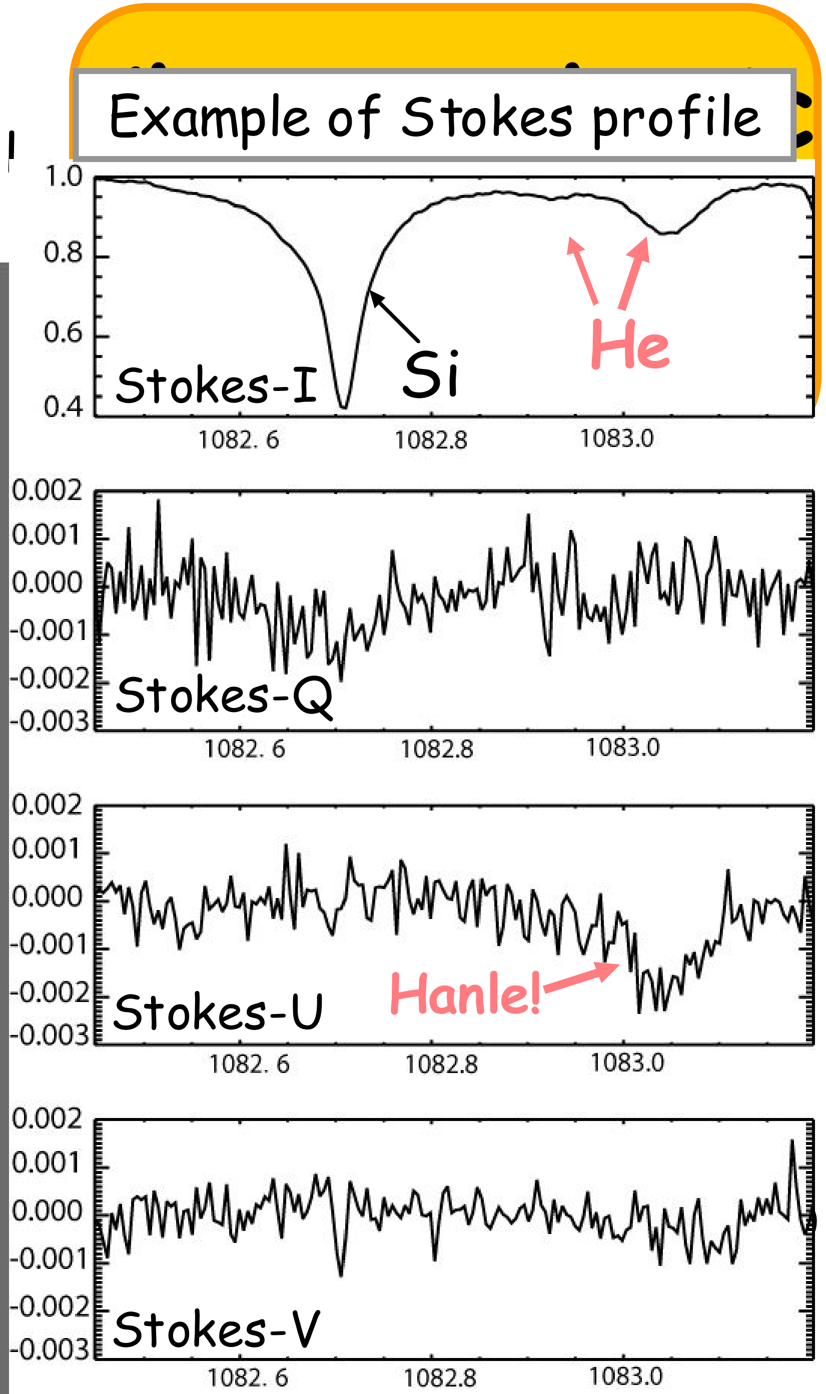
Stokes signals are dominated by **Zeeman** and Hanle.

Integration time: 7sec
S/N: 7x10^{-4}
Spatial resolution:
0.64"(scan direction), 0.72"(slit direction)

FOV:20"x78"

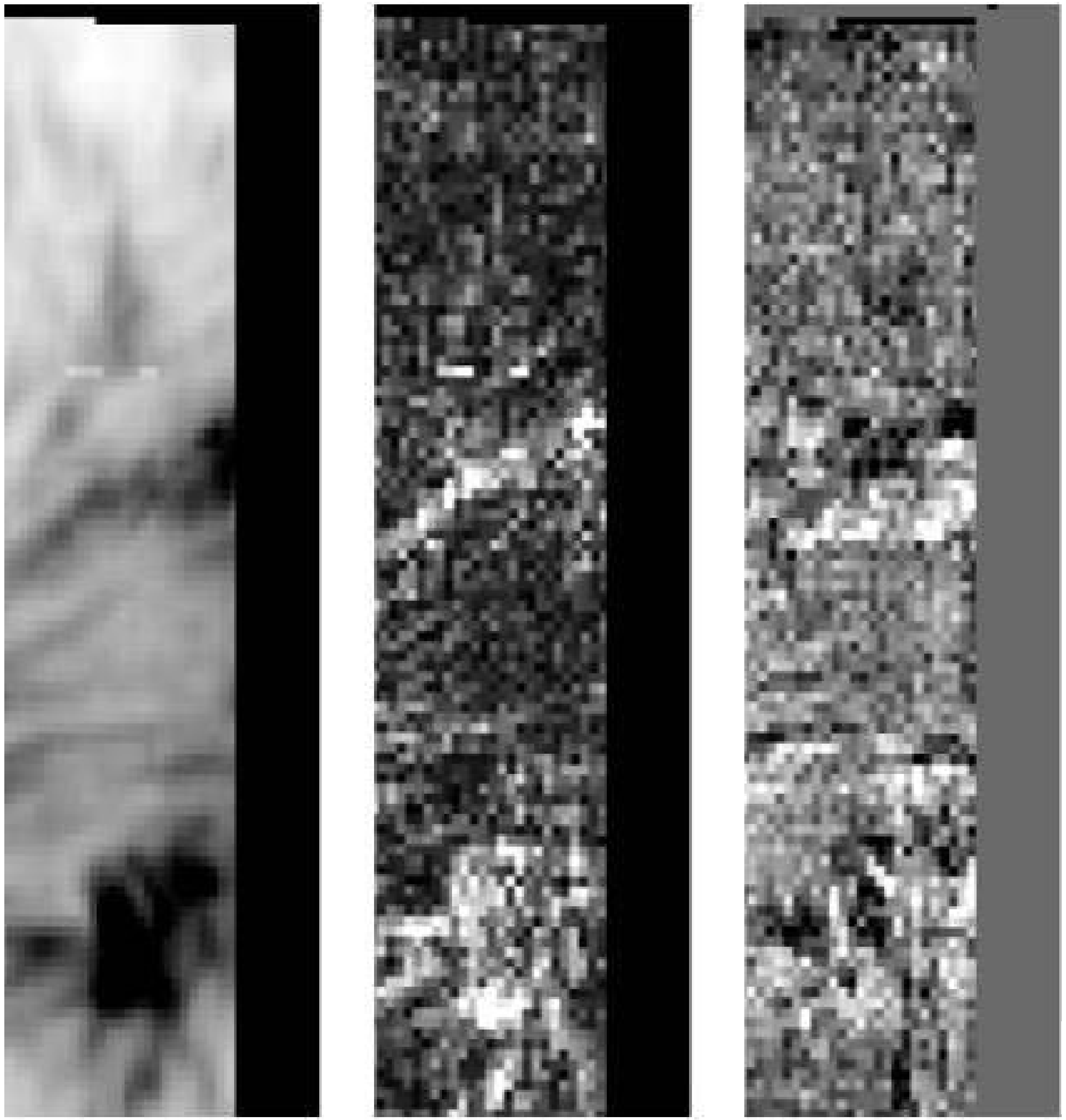
VTT-TIP HeI 1083 nm





Chromospheric mag. signals 7.5 min later

VTT-TIP HeI 1083 nm



FOV:20"x78"

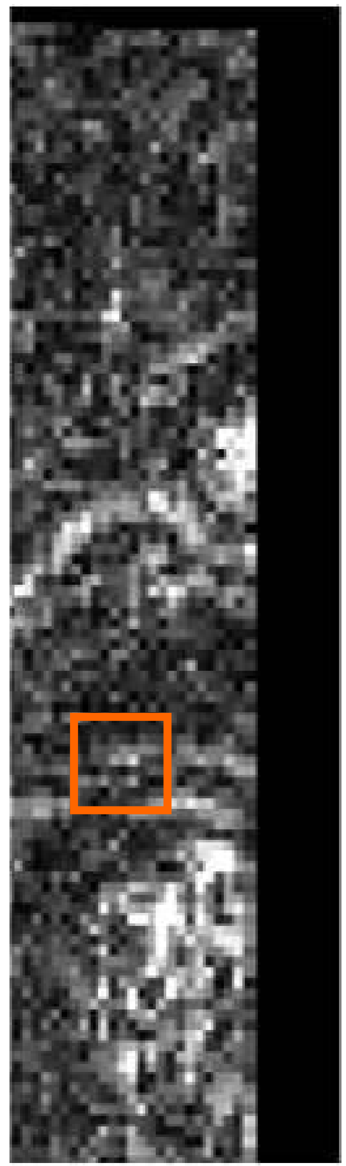
Stokes signals have changed in 7.5 min!!!

Change of LP

↓

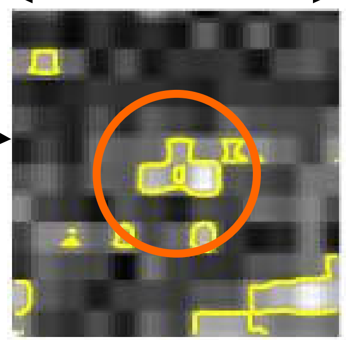
Change of magnetic field vector in Hanle regime (field strength, azimuth, inclination)

Possible case of emerging flux in the chromosphere



8″

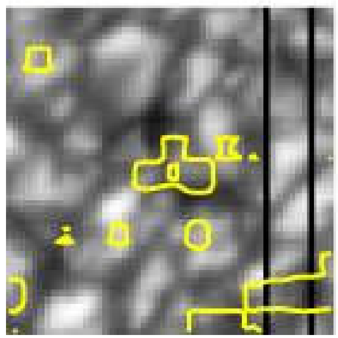
Chromosphere (HeI 1083nm)



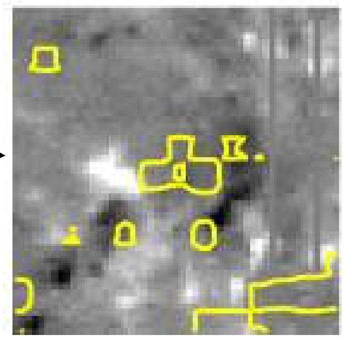
Stokes-I

Linear Pol.

Circular Pol.

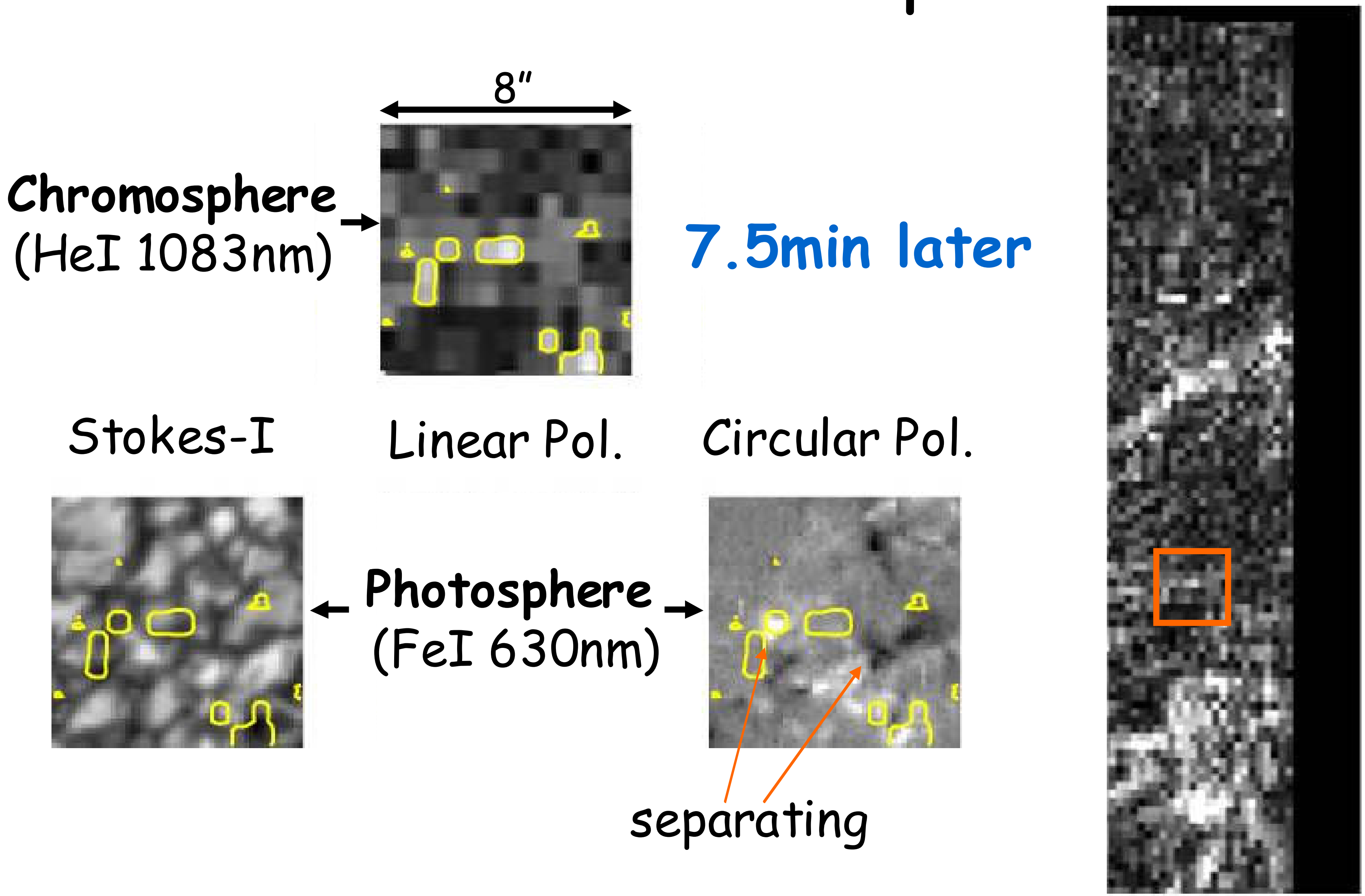


Photosphere (FeI 630nm)

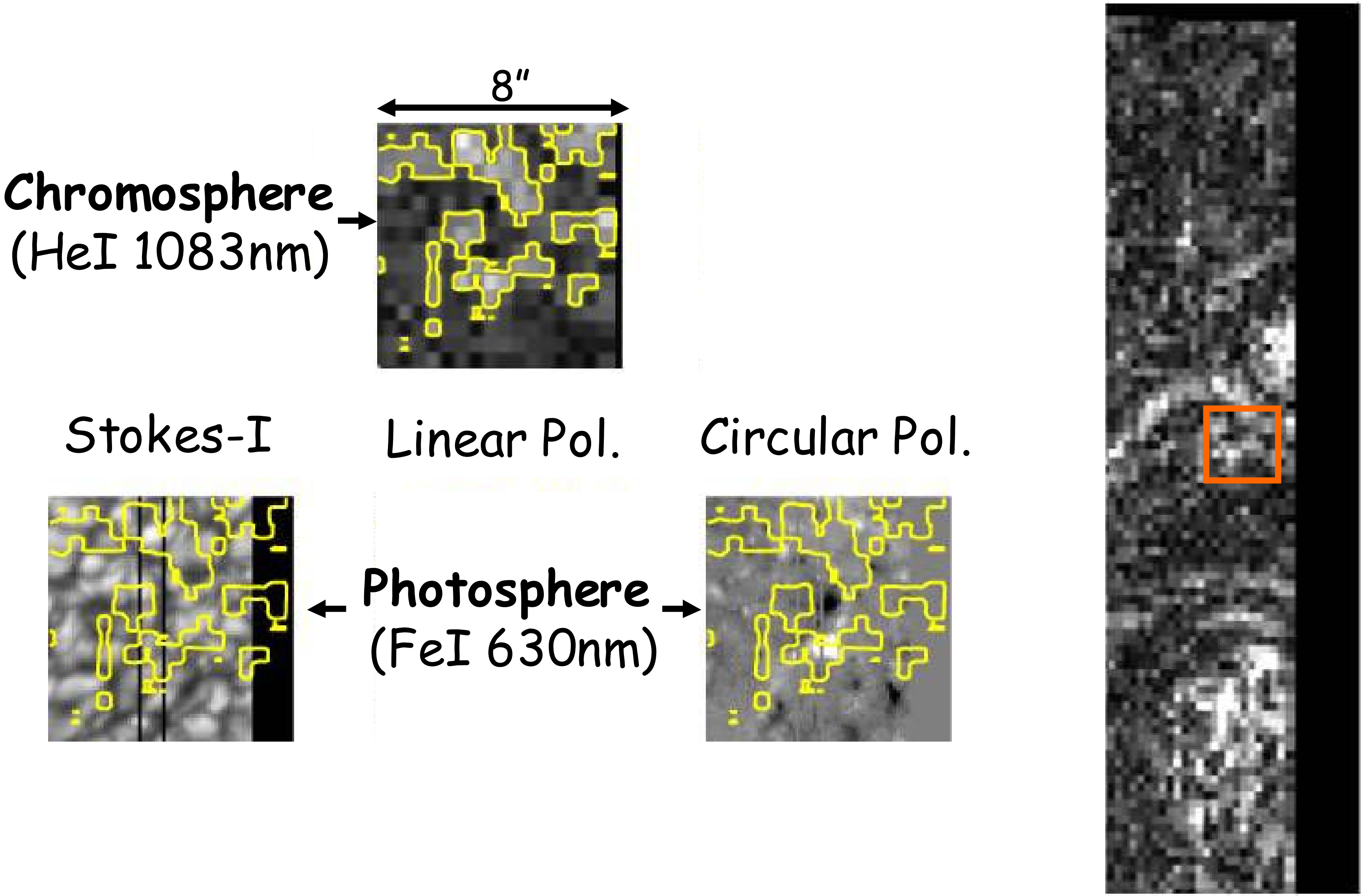


LP between negative and positive patches in the photosphere

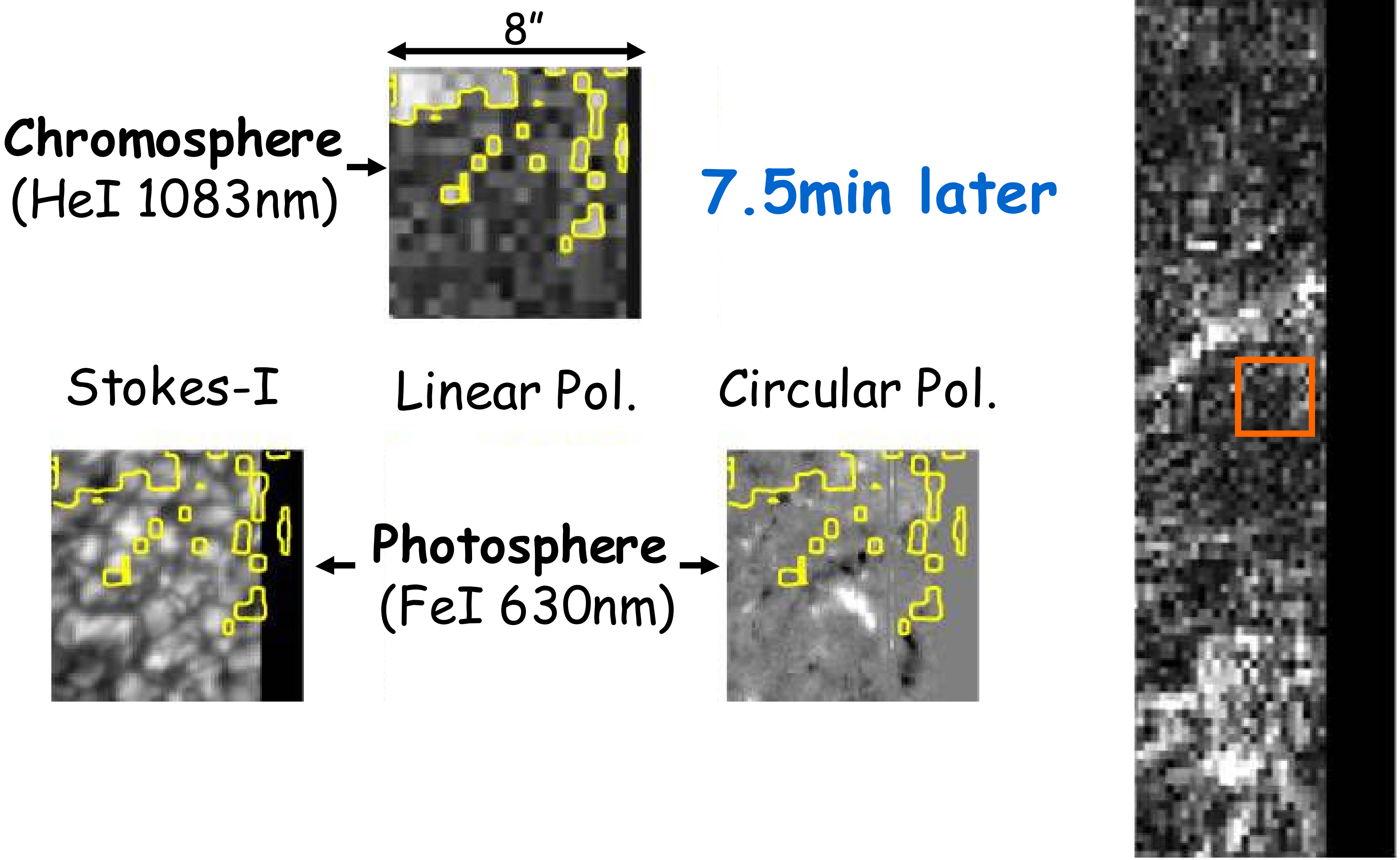
Possible case of emerging flux in the chromosphere



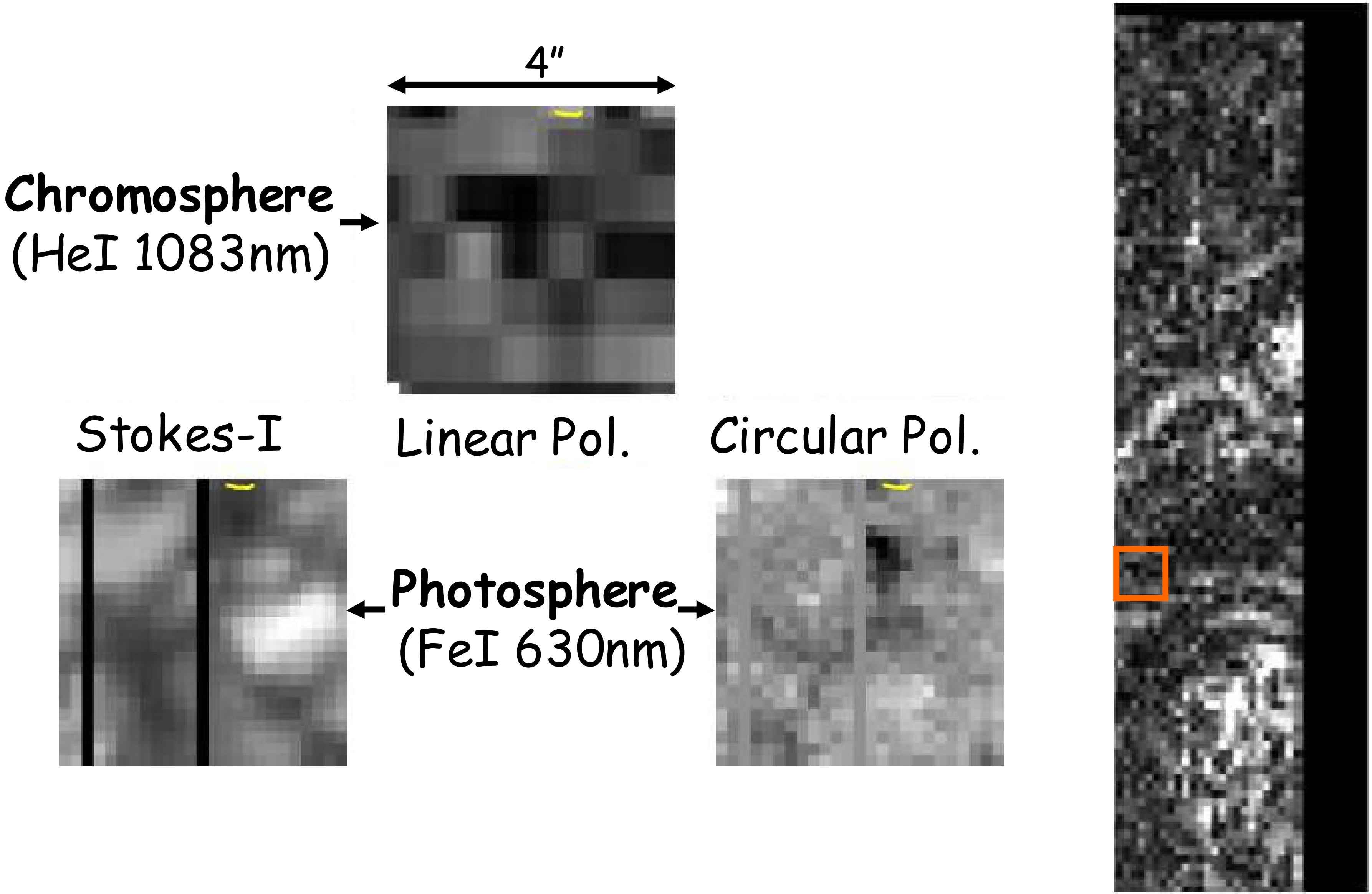
Disappearance of chromospheric fields with photospheric magnetic cancellation



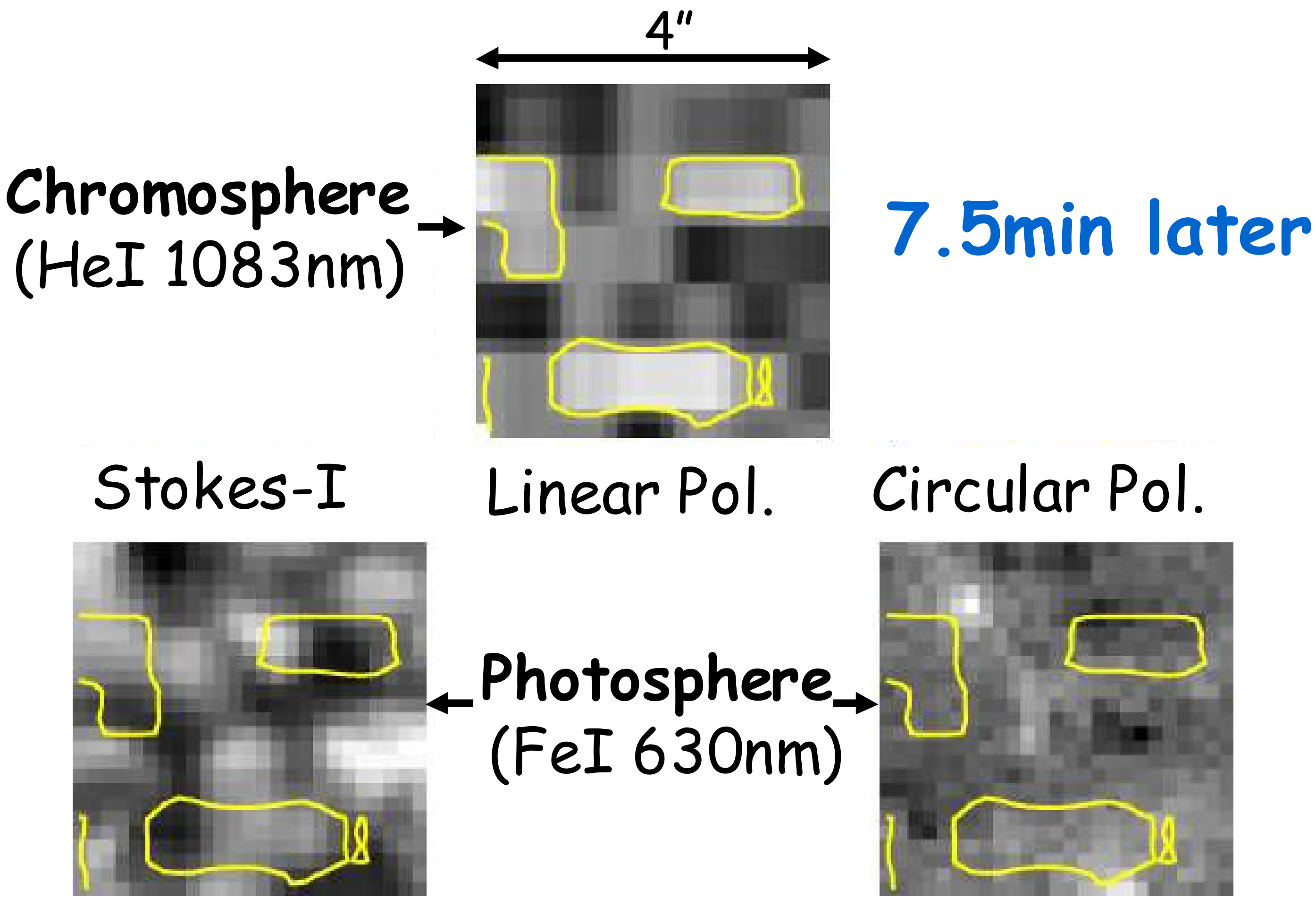
Disappearance of chromospheric fields with photospheric magnetic cancellation

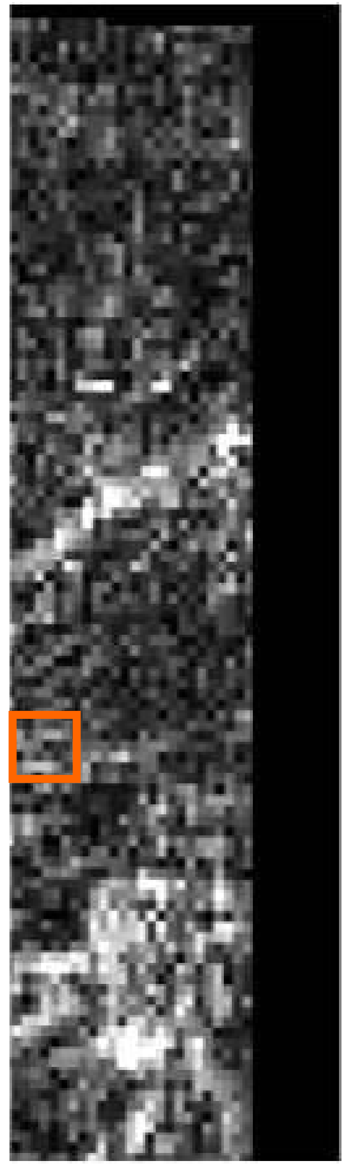


Sudden appearances of chromospheric magnetic fields without photospheric signature



Sudden appearances of chromospheric magnetic fields without photospheric signature





Significant difference in photospheric magnetic fields are not seen.

New insights from He 1083nm

- Chromospheric magnetic fields appear to be completely different from photosphere: for example.
  - Chromospheric small loops with the size of a few granules are detected.
  - Magnetic signals without photospheric counterparts are also found.

  Nice feature of He 1083
  - Purely chromospheric
  - Enable us to detect 1G to a few kG with Hanle & Zeeman effects
  - Easy to interpret (inversion code is already available)

  Lessons learned from Hinode observation
  - Long integration can be done, and we will be able to detect much weaker magnetic signals.
  - Spectro-polarimetry is compatible with high spatial resolution.

  Disadvantage
  - He 1083 nm needs coronal illumination, and it may be difficult to observe the pure quiet region. Further verification should be needed.
  - Spatial resolution (0.5"@50cm telescope) is not as good as that in visible light.
- **Seeing free He 1083** observation potentially brings us to the new world of chromospheric magnetic fields.

S/N comparison between VTT and Solar-*C*

VTT-TIP He 1083nm
Integration time: 24sec
S/N: 4x10^{-4}
Pixel size: 0.5"

Size of telescope
Solar-*C*:50cm
VTT:70cm

→ Factor of (5/7)^2 gain

Telescope and spectrograph throughput
Solar-*C*:13.4% (assume SOT-SP at 630.2nm)
VTT:1% (assume 70% atmosphere transmission)

→ Factor of 13.4 gain

Quantum efficiency of detector
Solar-*C*:60% (NICMOS)
VTT:60% (NICMOS)

→ Factor of 1 gain

S/N comparison between VTT and Solar-C

VTT-TIP He 1083nm

Integration time: 24sec

S/N: 4x10^{-4}

Pixel size: 0.5"

Total gain of Solar-C relative to VTT:
Factor of 7 gain

Solar-C exposure time :
24 sec/7 < **4sec**

Quantum efficiency of detector
Solar-C:60% (NICMOS)
VTT:60% (NICMOS)

Factor of 1 gain

S/N comparison between VTT and Solar-C

VTT-TIP He 1083nm
Integration time: 24sec
S/N: 4x10^{-4}
Pixel size: 0.5"

Total gain of Solar-C relative to VTT:
Factor of 7 gain

Solar-C exposure time :
24 sec/7 < **4sec**

Quantum efficiency of detector

50cm Solar-C telescope is factor of 7 more sensitive than VTT

+Achieve better S/N by increasing integration time
+Scan with higher cadence keeping the good S/N
+Achieve better spatial resolution keeping good S/N