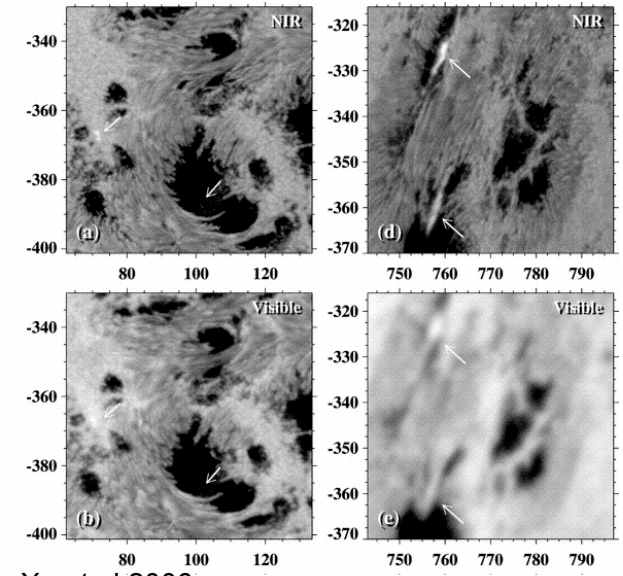
Some further diagnostics

- Continua (blue, visible, IR)
- Molecular bands
- Non-magnetic photospheric lines
- Chromospheric lines (dynamics, density)

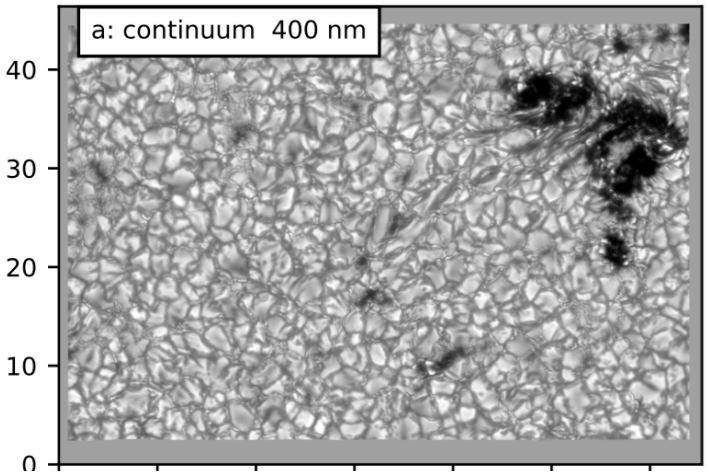
1. Continua

- Visible continuum formed at “base of photosphere”: h~ 0 km (τ_{5000} = 1)
- IR continuum at ~ 1.5 μm forms at continuum opacity minimum – h ~ – 50 km

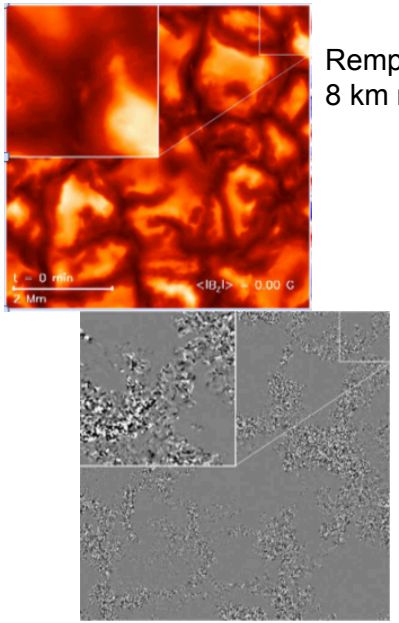
Granulation, intergranular “bright points” (magnetic?), horizontal motions. Occasionally, WL flares



Xu et al 2006



Leenaarts et al 2017, SST (~ 70 km res.)

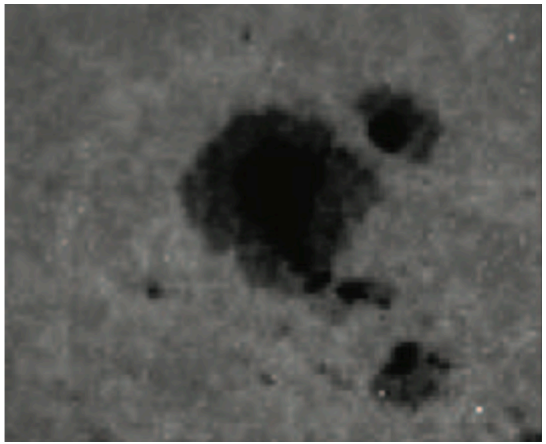


Rempel 2014
8 km res.

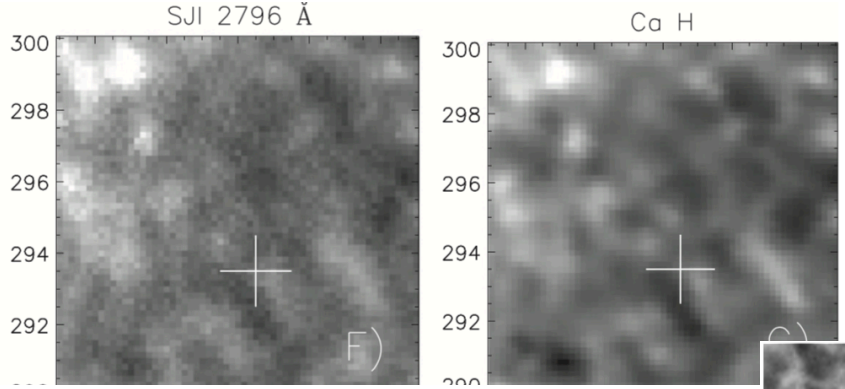
1. Continua

- IR continuum (~ 3-4 μm and above) forms higher in the atmosphere, ~ mid-photosphere (like, e.g. 170nm channel of AIA, or IRIS SJI 279.6)

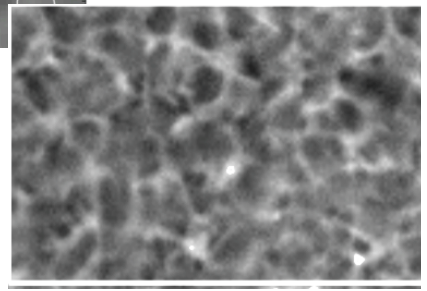
Reverse granulation, waves, shocks



Penn et al 2016, 5 μm



Martinez-Sykora et al 2015, 5 μm



CaII 854.2 wing; Janssen & Cauzzi 2006

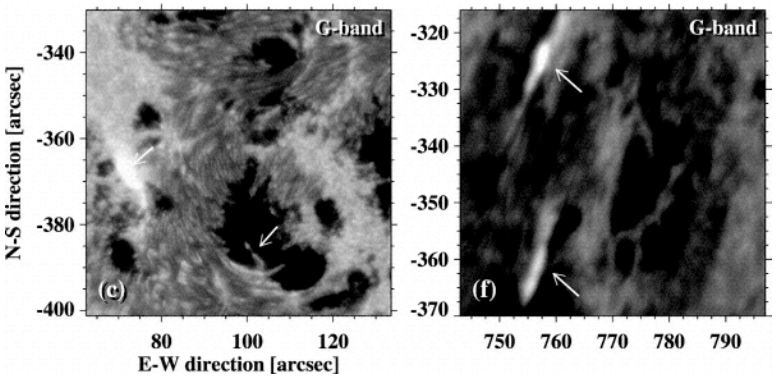
1. Continua: DKIST instruments

- ALL visible range: 390 – 900 nm (VISP)
- 450.3 (VBI blue) ; 668.4 nm (VBI red)
- Broadband filters (VTF, currently ~590, 630, 660, 860 nm)
- 860 nm (DL-NIRSP)
- ~ 1 μm (DL-NIRSP, CRYO-NIRSP)
- ~1.5 μm (DL-NIRSP, CRYO-NIRSP)
- ~ 4 μm (CRYO-NIRSP)

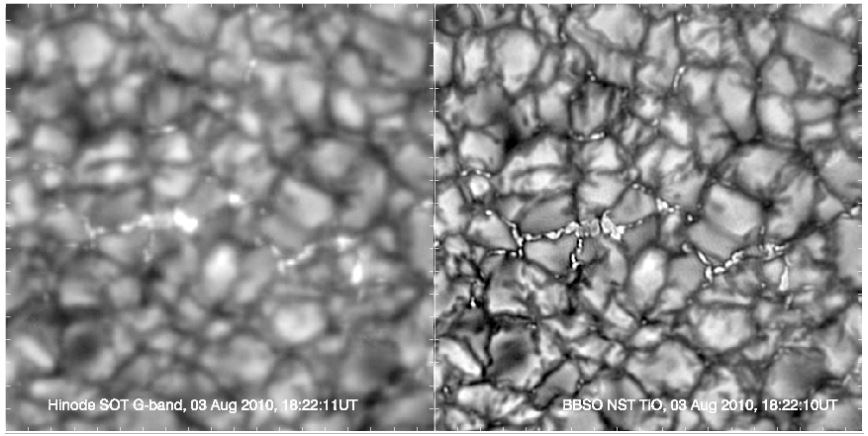
2. Molecular lines, bands

- Formed in the low photosphere, provide large intensity contrast for “hot” vs. “cold” structures (strong T dependence of opacity). E.g. TiO, CN (G-band), CH.

Granulation, intergranular “bright points”, horizontal motions. Occasionally, WL flares.



Xu et al 2006



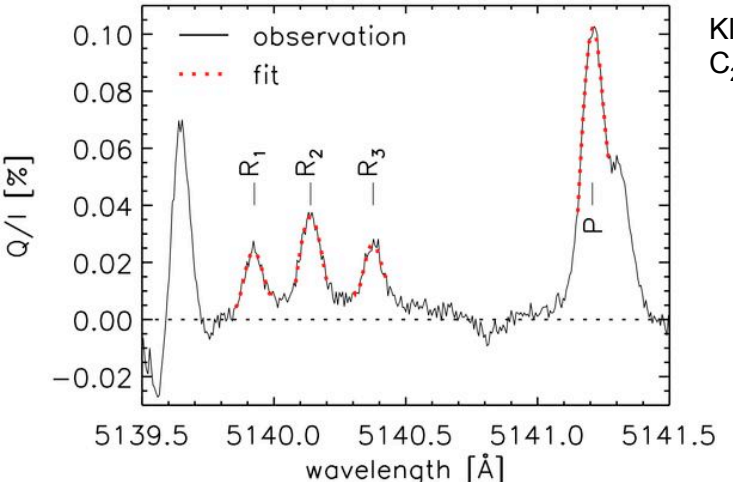
NST 2010. TiO vs Hinode G-band

2. Molecular lines, bands

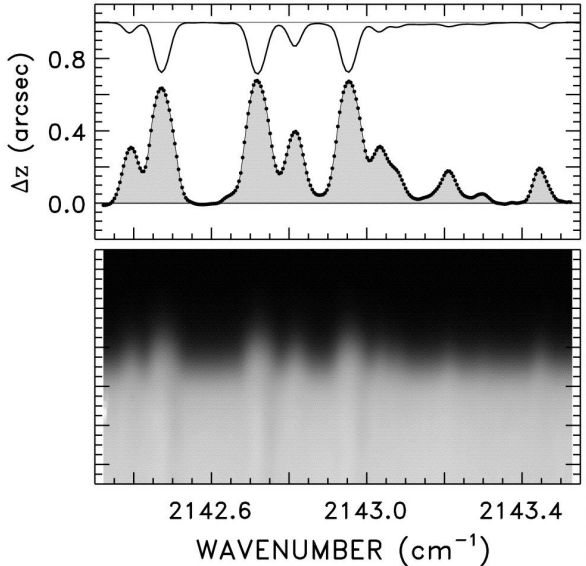
- Sensitive to Hanle effect, e.g. MgH, C_2 lines.
- Presence of molecular lines indicate low temperatures – e.g. CO roto-vibration transitions at 4.7 μm, require $T_e < 3700$ K.

Investigate small scale, tangled magnetic fields in the photosphere (e.g. via differential Hanle effect)

Investigate spatio-temporal structure of low chromosphere, presence of cold bubbles ?



Kleint et al 2010;
C_2 R triplet + P triplet



Ayres, 2002;
Emission 7-800 km
above limb

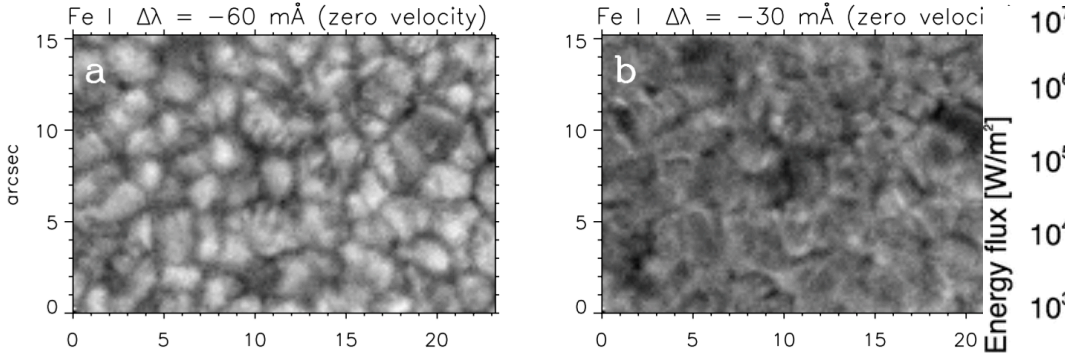
2. Molecular lines: DKIST instruments

- ALL visible range: 390 – 900 nm (VISP)
- 430.5 (CH band-head; VBI blue) ; 707.8 nm (TiO; VBI red)
- 4.7 μm (CO roto-vibration transitions; CRYO-NIRSP)

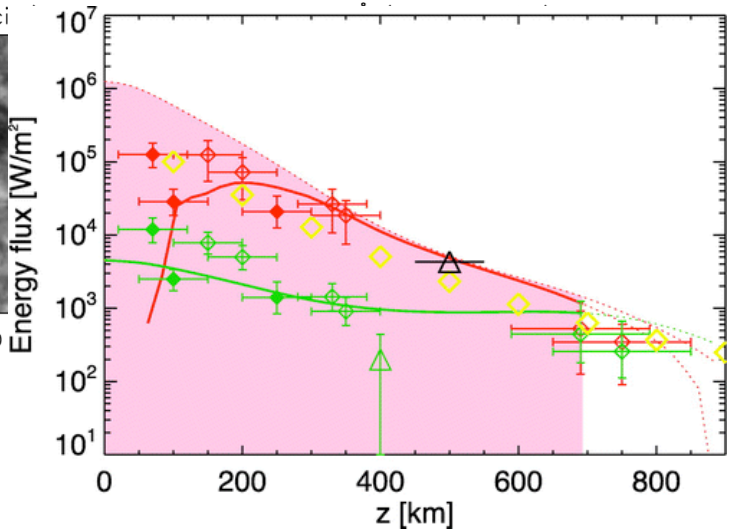
3. Non-magnetic photospheric lines

- Several photospheric lines have g_L =0, so they are not influenced by the presence of magnetic fields. Can be formed over a large span of photospheric heights (e.g. FeII 512.3 FeI 543.4, FeI 567.6; FeI 709.0, FeII 722.4, TiI 839.7 nm).

Accurate thermo-dynamical structure of atmosphere, waves through T_{min}



Janssen & Cauzzi 2006



Straus et al 2008

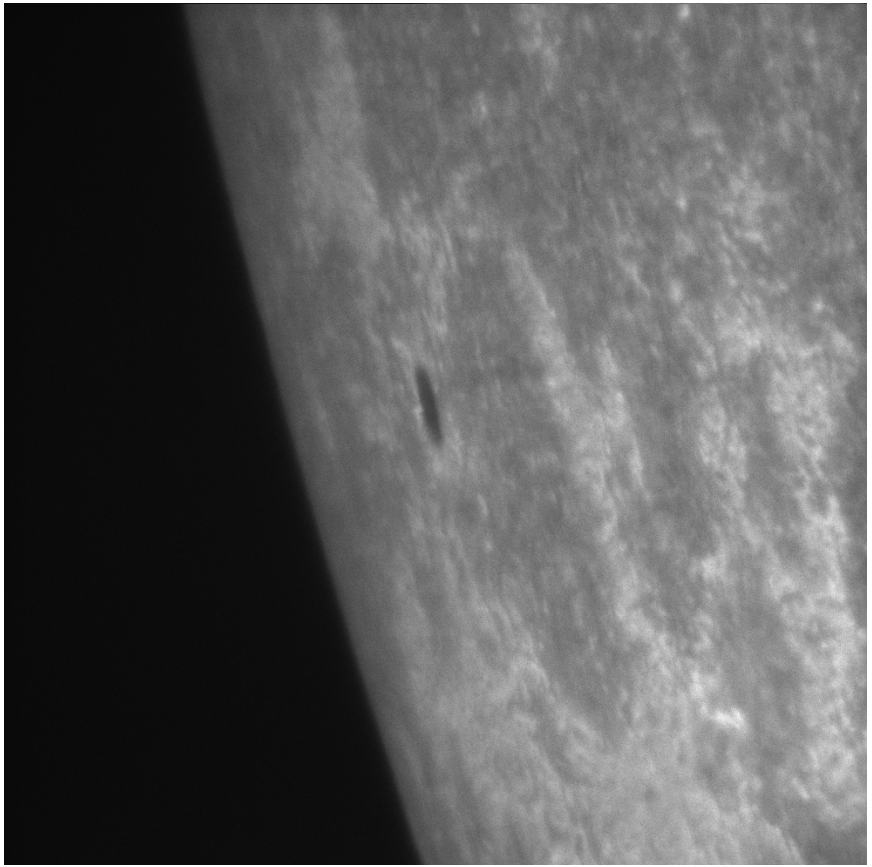
3. Non-magnetic photospheric lines: DKIST instruments

- ALL visible range: 390 – 900 nm (VISP)
- FeI 709.0 nm (VTF, not at first light)

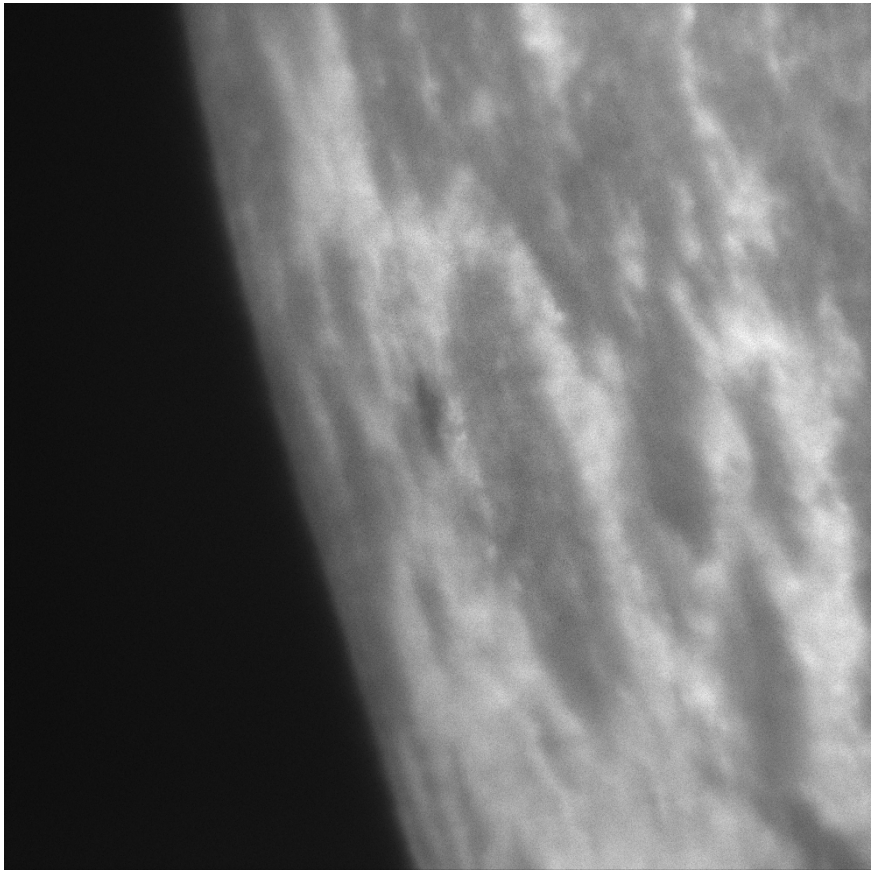
3. Magnetic ~mid-photospheric lines: DKIST instruments

- ALL visible range: 390 – 900 nm (VISP)
- FeI 630.15 nm, Na D_1 589.6 nm (VTF)

K I 7699 Å



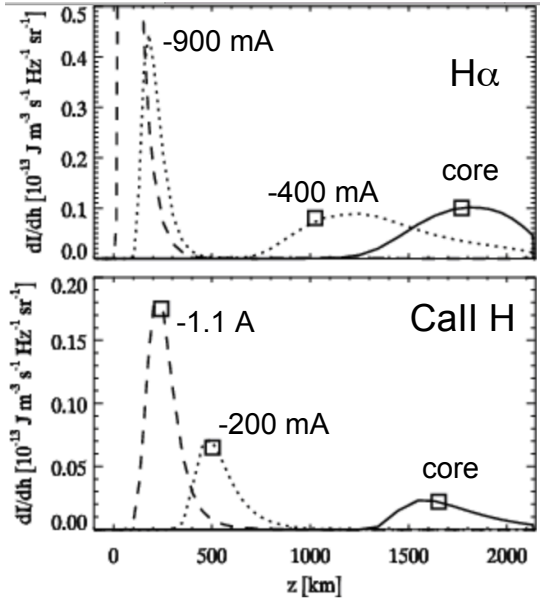
Na D_1 5896 Å

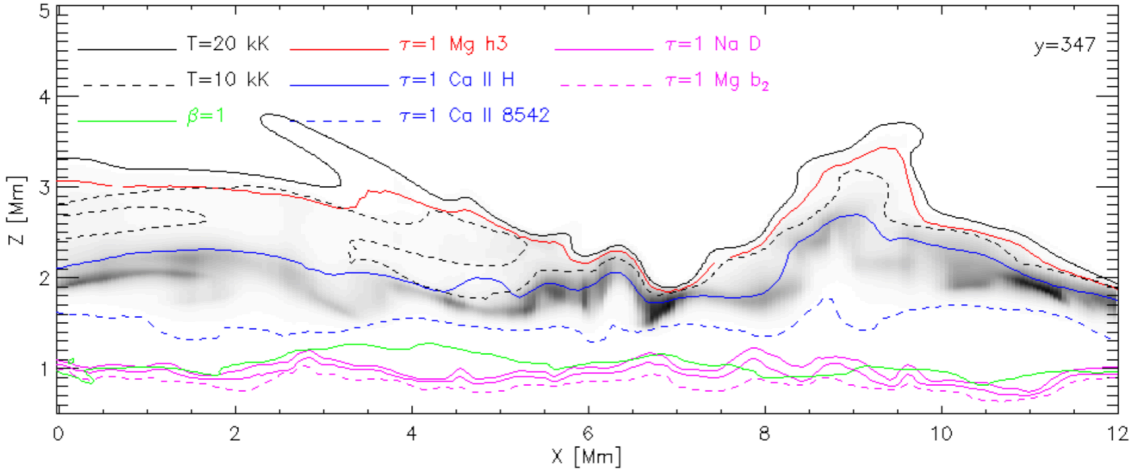


4. Chromospheric lines

- Chromosphere is optically thin in most of the visible/near IR, apart from few strong lines: Balmer and Paschen series, CaII resonance (H&K) and subordinate triplet (849.8, 854.2, 866.2 nm), HeI triplet (1083 nm), subordinate HeI D_3 (587.6 nm)

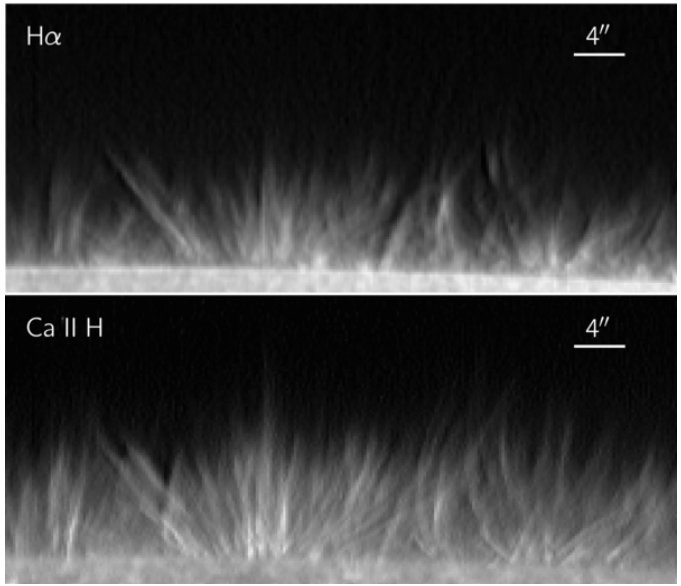
- “Height of formation” is an over-simplification. Lines form over a large span, and heavily depend on local spatio-temporal conditions. HeI also strongly depends on local UV irradiation.



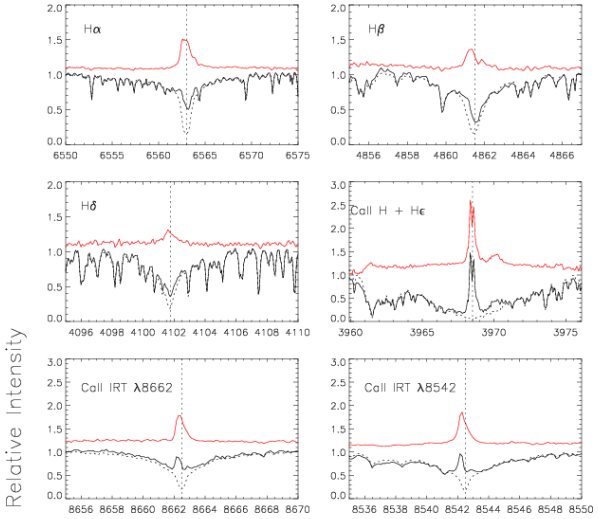


4. Chromospheric lines

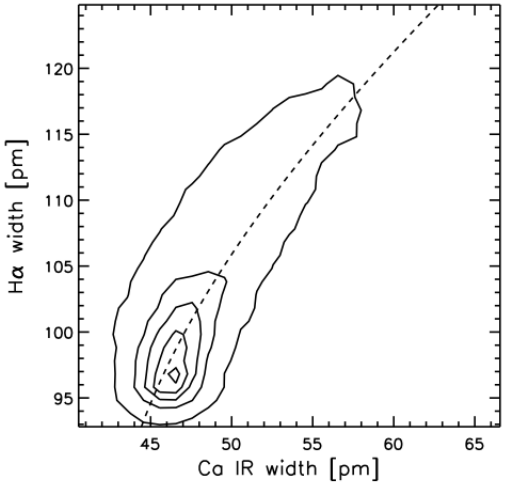
- *Hα, Balmer series: dynamics, temperature, density, depth of TR*
- *Paschen lines: electric fields*
  CaII lines: chromospheric dynamics, temperature
- *HeI: dynamics, density in flares (esp. D_3)*



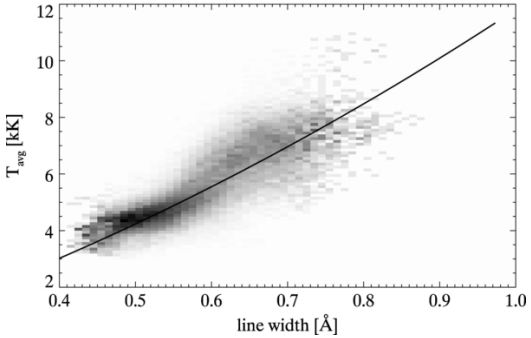
Pereira et al 2013



Garcia Alvarez et al 2005



Cauzzi et al. 2009



Leenaarts et al 2012

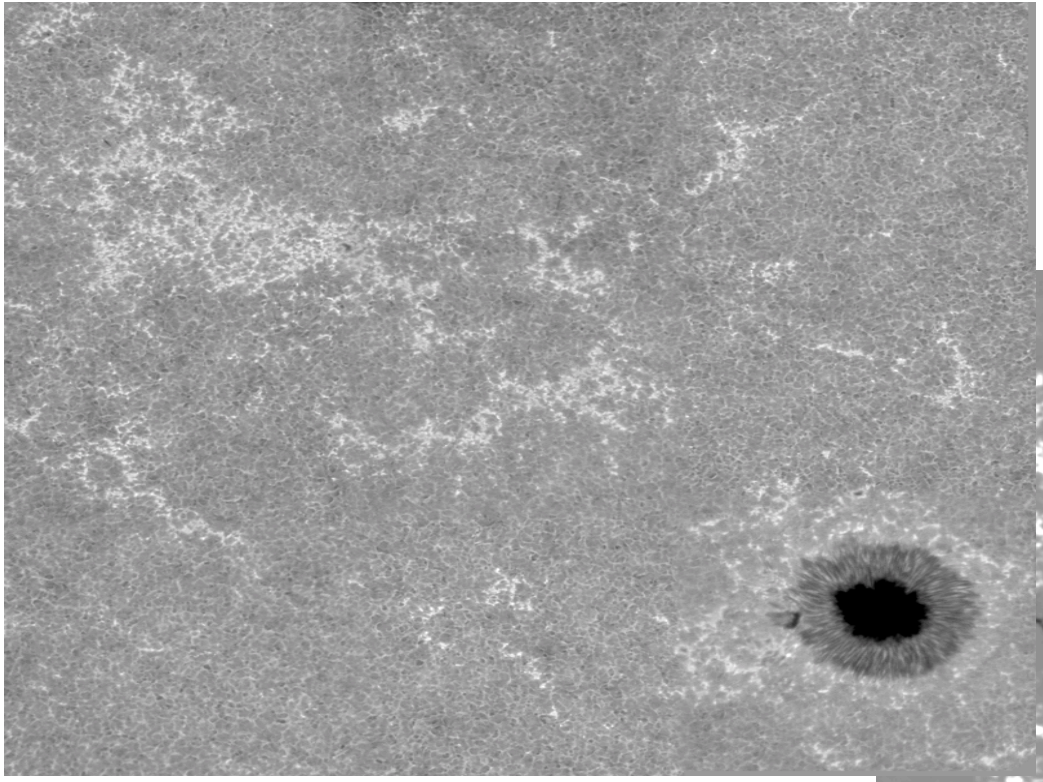
4. Chromospheric lines: DKIST instruments

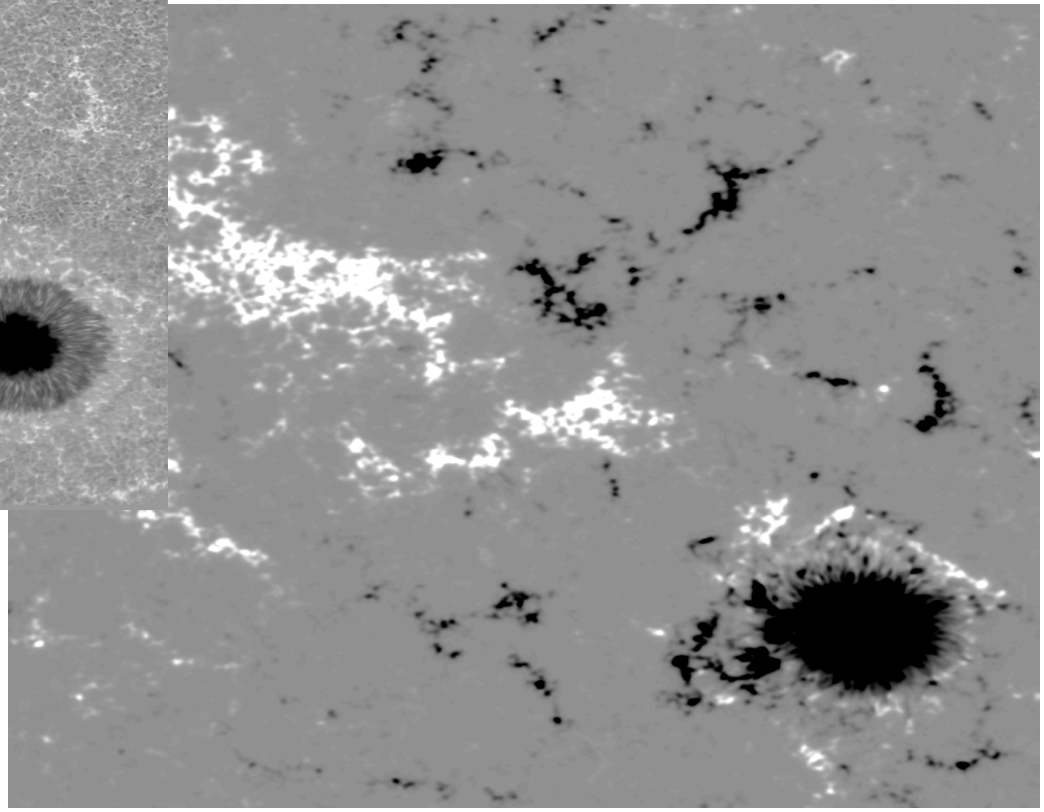
- Balmer series:
  Hα 656.3 nm (VBI, VISP, VTF)
  Hβ 486.1 nm (VBI, VISP)
  Hγ 434.0, Hδ 410.1, Hε 397.0 nm (VISP)
  (Balmer limit is NOT reached by telescope/instruments)

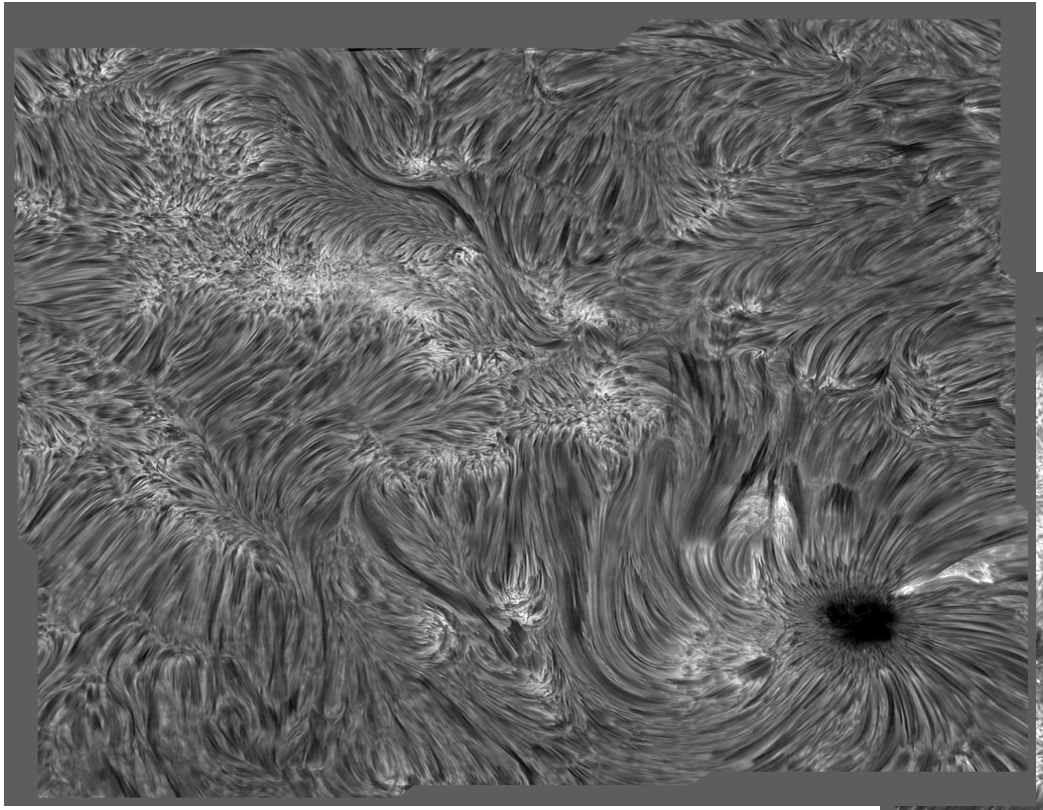
- Paschen series:
  Higher terms of Paschen series (P_{11} and higher; VISP,)
  Paschen limit 820.4 nm (VISP)

- CaII:
  resonance H&K 396.8, 393.3 (VISP,VBI)
  subordinate triplet: 854.2 (VTF, VISP, DL-NIRSP), 849.8 & 866.2 nm (VISP)

- He I:
  ortho-helium triplet 1083.0 nm (DL-NIRSP, Cryo-NIRSP)
  subordinate D_3 587.6 nm (VISP)

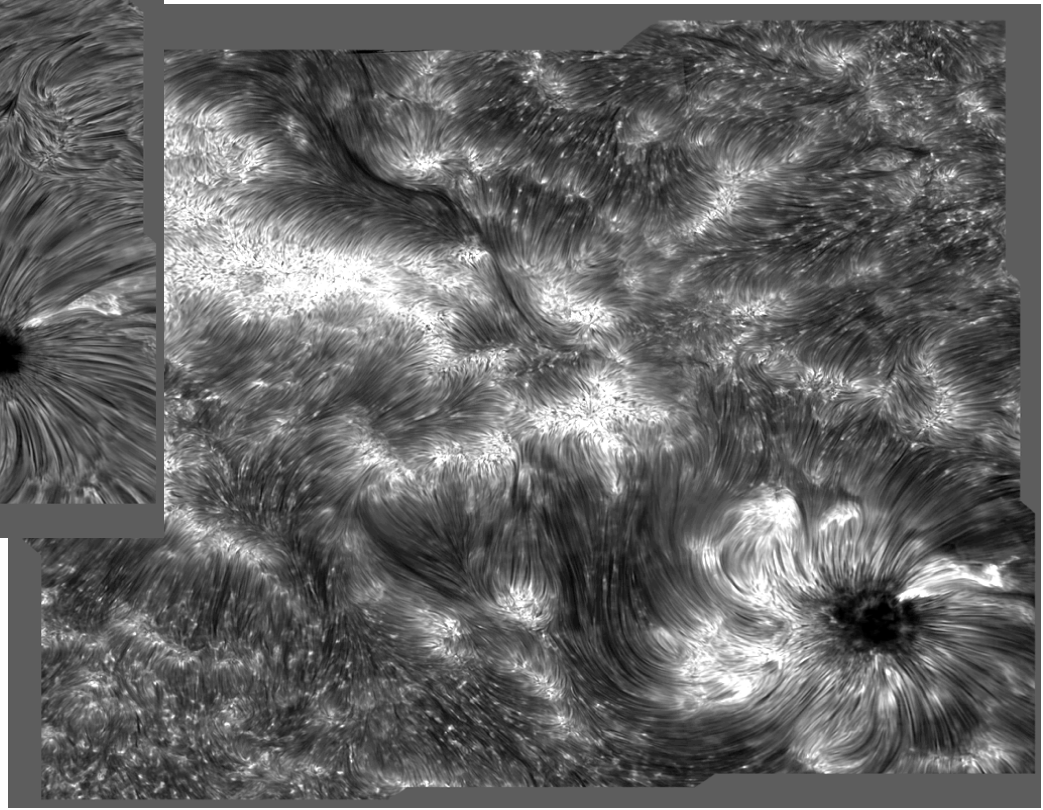


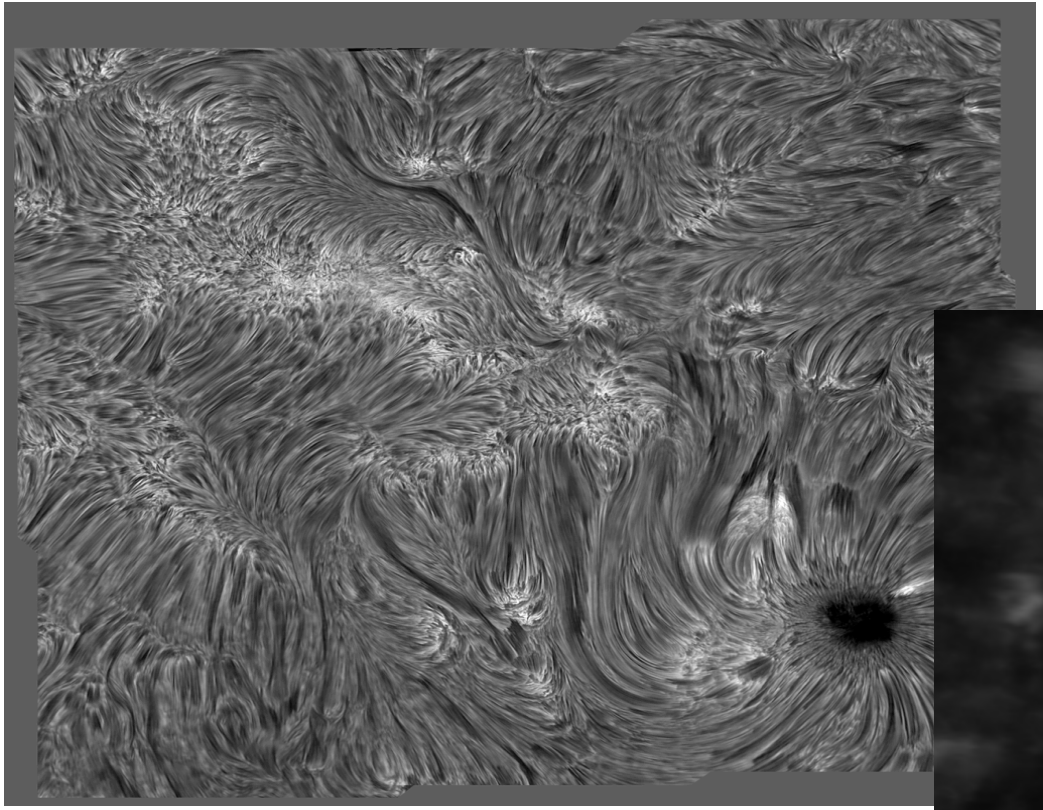




IBIS
Hα 6563 Å

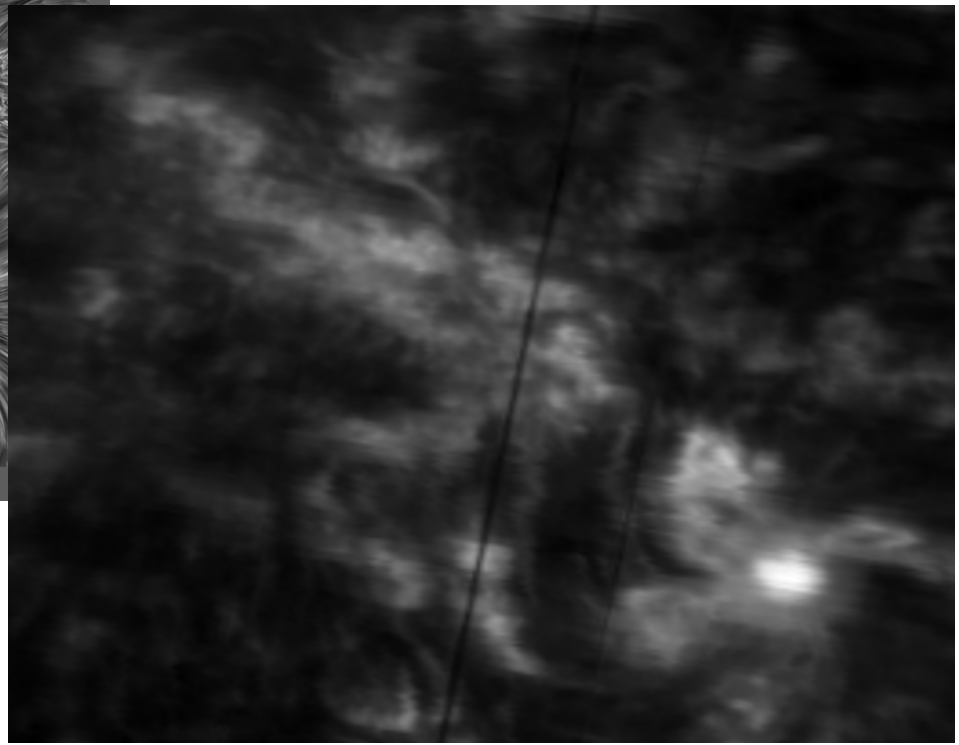
IBIS
Ca II 8542 Å

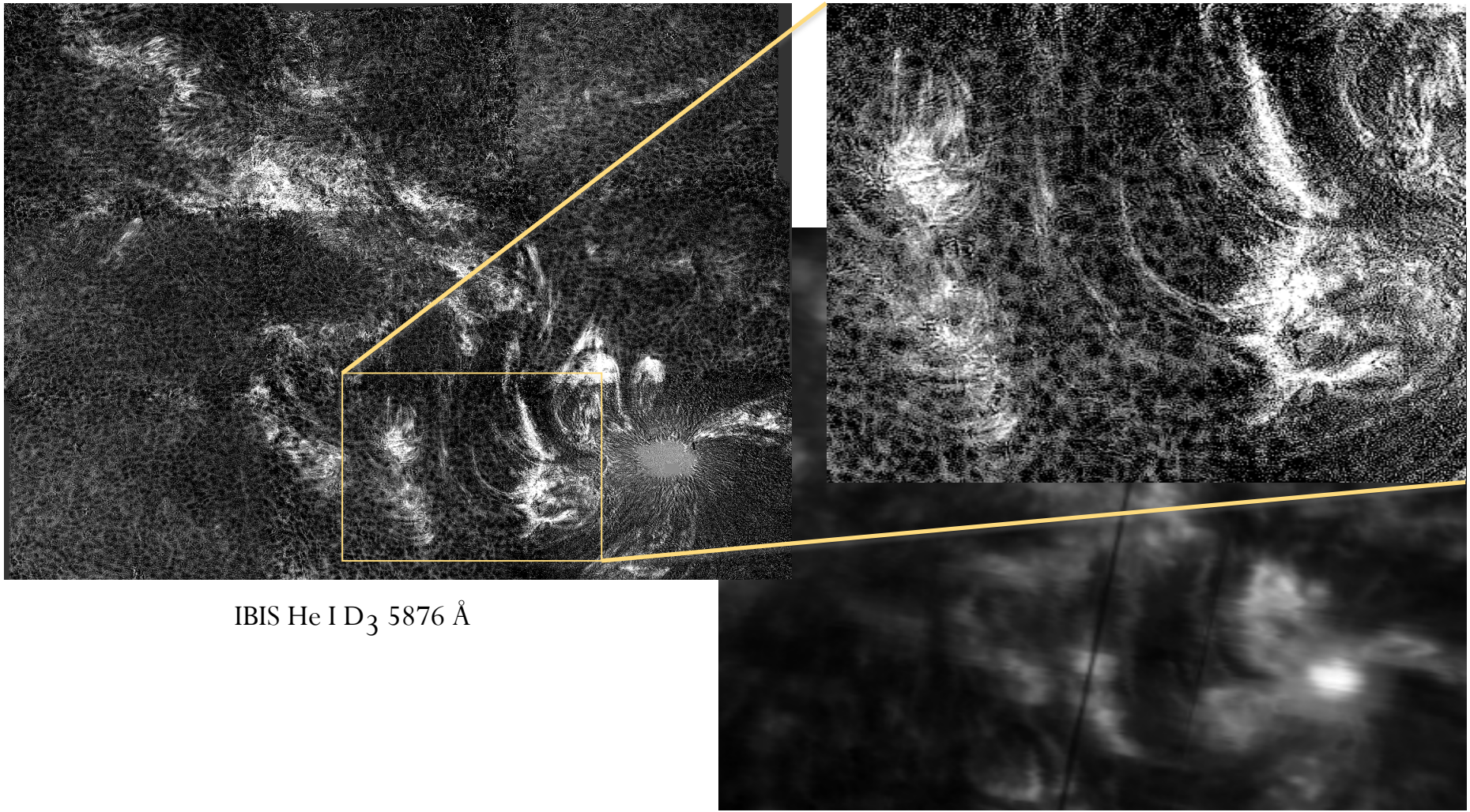




Hα 6563 Å

SOLIS He I 10830 Å





IBIS He I D_3 5876 Å