

# The Chromospheric Layer Spectro-Polarimeter (CLASP2) Sounding Rocket Mission: First Results

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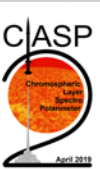
<sup>1</sup>NASA/MSFC, <sup>2</sup>NAOJ, <sup>3</sup>IAC, <sup>4</sup>IAS



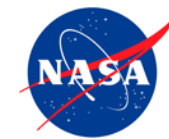
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# CLASP2 Team



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Patrick Champey (NASA/MSFC)

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Yoshinori Suematsu (NAOJ)

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Fumihito Uraguchi (NAOJ)

Andres Asensio Ramos (IAC)

Luca Belluzzi (IRSOL)

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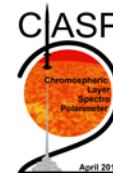
Mats Carlsson (UiO)

Tanausú del Pino Alemán (IAC)

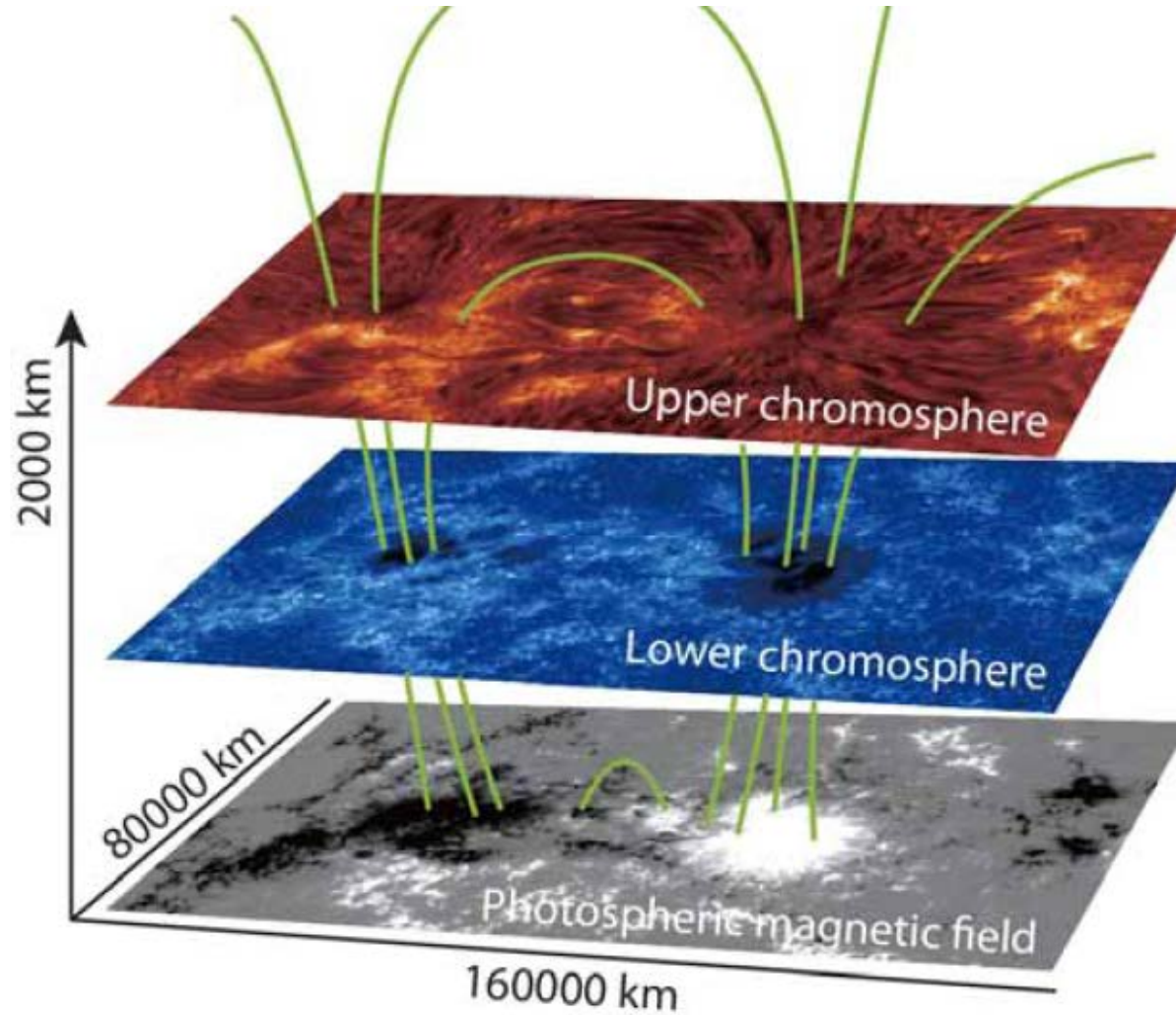
Ernest Alsina Ballester (IAC)

Jorritt Leenaarts (Stockholms U)

Anne Philippon (IAS)



# CLASP/CLASP2 Scientific Objectives



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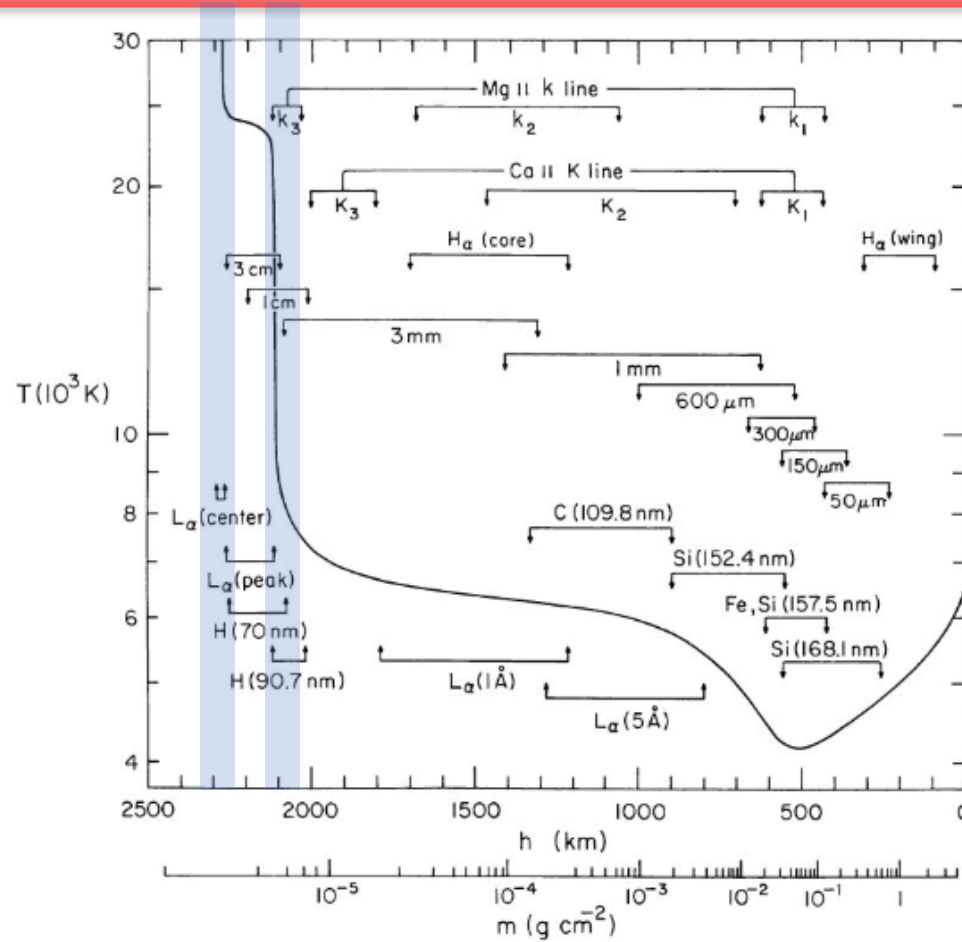


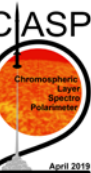
FIG. 1.—The average quiet-Sun temperature distribution derived from the EUV continuum, the  $L\alpha$  line, and other observations. The approximate depths where the various continua and lines originate are indicated.

Vernazza J.E., Avrett E.H., and Loeser R. The Solar Chromosphere. III. Models of the EUV Brightness Components of the Quiet Sun. *The Astrophysical Journal Supplement Series*, 45:635-725, 1981 April.



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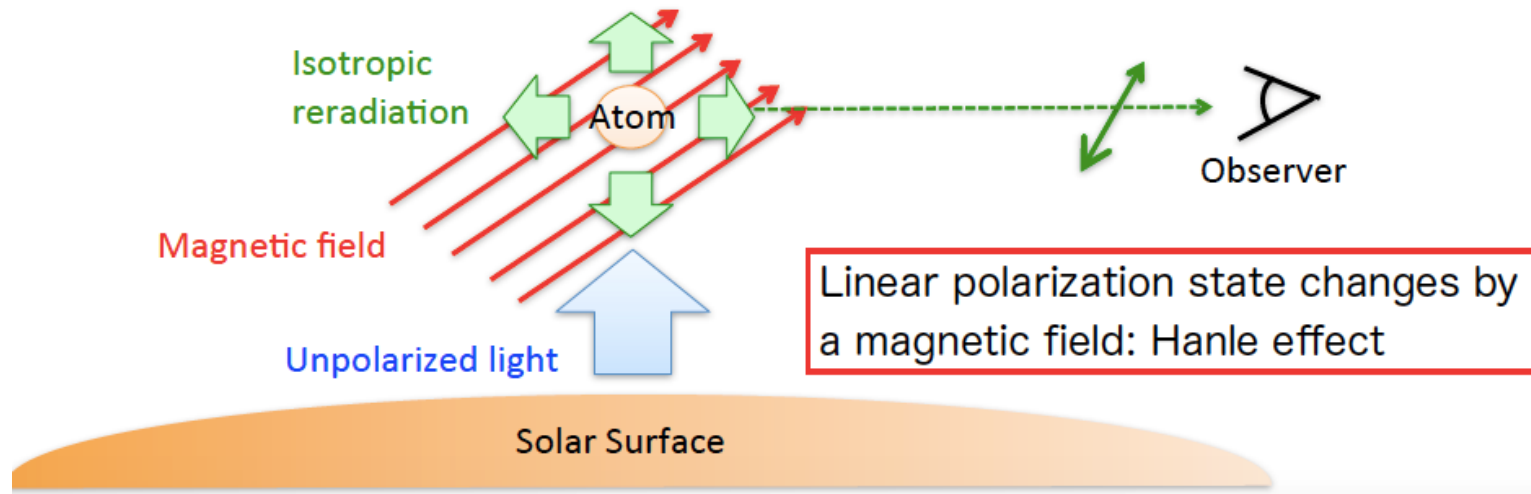
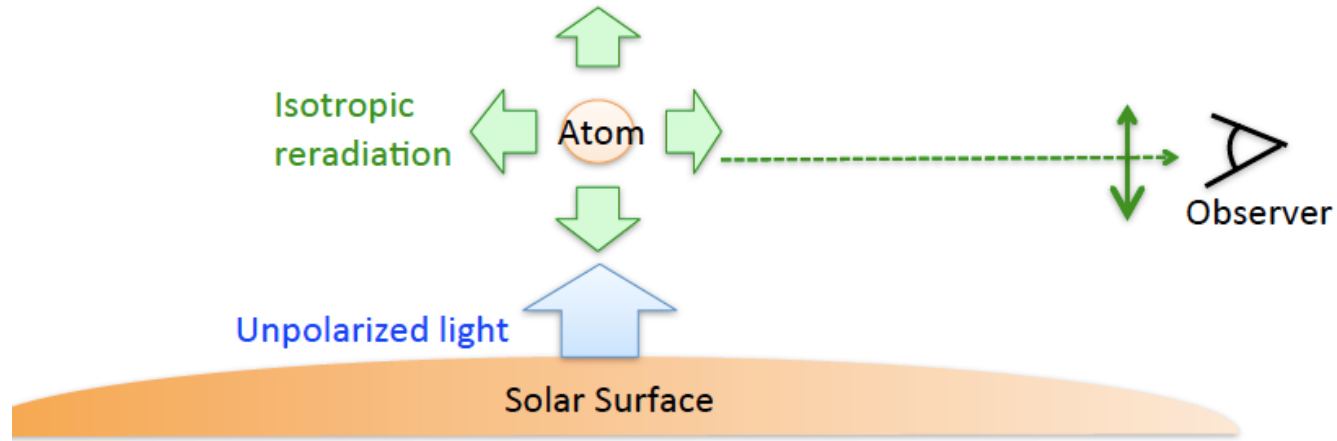
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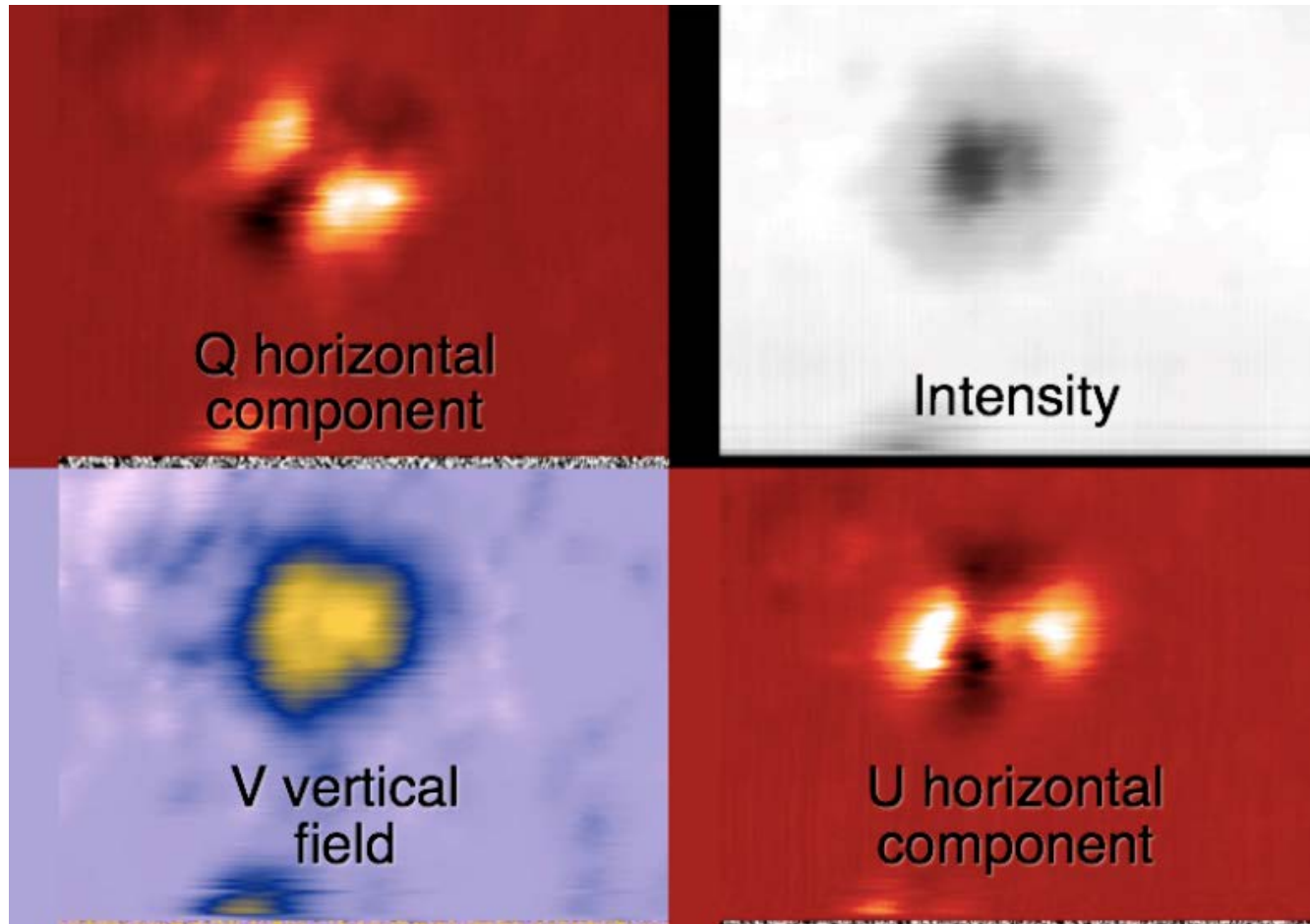
# CLASP/CLASP2 Scientific Objectives

Magnetic field measurement of the upper layers:

## Hanle effect



# CLASP/CLASP2 Scientific Objectives



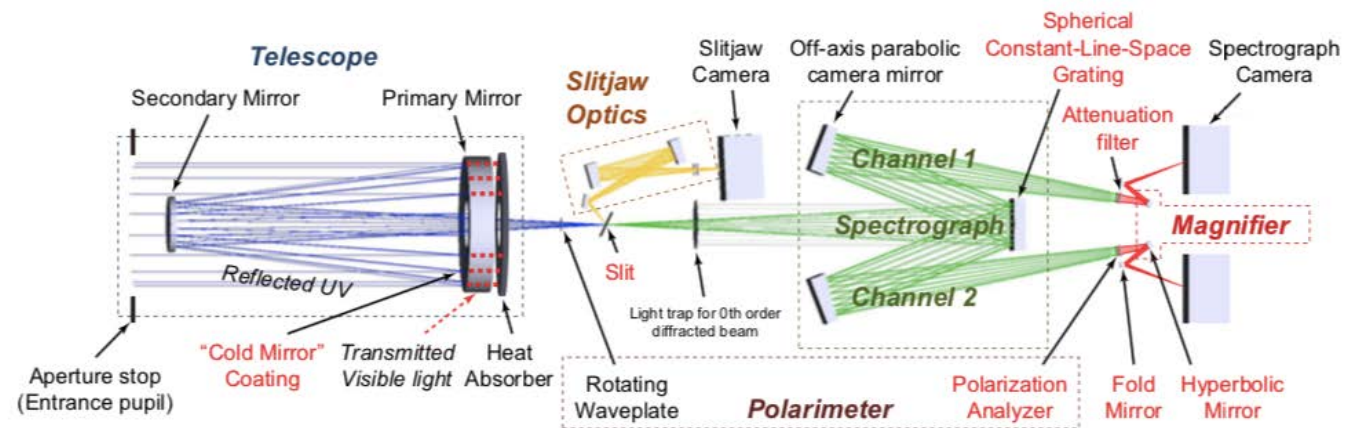
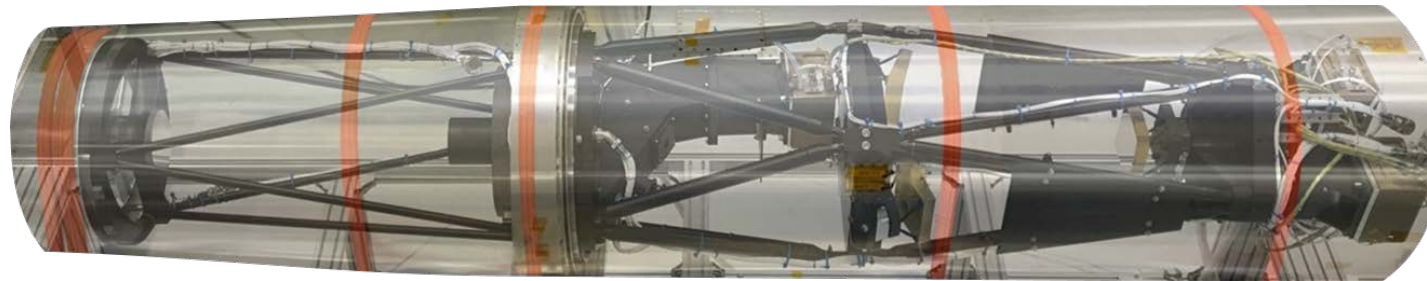
CLASP and CLASP2 are designed to measure polarization in the chromospheric UV, to derive the Stokes parameters.

Example: Stokes I, Q, U, V in a small sunspot measured by Hinode/FPP.

# CLASP/CLASP2 Functional Principles



- “Cold mirror” coating selects the range of wavelengths to be fed into the spectrograph.
- A rotating waveplate varies the polarization angle of light seen by the spectro-polarimeter (SP).
- Polarization analyzers in front of the SP cameras determine the intensity of light that falls upon the detectors.
- Slitjaw imager (SJ) provides context imaging and pointing feedback.



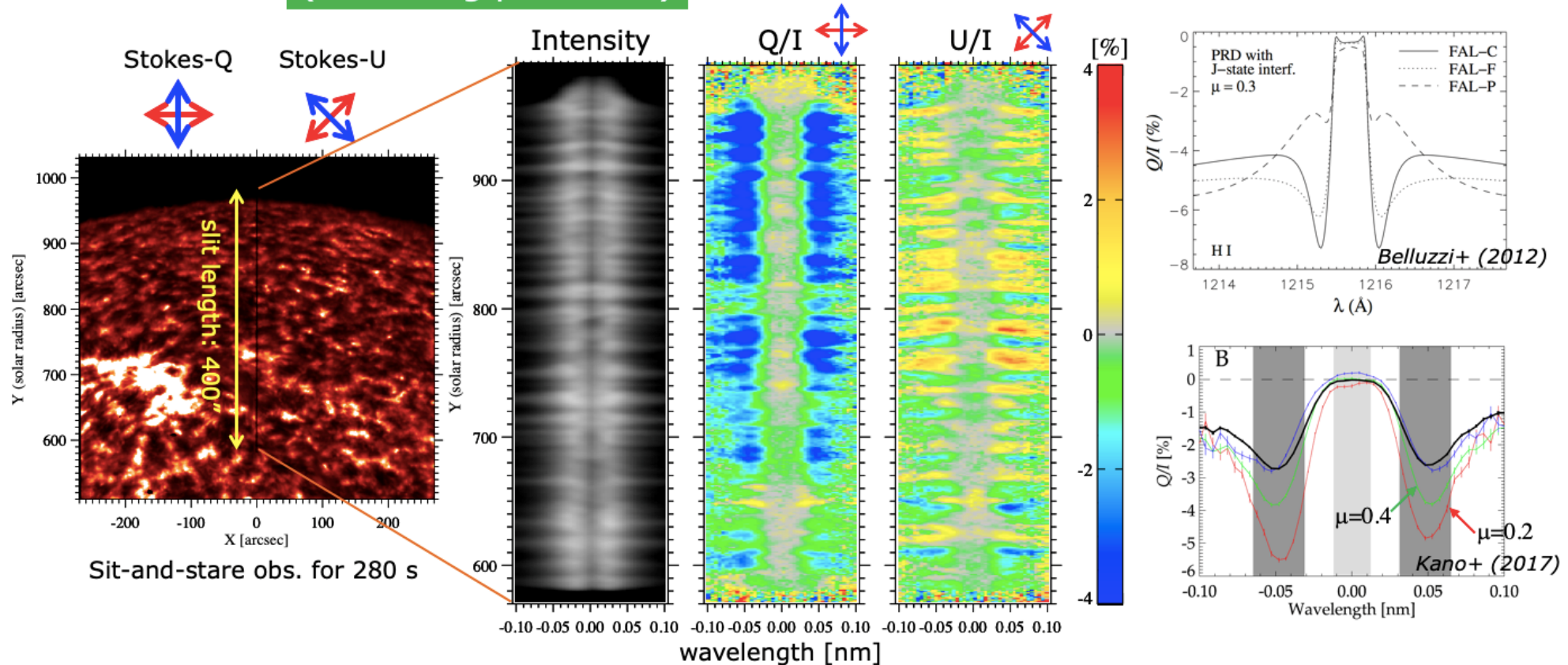
## CLASP Science Highlights (Polarimetry)

### First Detection of Scattering Pol. in VUV

*Kano+ (2017)*

HI Ly $\alpha$  wing  
(scattering pol. ONLY)

Clear center-to-limb variation up to 6% in Q/I  
Fluctuating at a few% at  $\sim 10''$  both in Q/I and U/I





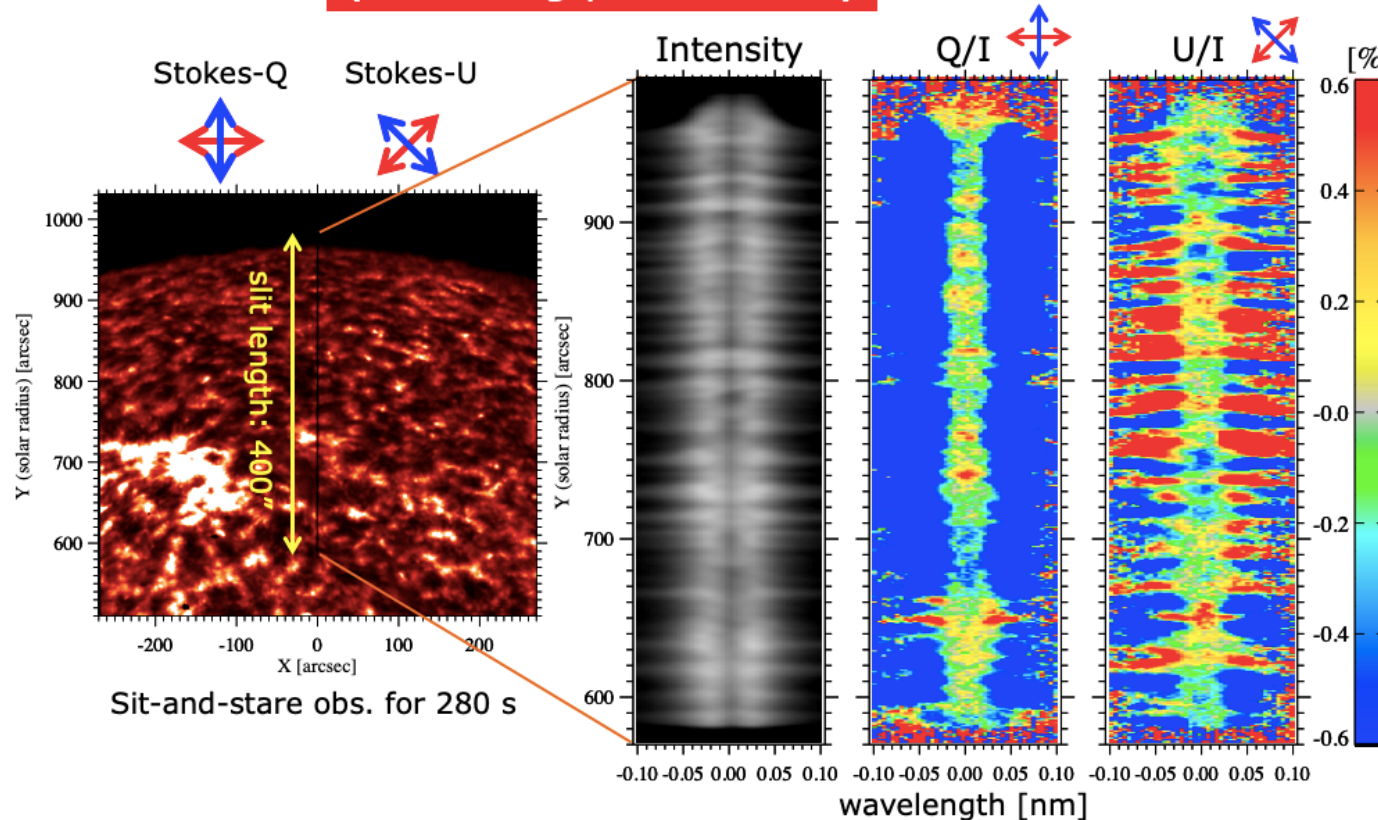
## CLASP Science Highlights (Polarimetry)

### First Detection of Scattering Pol. in VUV

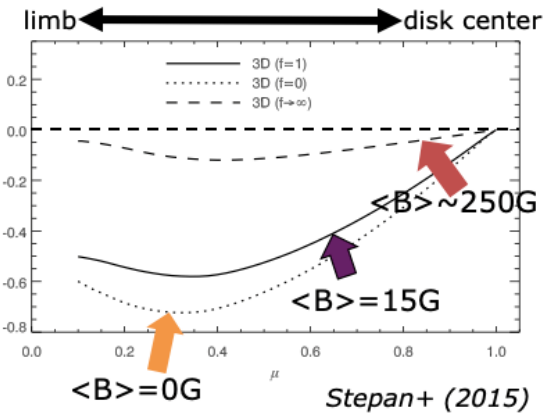
*Kano+ (2017)*

HI Ly $\alpha$  core  
(scattering pol. & Hanle)

No clear center-to-limb variation (CLV) in Q/I  
Fluctuating at a few of 0.1% both in Q/I and U/I

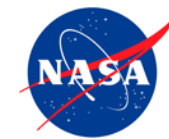


CLV of spatial average of pol. with 3D MHD model



*Stepan+ (2015)*

# CLASP2 Vital Statistics



## “JUST OFF THE PAD”

**DATE LAUNCHED** April 11, 2019

**TIME:** 10:51:00 MT

**TYPE OF ROCKET:** Black Brant IX Mk 4

**FLIGHT NO:** 36.332

**LAUNCH SITE:** White Sands Missile Range, NM

**ALTITUDE PREDICTED:** 269.0 km

**ACTUAL ALTITUDE:** 274.1 km

**PAYLOAD WEIGHT:** 1244 lbs (564 kg)

**ACS SYSTEM:** SPARCS

**RECOVERY SYSTEM:** 1250# NFORSe

**EXPERIMENT:** Good target, good data, good science.

**REMARKS:** All payload systems appeared to function nominally

**MISSION MANAGER:** Rick Weaver/NSROC/Northrop Grumman

**SRPO MANAGER:** Nathan Empson



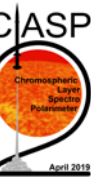
# CLASP2 Launch!



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# CLASP2 Targets

- Disk center for calibration (13s)
- Active region plage (157s)
- Quiet Sun near the limb (142s)

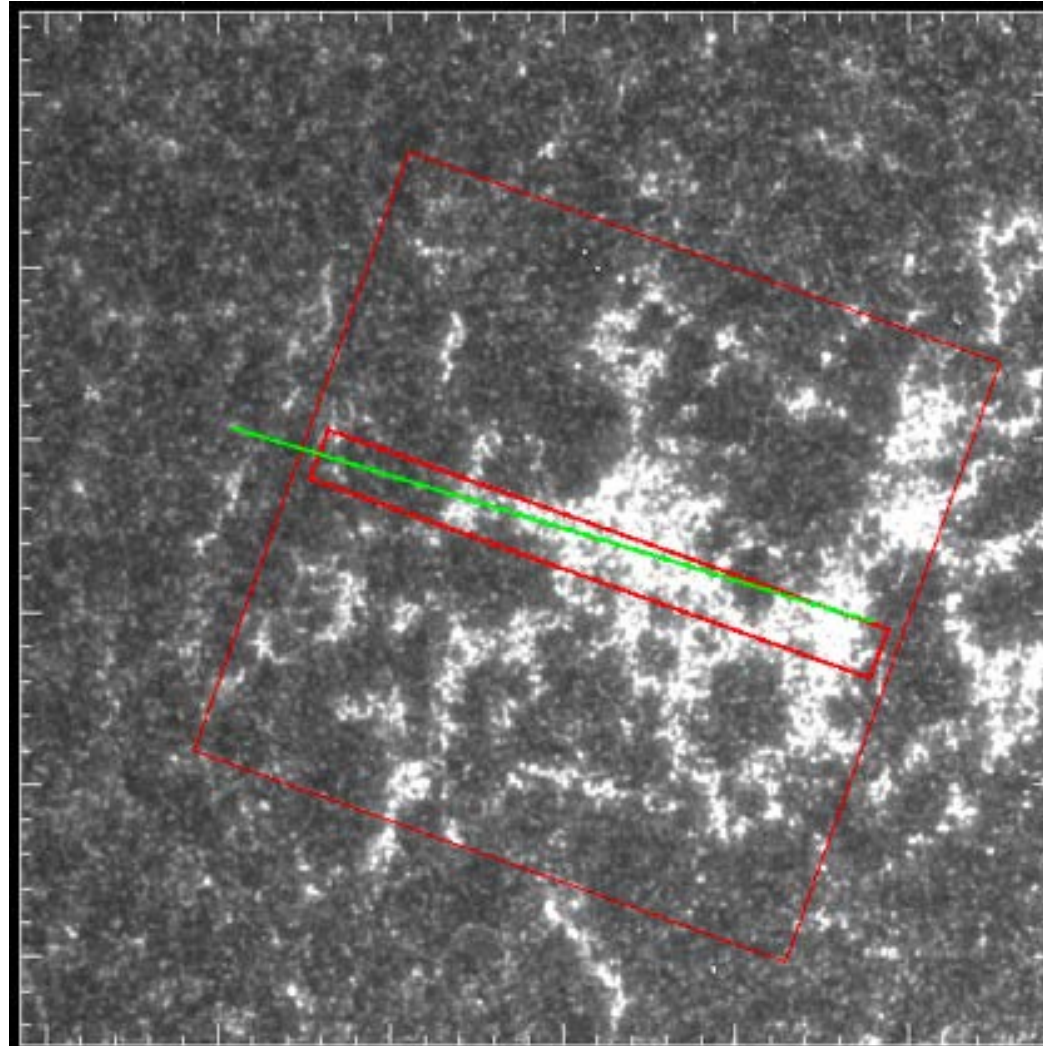


Pointing video  
prepared by Joten  
Okamoto (NAOJ)

# CLASP2 Co-observations



Plage target was simultaneously observed by IRIS, Hinode, and IBIS at NSO/Sac Peak. The result is a combination of imaging, spectroscopy, and polarimetry in NIR, visible, UV, EUV, and soft X-rays.

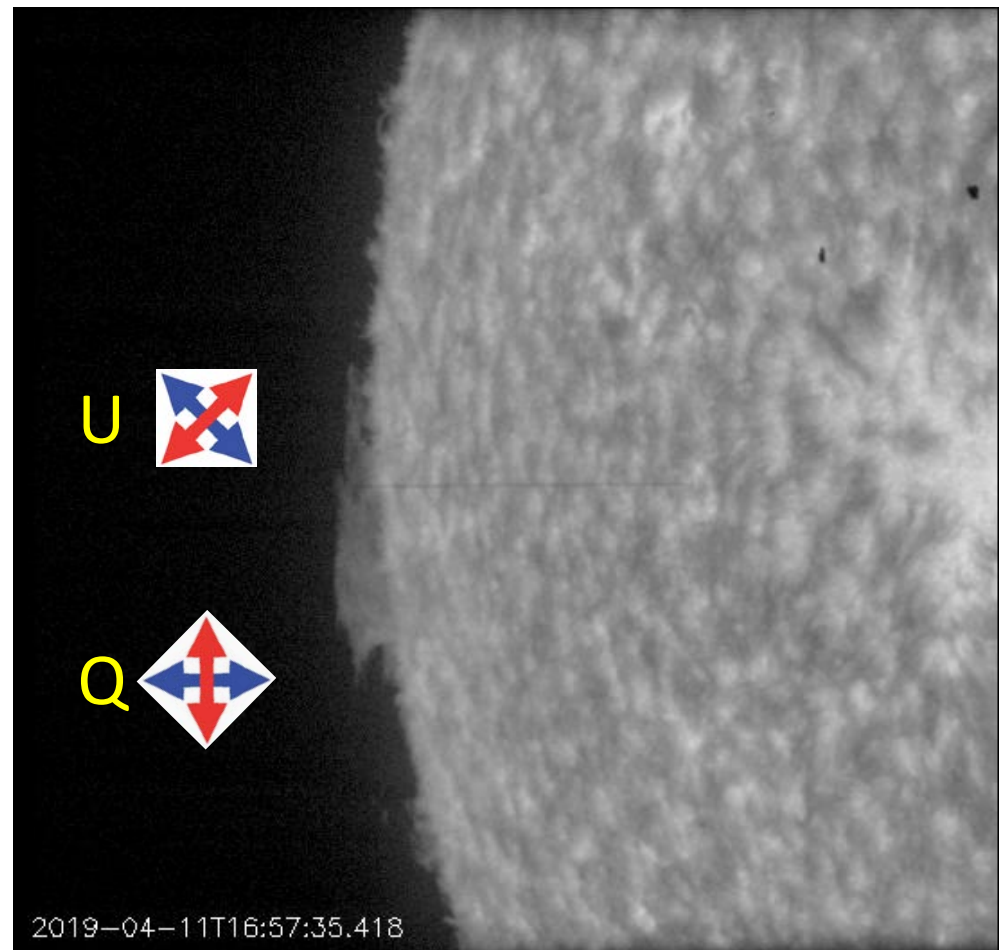


Green: CLASP2 slit  
Red: IRIS raster area & slit-jaw FOV

# CLASP2 Preliminary Results



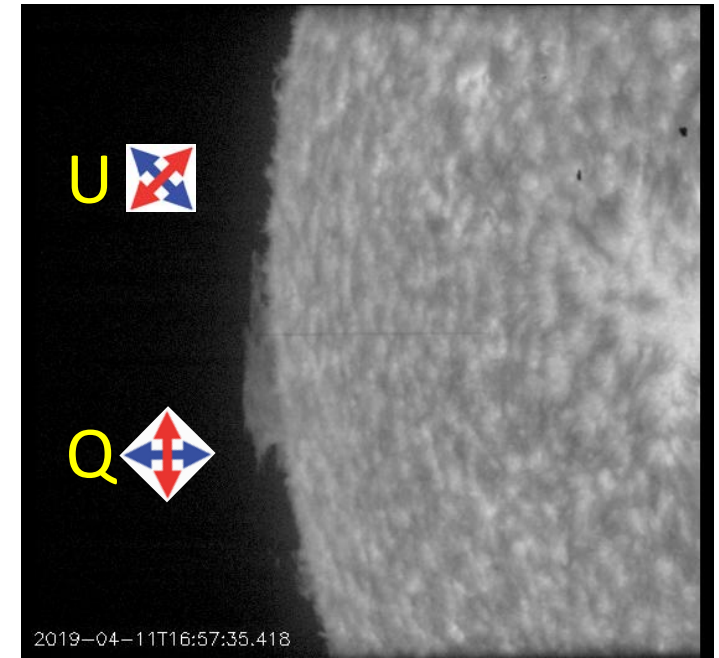
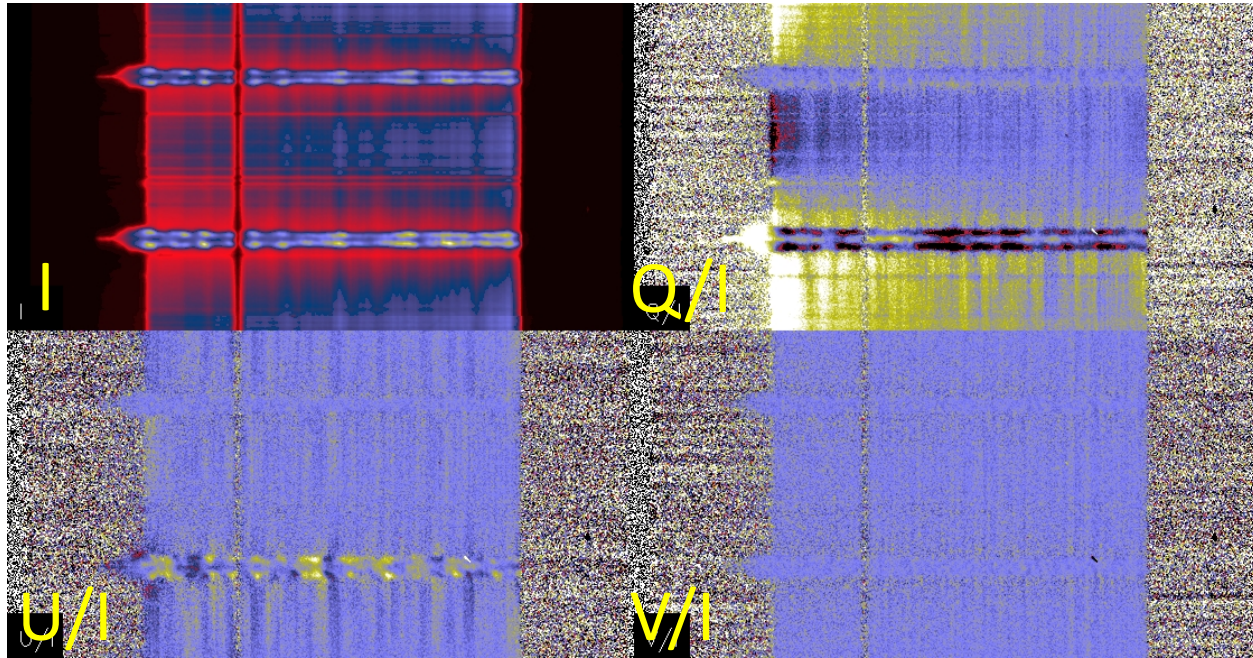
- Both the slitjaw (SJ) and spectro-polarimeter (SP) systems performed nominally.
- Acquired more than 500 SJ images in Ly-alpha, more than 3000 spectra near 280 nm.
- Both SP channels reduceable to I, Q, U, V profiles: >40 sets of Stokes *in each channel* at plage, *and* in QS near limb.
- Calibrations are in progress.



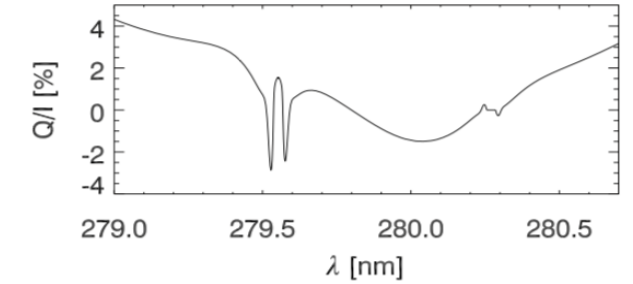
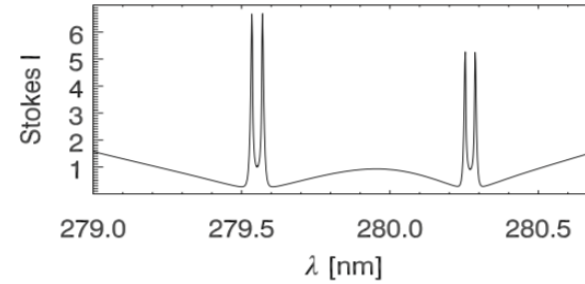
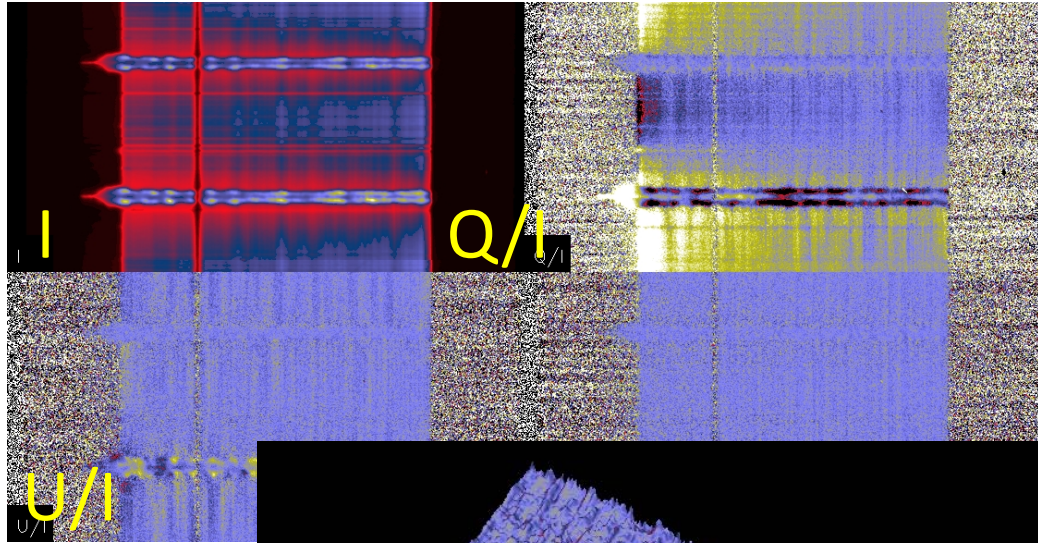
# CLASP2 Preliminary Results: Quiet Sun



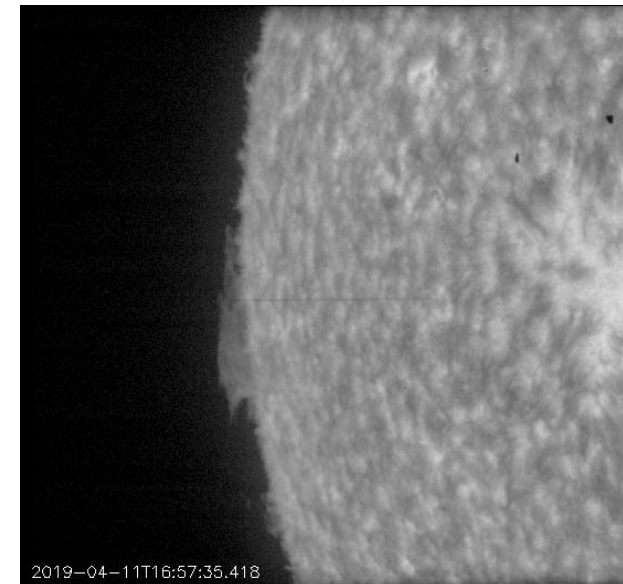
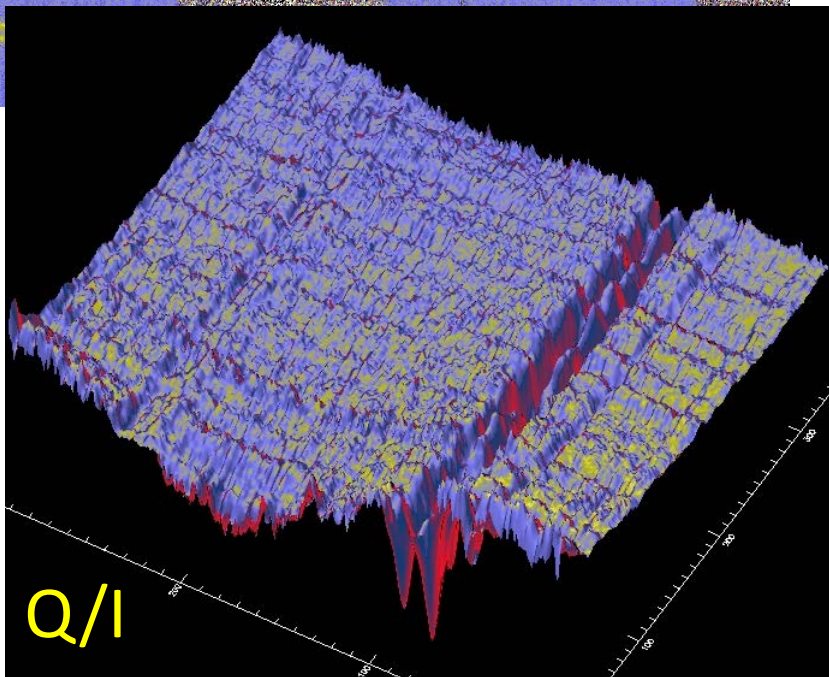
SP1 & SP2 coaligned and co-added, then temporally averaged



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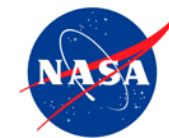


Model prediction (Belluzzi & Trujillo Bueno 2012, *ApJL*, vol. 750, L11), for quiet Sun,  $B=0$ , close to solar limb ( $\mu = \cos \theta = 0.1$ ). Positive Stokes Q is parallel to the nearest limb. Strong scattering polarization in  $k$  line, zero polarization in center of  $h$  line.

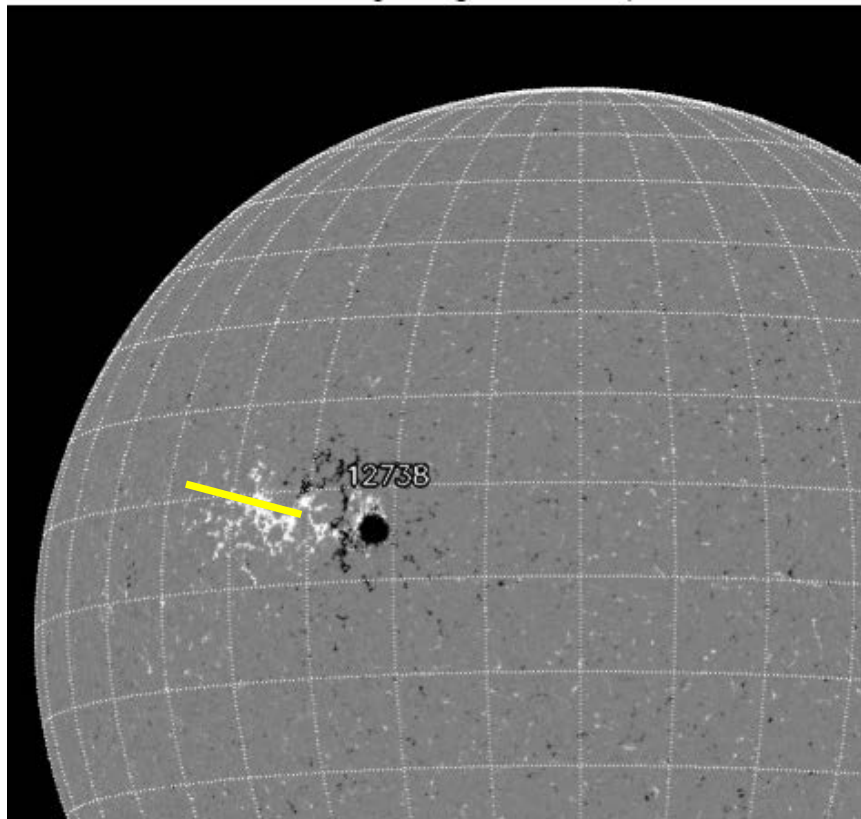




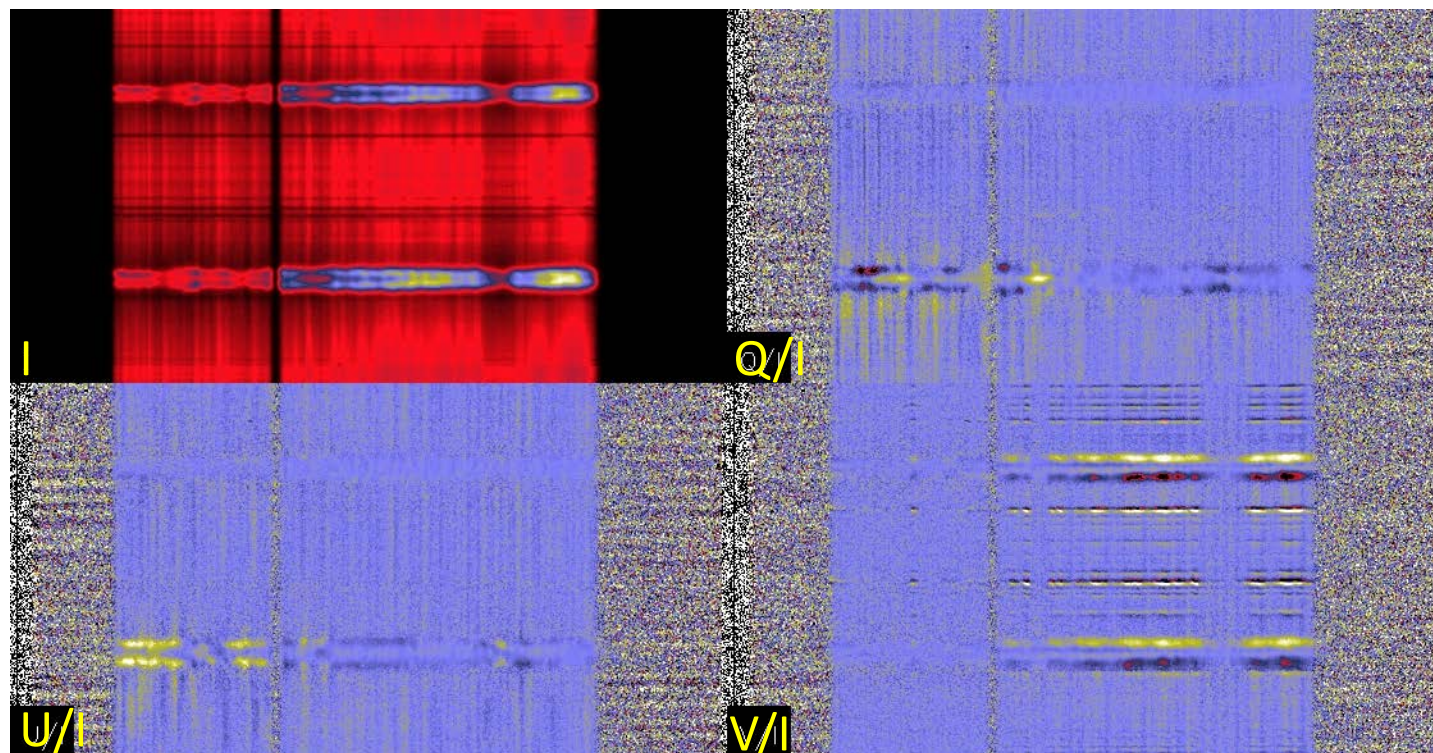
# CLASP2 Preliminary Results: Plage



SDO HMI Magnetogram 11-Apr-2019 18:34:



SP1 & SP2 coaligned and co-added, then temporally averaged

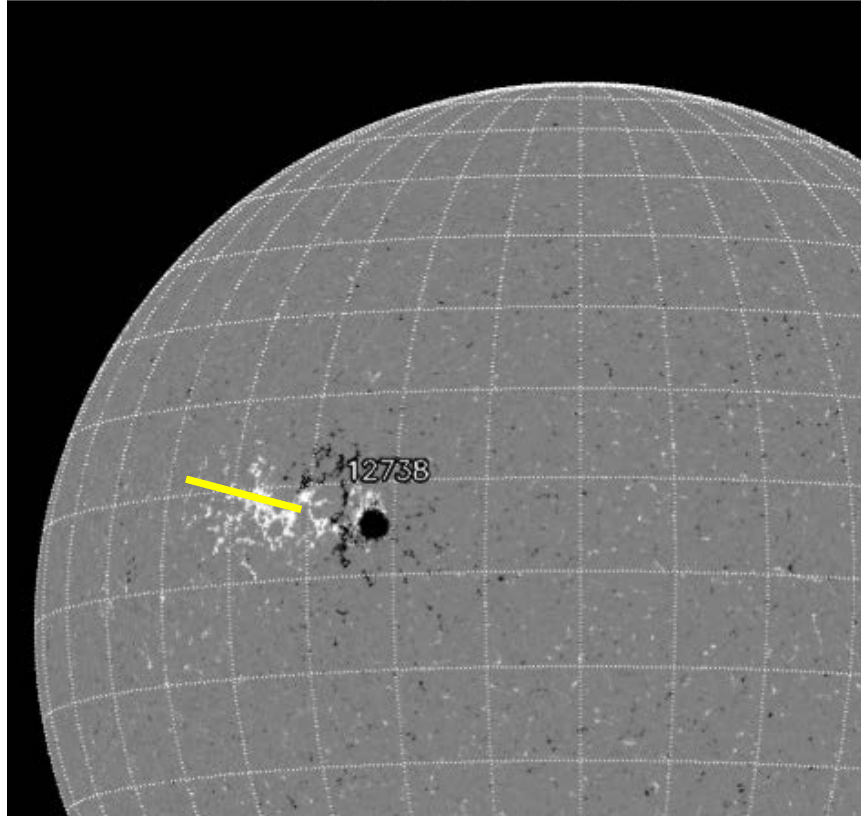


Strong Stokes V/I in plage, presumed due to Zeeman effect. *First observation in chromospheric UV. And so many lines!*

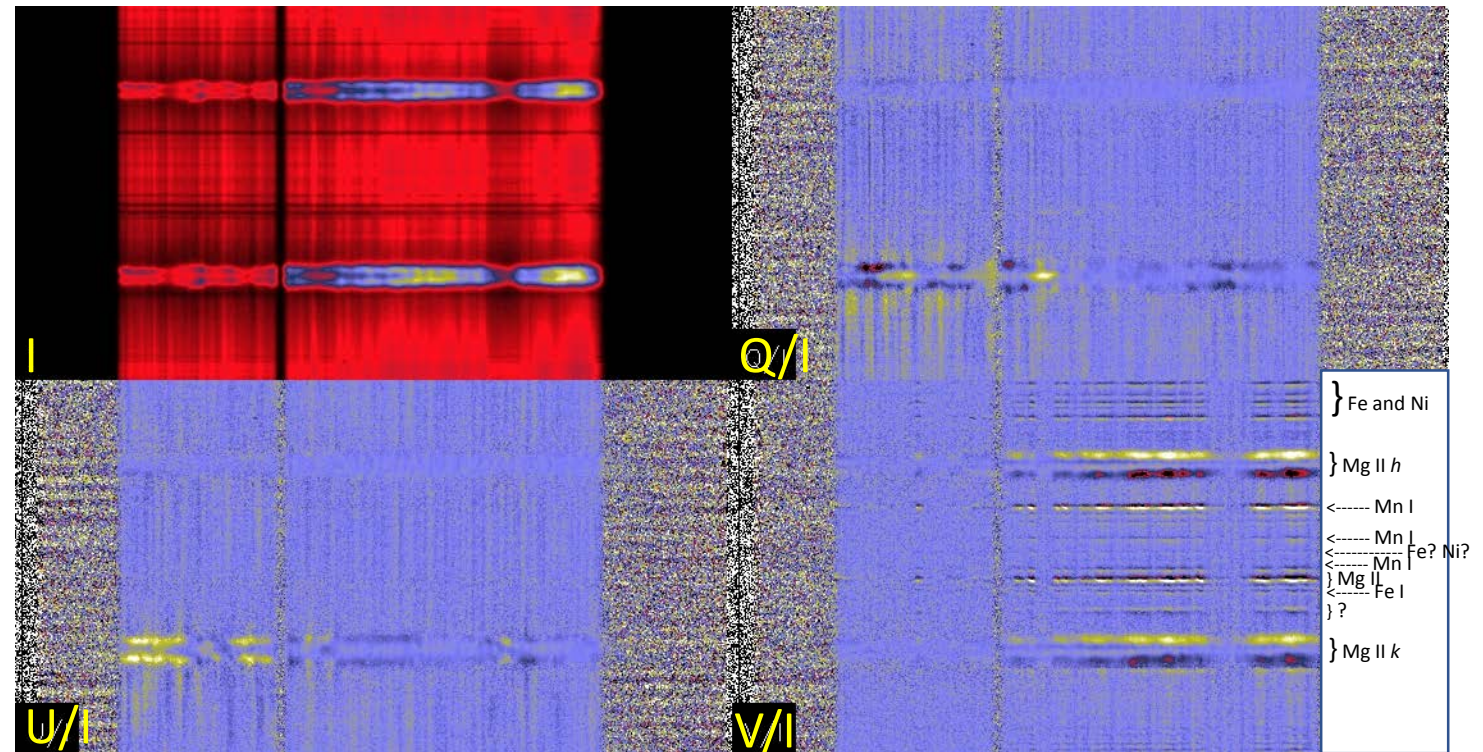
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# The End



- Some remaining calibrations, but we're in good shape
- Data will be published on VSO