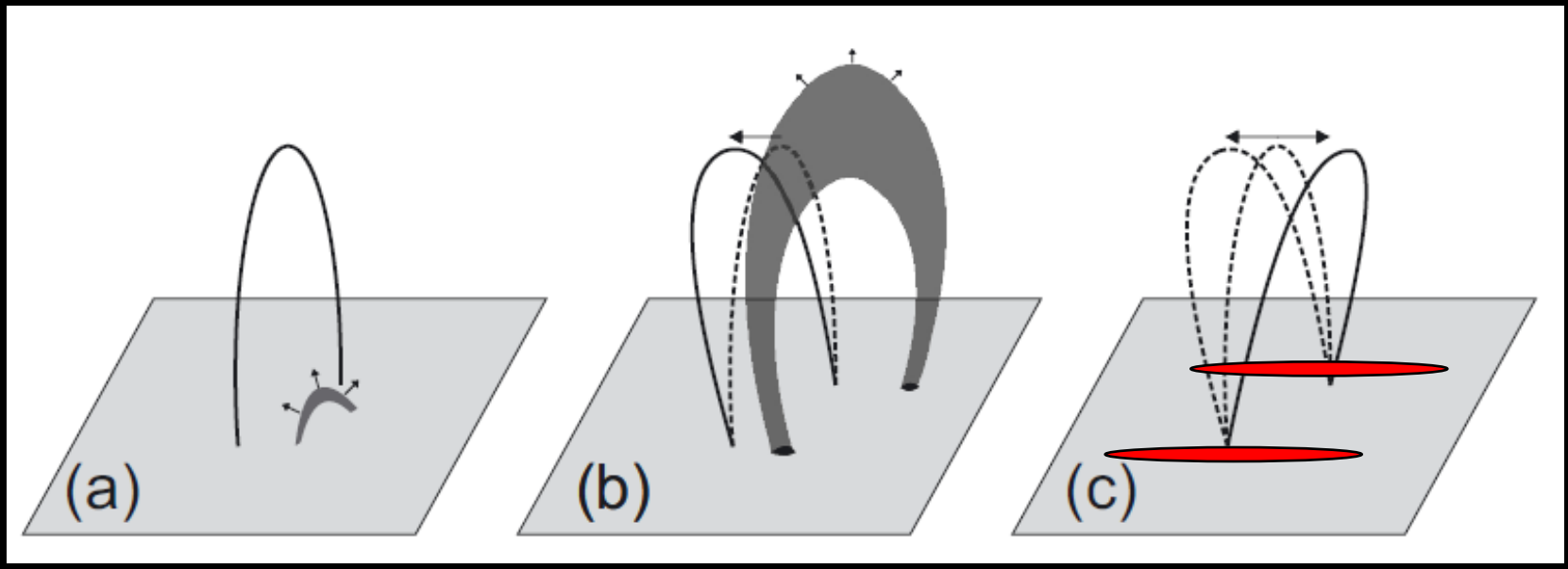
Intensity Oscillations in the solar flares

Zongjun Ning

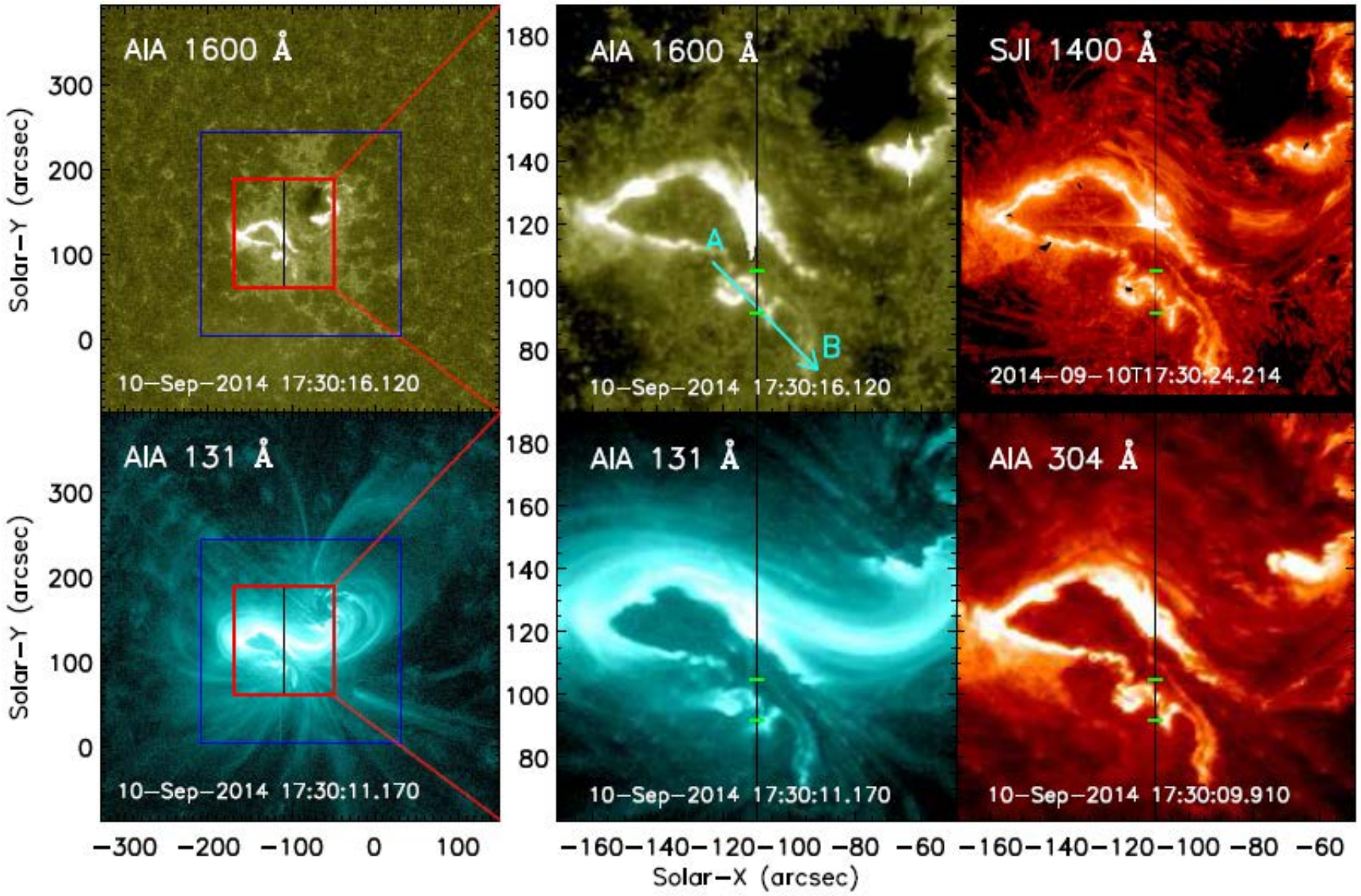
ningzongjun@pmo.ac.cn

Purple Mountain Observatory, China

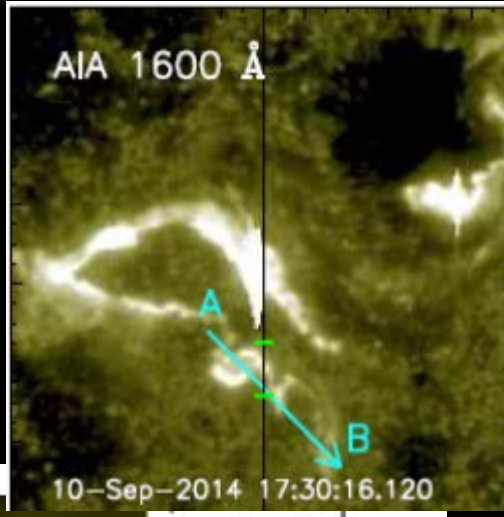


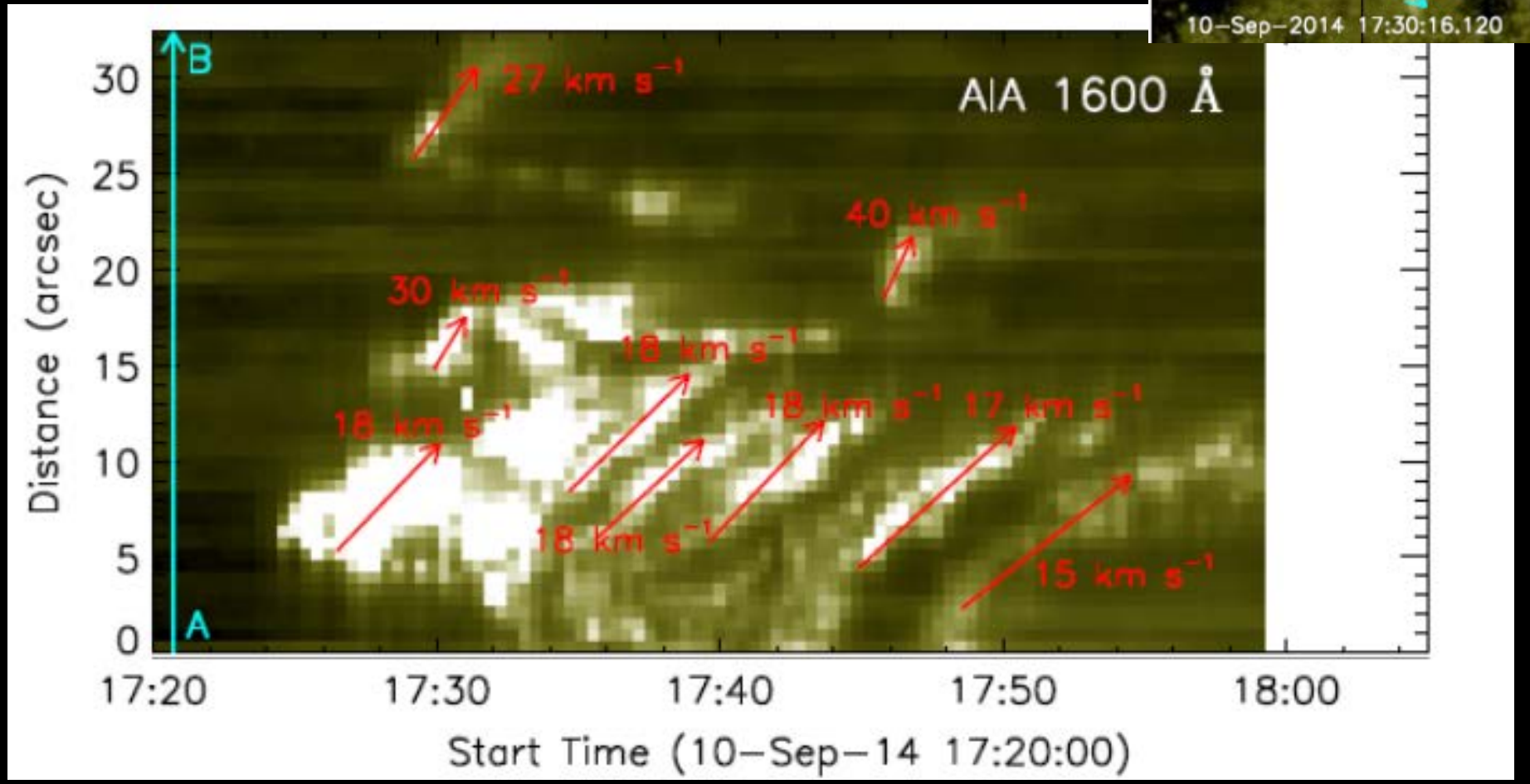
- In this ISSI-bj workshop, several presentations are about the oscillations along the coronal loop, how about on the footpoint (flare ribbon & footpoints)?

2014Sep.10 flare (SDO/AIA)

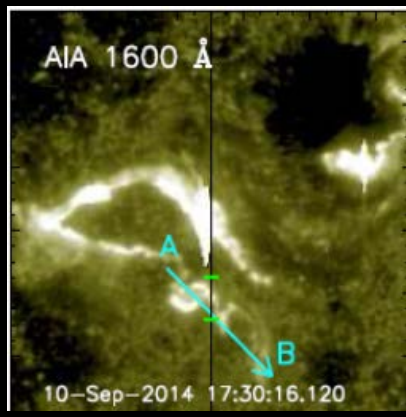


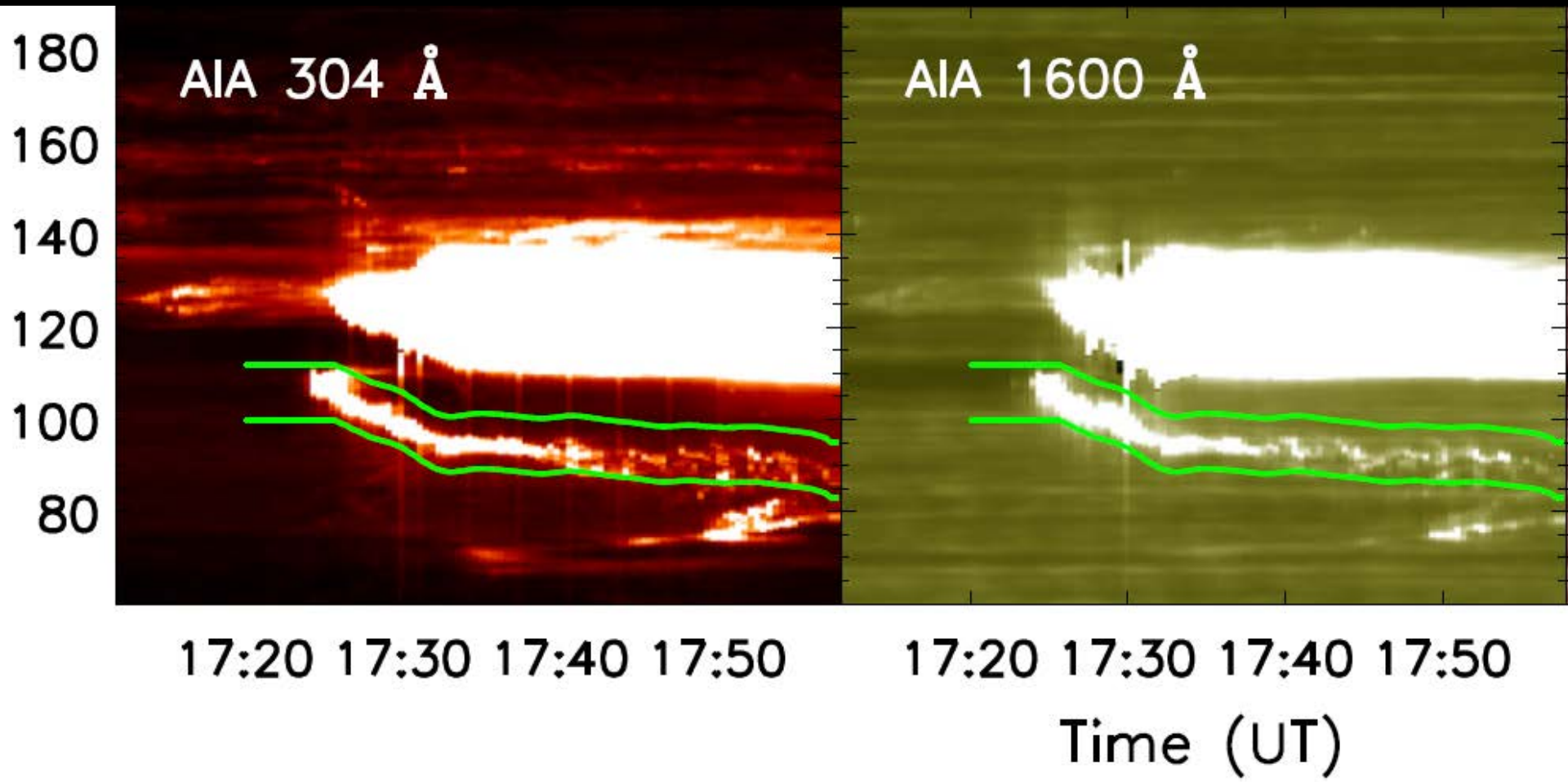
Time-distance maps (Intermittent motions)

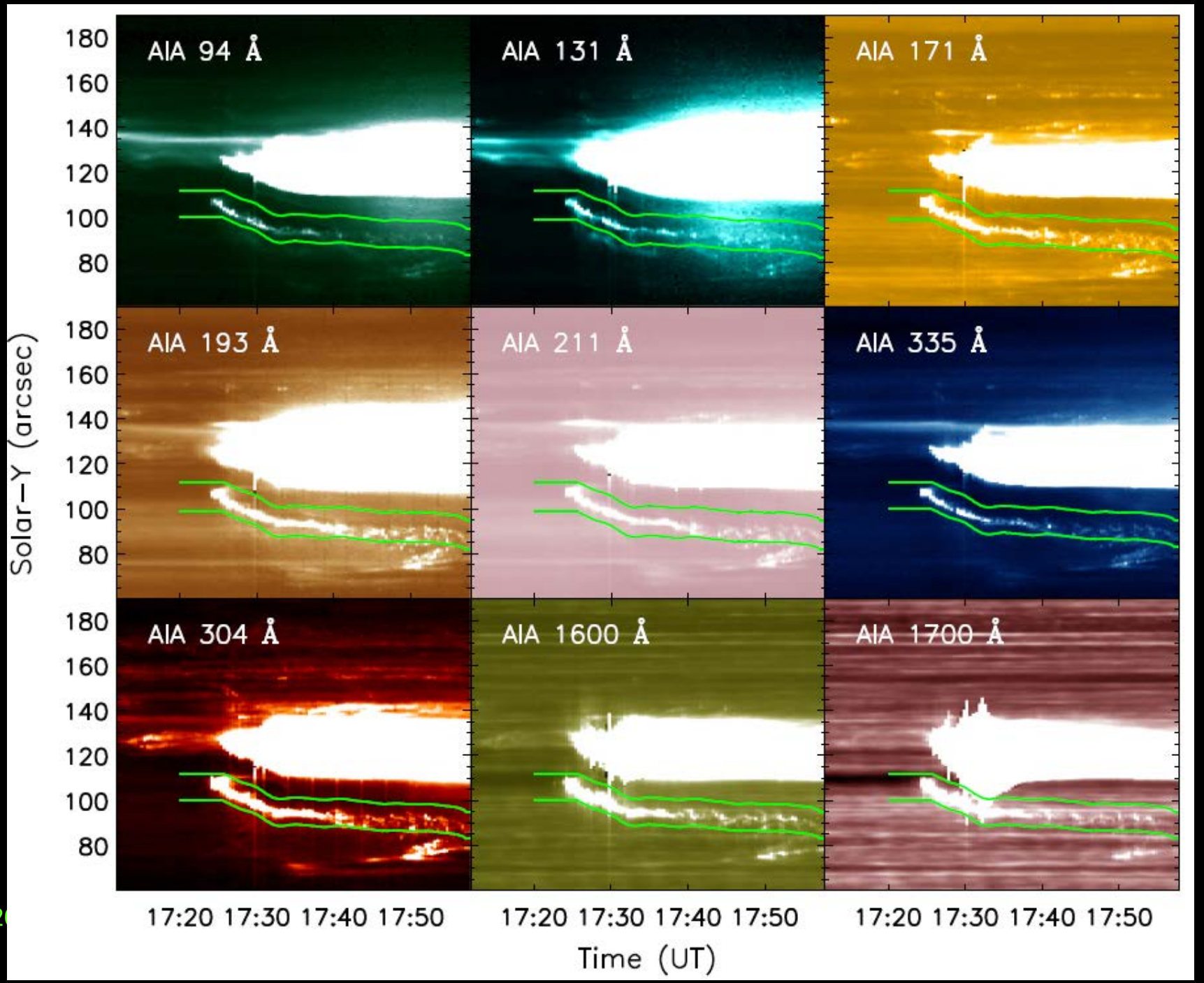




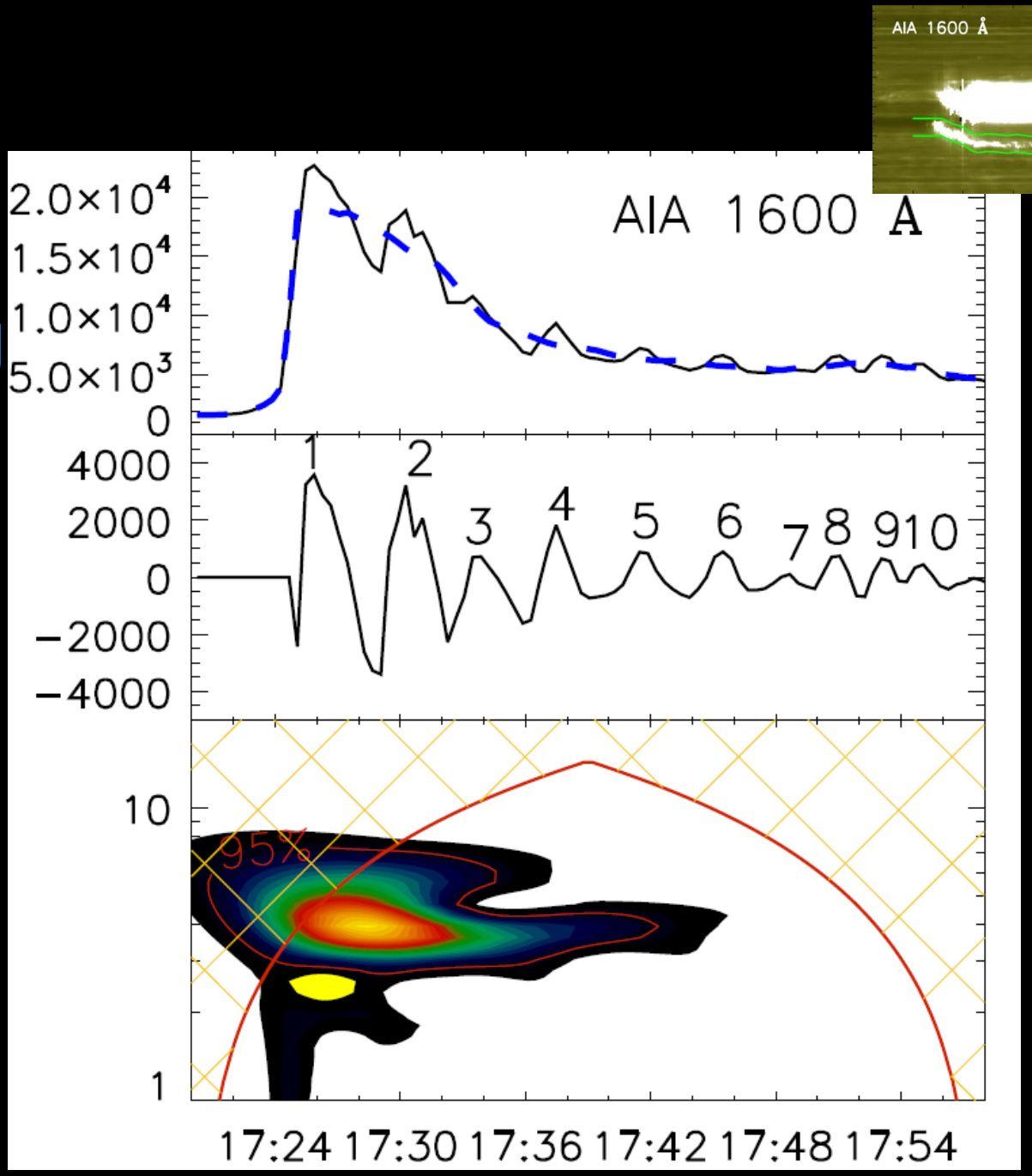
Time-distance maps

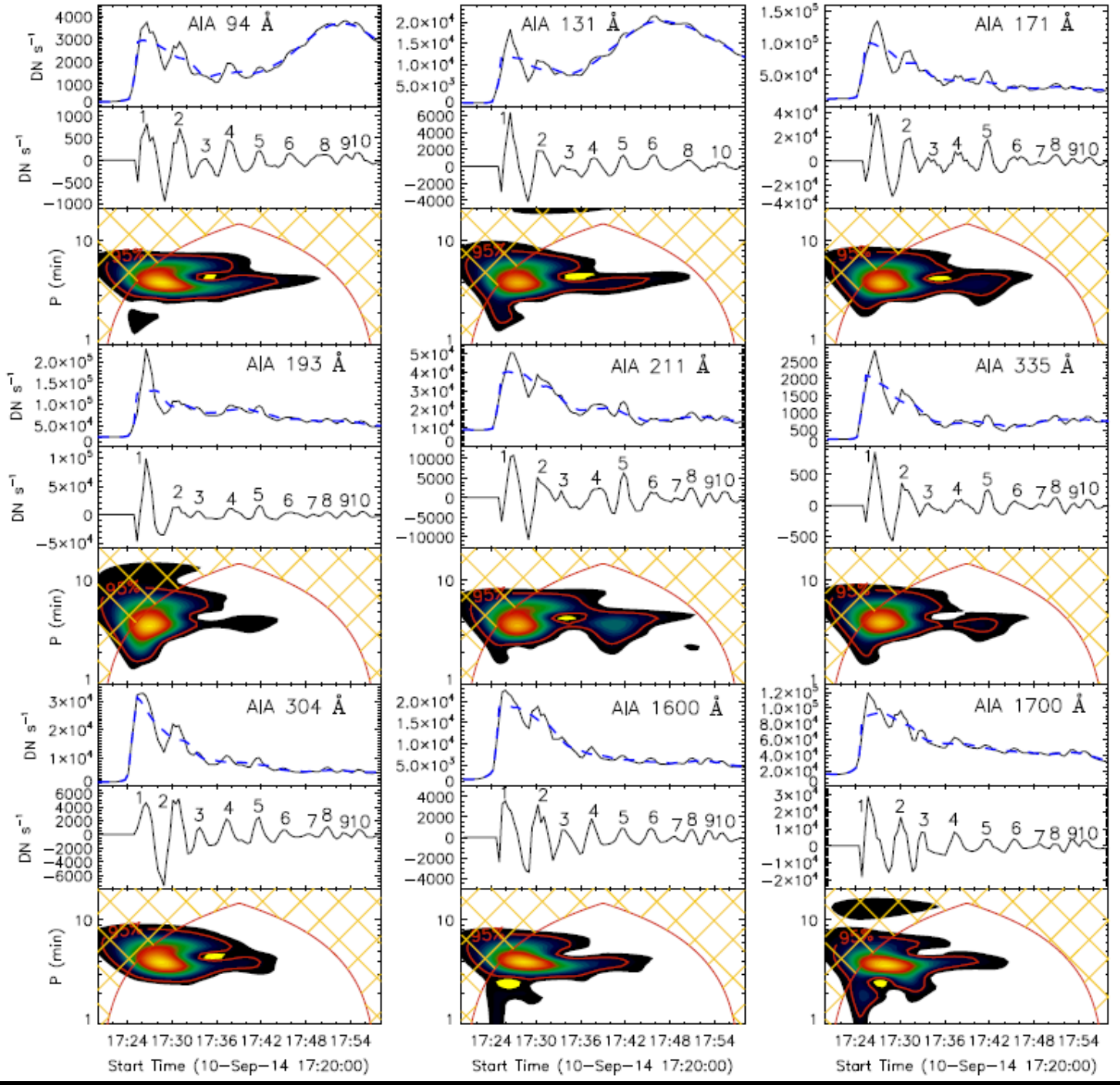




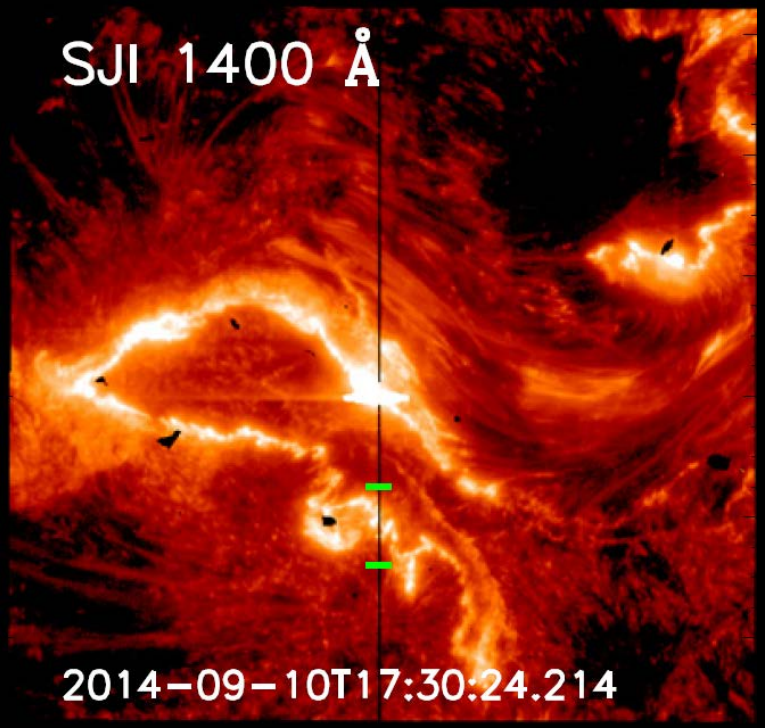

AIA 94 Å
AIA 131 Å
AIA 171 Å
AIA 193 Å
AIA 211 Å
AIA 335 Å
AIA 304 Å
AIA 1600 Å
AIA 1700 Å
180
160
140
120
100
80
Solar−Y (arcsec)
17:20 17:30 17:40 17:50
Time (UT)

- Intensity
- Slowly-varying component
- Fast-varying component
- period
  - 4min

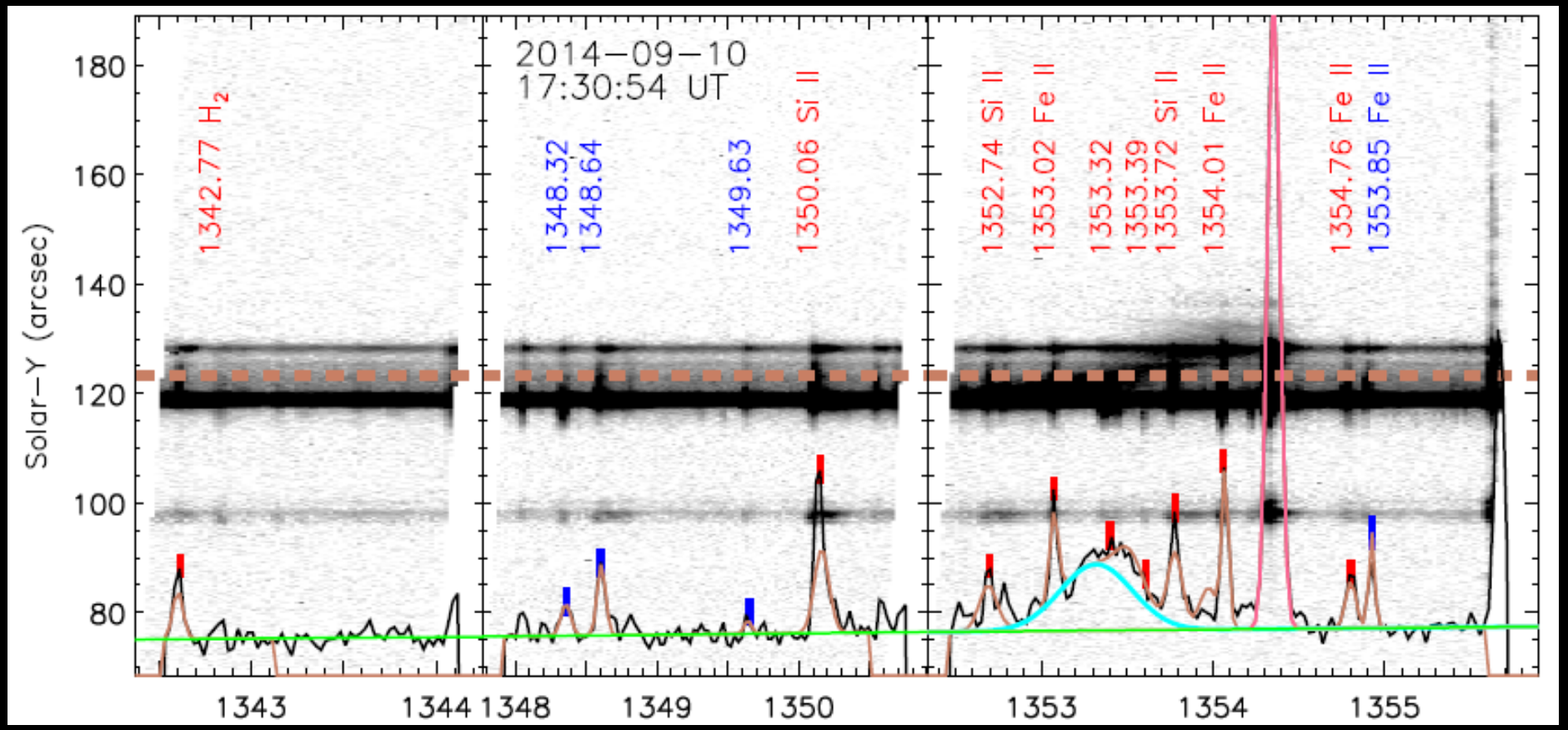



AIA 94 Å
AIA 131 Å
AIA 171 Å
AIA 193 Å
AIA 211 Å
AIA 335 Å
AIA 304 Å
AIA 1600 Å
AIA 1700 Å
DN s⁻¹
P (min)
95%
17:24 17:30 17:36 17:42 17:48 17:54
Start Time (10−Sep−14 17:20:00)

How about the IRIS spectral observations?



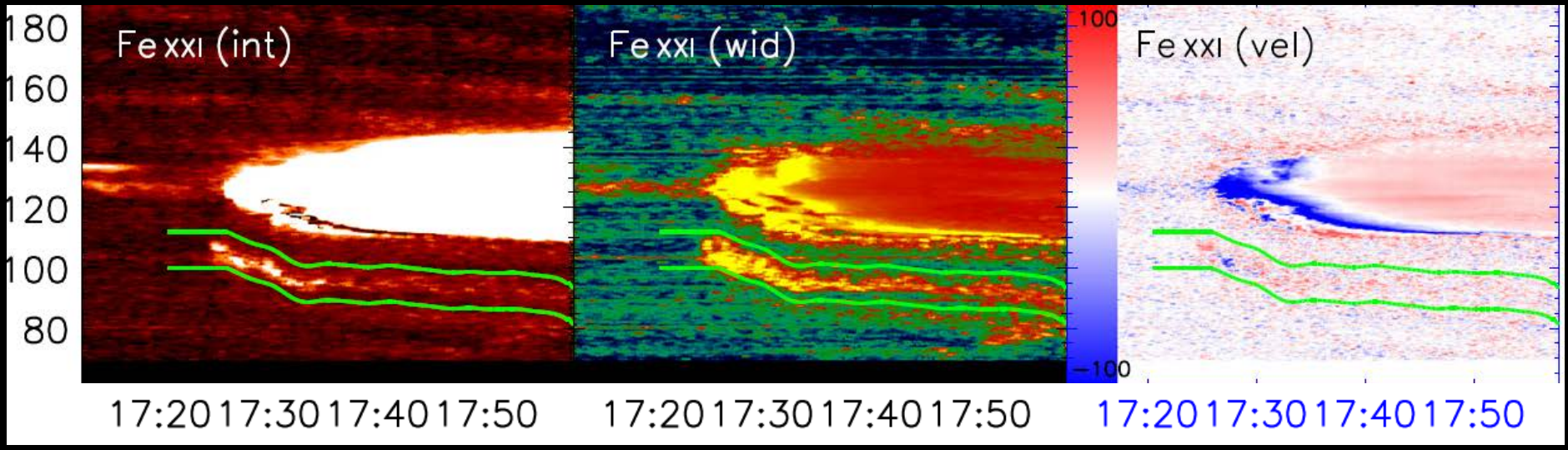
IRIS spectra

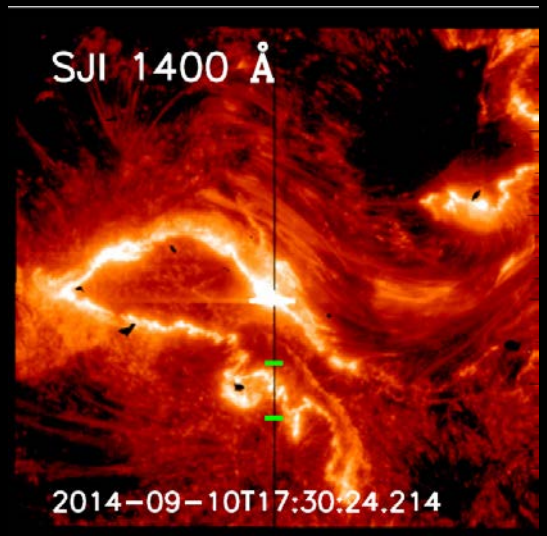


Spectral Parameters (15 lines)

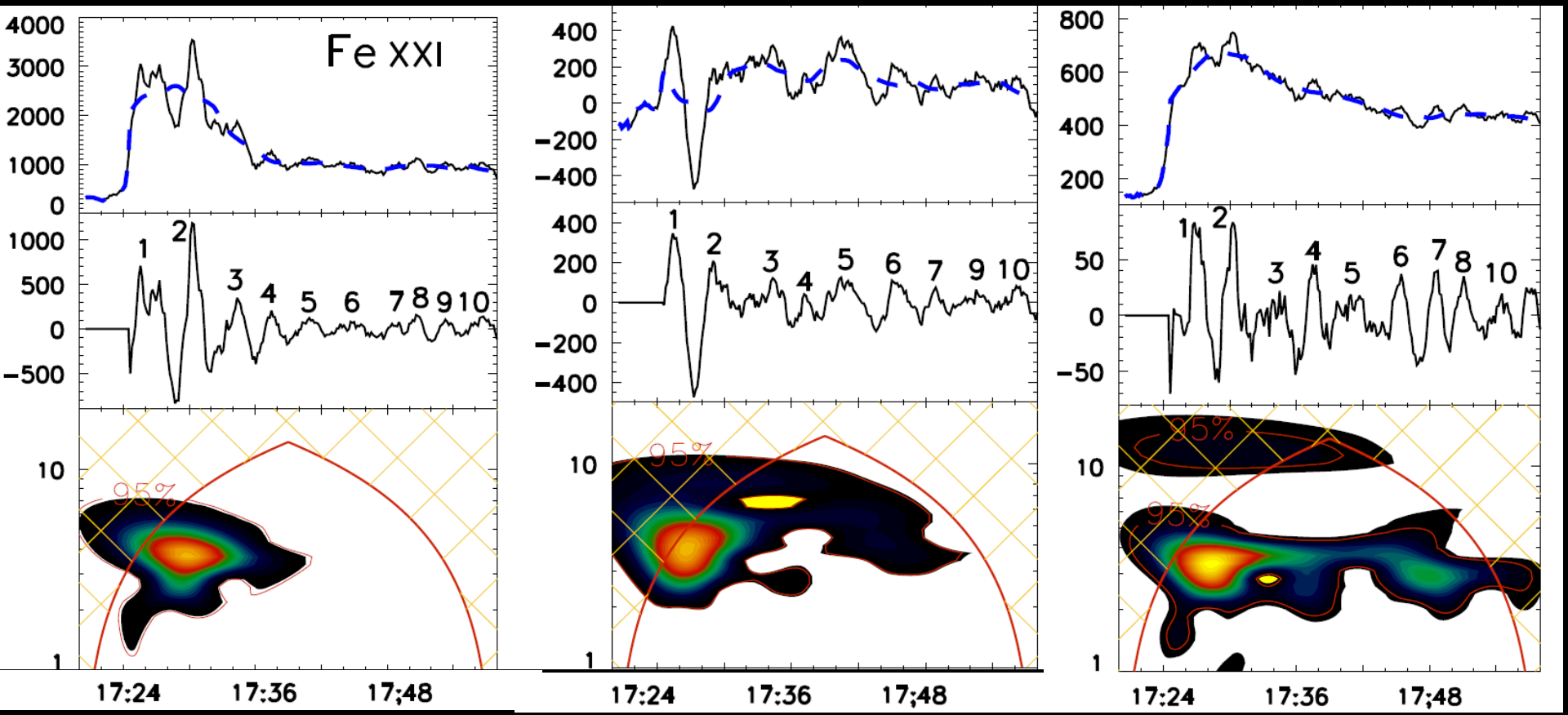
IRIS Window	Ion	Wavelength (Å)	Width (mÅ)	Intensity Tied to
	Si II	1352.69 ± 0.102	⩽260	Si II 1350.13
	Fe II	1353.07 ± 0.051	⩽88	Fe II 1354.80
	Unknown	1353.40 ± 0.061	⩽102	H_2 1342.83
	Unknown	1353.61 ± 0.061	⩽102	H_2 1342.83
"O I"	Si II	1353.78 ± 0.102	⩽260	Si II 1350.13
	Fe II	1354.06 ± 0.051	⩽88	Fe II 1354.80
	Fe XXI	1354.09 ± 1.28	⩾230	···
	C I	1354.29 ± 0.26	⩽130	···
	Fe II	1354.80 ± 0.051	⩽88	···
	Fe II	1354.91 ± 0.061	⩽102	···
	Si II	1350.13 ± 0.102	⩽260	···
	Unknown	1348.34 ± 0.067	⩽102	···
"Fe XII"	Unknown	1348.60 ± 0.067	⩽102	···
	Unknown	1349.65 ± 0.051	⩽77	···
"1343"	H_2	1342.83 ± 0.061	⩽102	

Intensity width Doppler

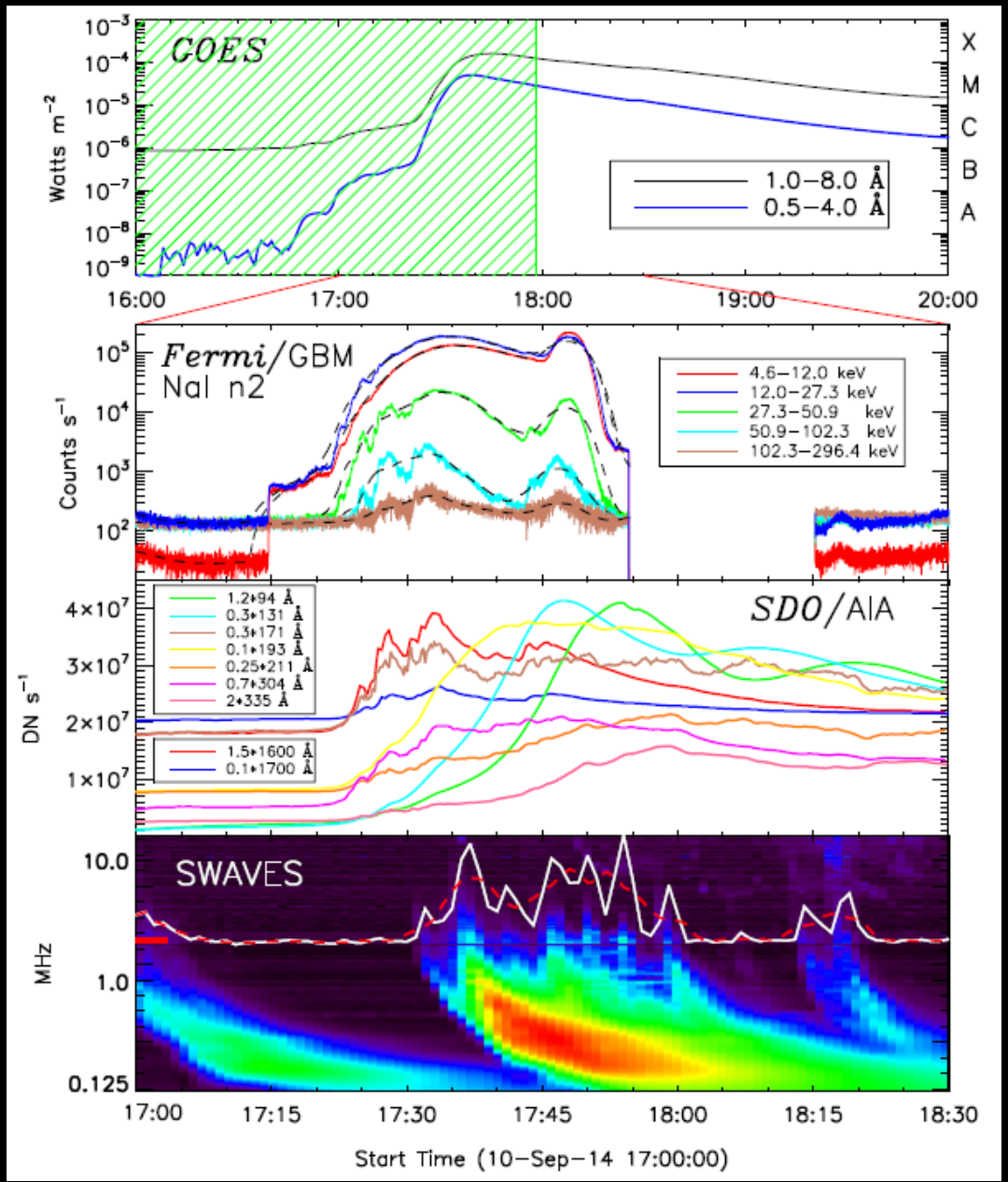




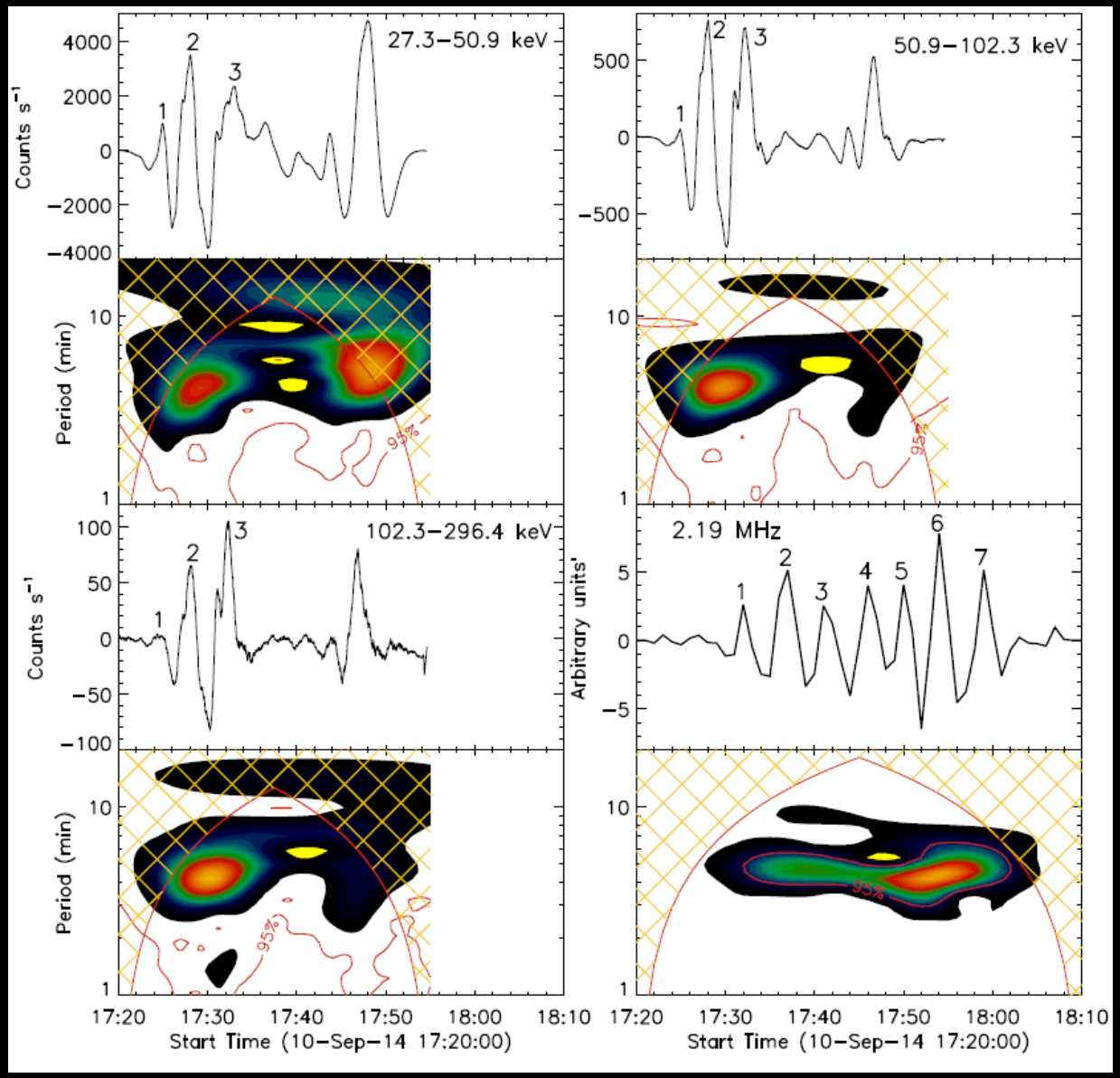
Intensity width Doppler



X1.6 Solar flare



HXR and radio



Summary

1. Quasi-period oscillations at multi-wavelengths, i.e. HXR, EUV, radio
2. IRIS spectral observations show the same phase oscillations on the line intensity, width and Doppler.
3. The physics mechanism of such oscillations is open.

The Astrophysical Journal, 807:72 (12pp), 2015 July 1 doi:10.1088/0004-637X/807/1/72

IMAGING AND SPECTRAL OBSERVATIONS OF QUASI-PERIODIC PULSATIONS IN A SOLAR FLARE

D. Li[1,2], Z. J. Ning[1], and Q. M. Zhang[1]
[1] Key Laboratory of Dark Matter and Space Astronomy, Purple Mountain Observatory, CAS, Nanjing 210008, China; lidong@pmo.ac.cn.
[2] University of Chinese Academy of Sciences, Beijing 100049, China
Received 2015 March 9; accepted 2015 May 11; published 2015 July 1

ABSTRACT

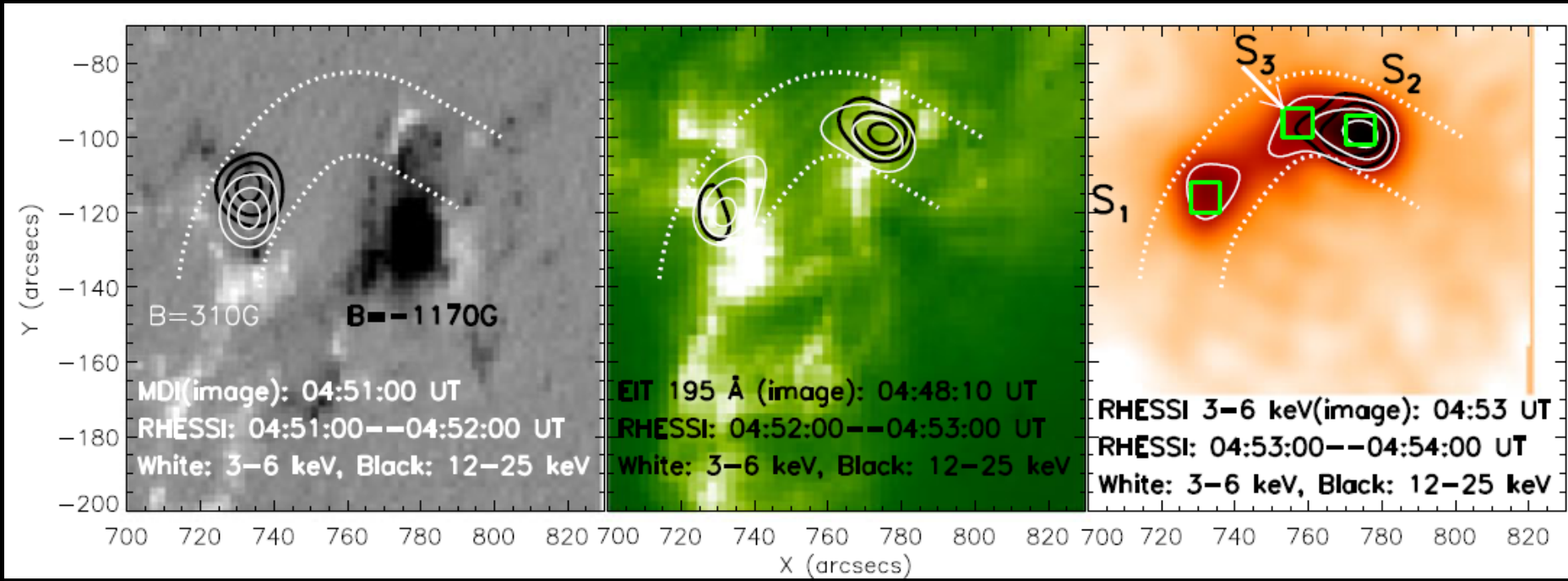
We explore the quasi-periodic pulsations (QPPs) in a solar flare observed by *Fermi* Gamma-ray Burst Monitor, *Solar Dynamics Observatory*, *Solar Terrestrial Relations Observatory*, and *Interface Region Imaging Spectrograph* (*IRIS*) on 2014 September 10. QPPs are identified as the regular and periodic peaks on the rapidly varying components, which are the light curves after removing the slowly varying components. The QPPs display only three peaks at the beginning on the hard X-ray emissions, but 10 peaks on the chromospheric and coronal line emissions, and more than seven peaks (each peak corresponds to a type III burst on the dynamic spectra) at the radio emissions. A uniform quasi-period of about 4 minutes is detected among them. AIA imaging observations exhibit that the 4-minute QPPs originate from the flare ribbon and tend to appear on the ribbon front. *IRIS* spectral observations show that each peak of the QPPs tends to a broad line width and a red Doppler velocity at C I, O IV, Si IV, and Fe XXI lines. Our findings indicate that the QPPs are produced by the non-thermal electrons that are accelerated by the induced quasi-periodic magnetic reconnections in this flare.

Key words: line: profiles – Sun: oscillations – Sun: radio radiation – Sun: UV radiation – Sun: X-rays, gamma-rays – techniques: spectroscopic

Supporting material: animation

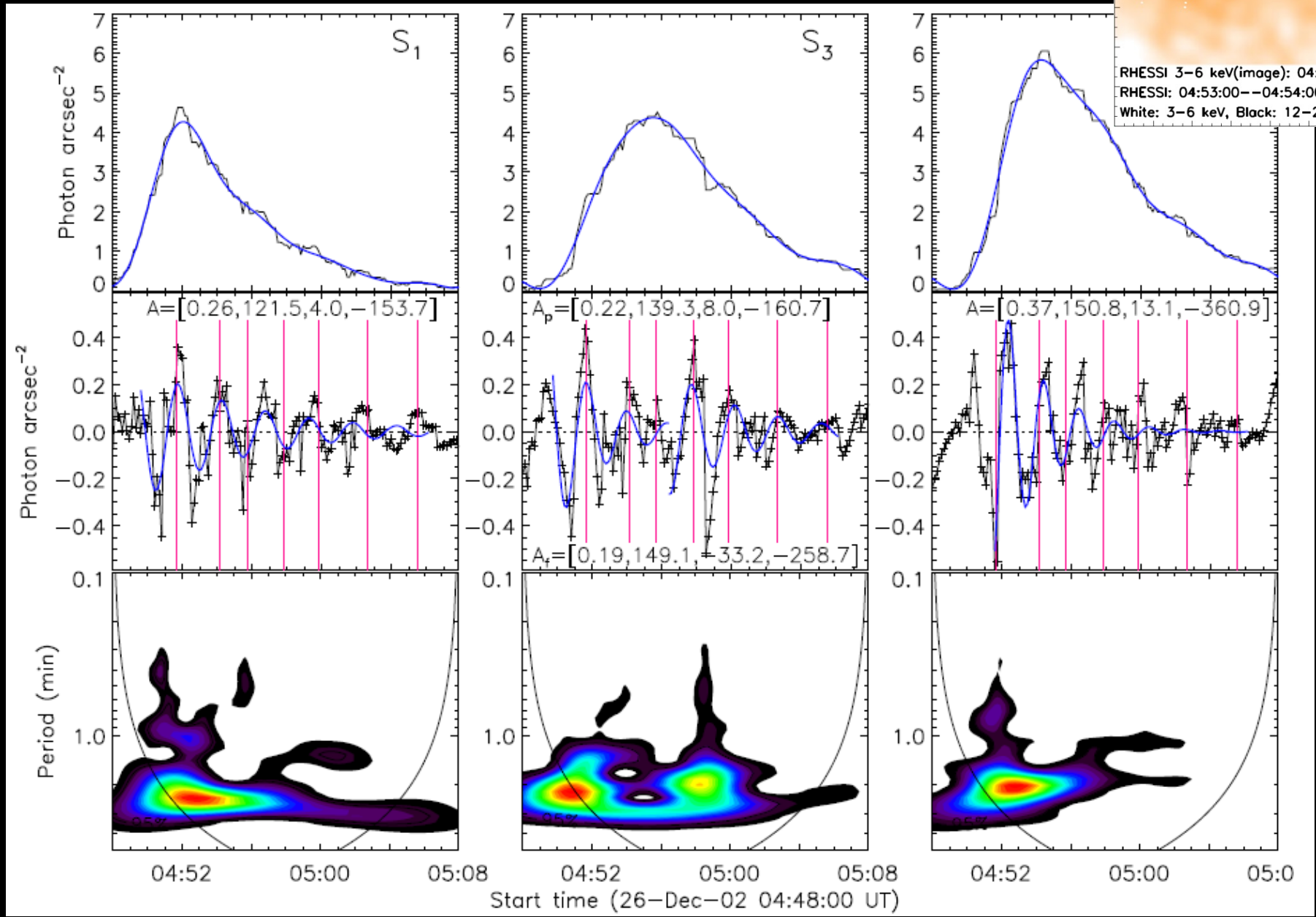
Li, Ning & Zhang 2015

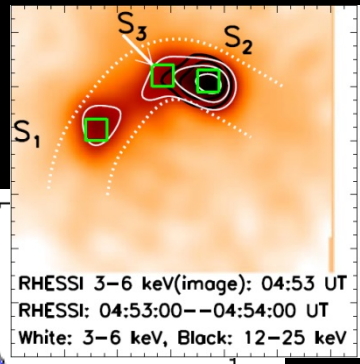
2012 Dec. 26 solar flare



MDI EIT/195 RHESSI

Quasi-period oscillation at SXR





Summary

- 2002 Dec. 26 B8.1flare：

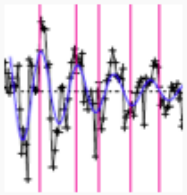
- 1. 3-6keV SXR shows ~4 min oscillations
- 2. decay time about ~2.5-6 min.
- 3. almost reverse-phase for two footpoints.
- 4. No oscillations seen in GOES light curve.

RHESSI Nuggets No.221

221

Imaging Quasi-Periodic Oscillations in a Simple Flare

17 March 2014 by Zongjun Ning and Hugh Hudson



Time-series imaging spectroscopy in a B8 flare. Click the title to read more.

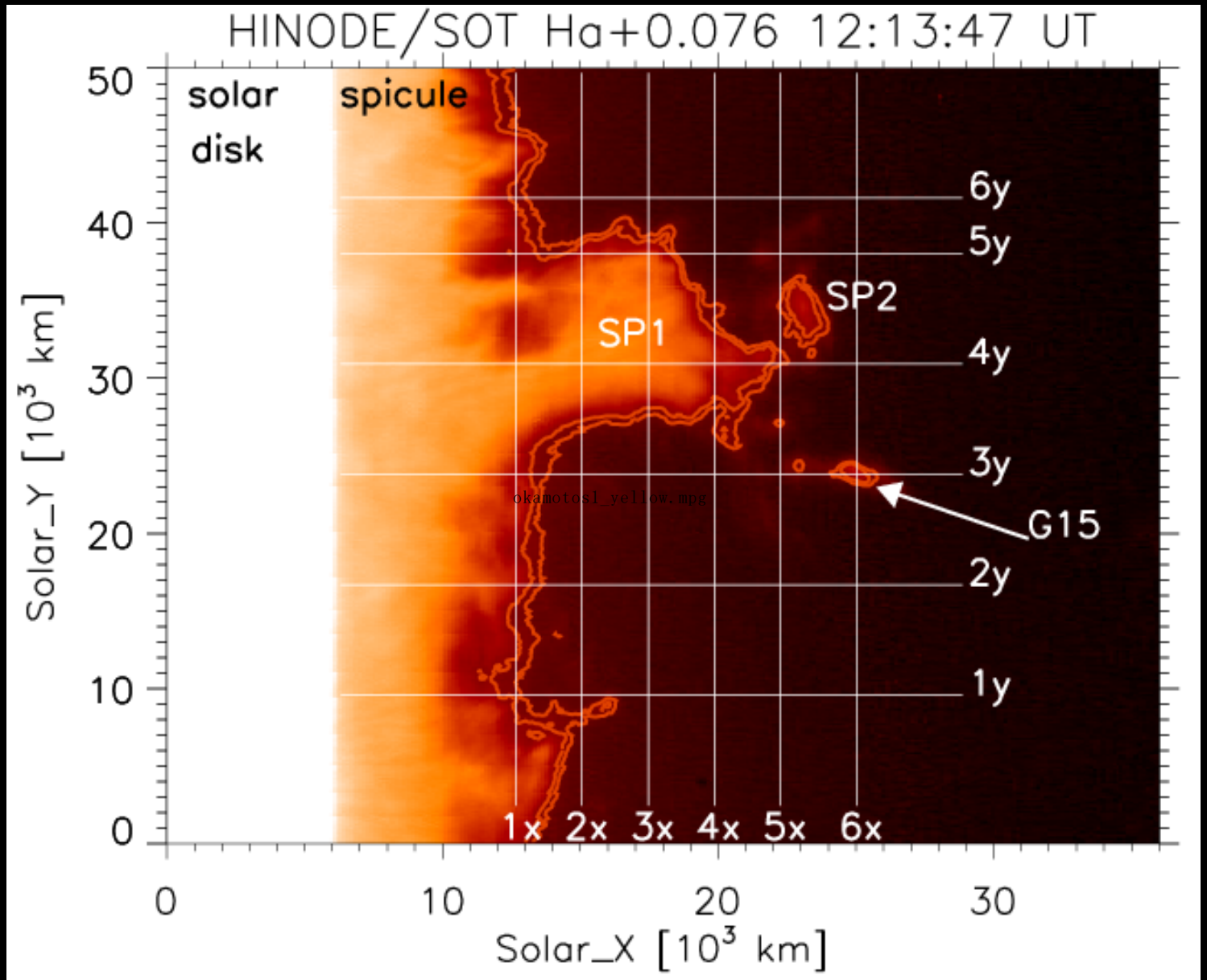
Solar Phys (2014) 289:1239–1256
DOI 10.1007/s11207-013-0405-6

Imaging Observations of X-Ray Quasi-periodic Oscillations at 3 – 6 keV in the 26 December 2002 Solar Flare

Zongjun Ning

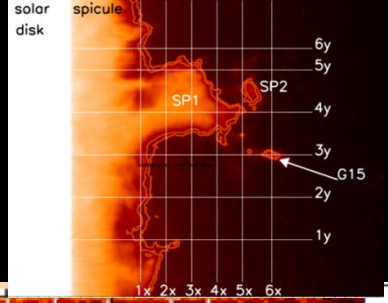
Received: 13 November 2012 / Accepted: 27 August 2013 / Published online: 2 October 2013

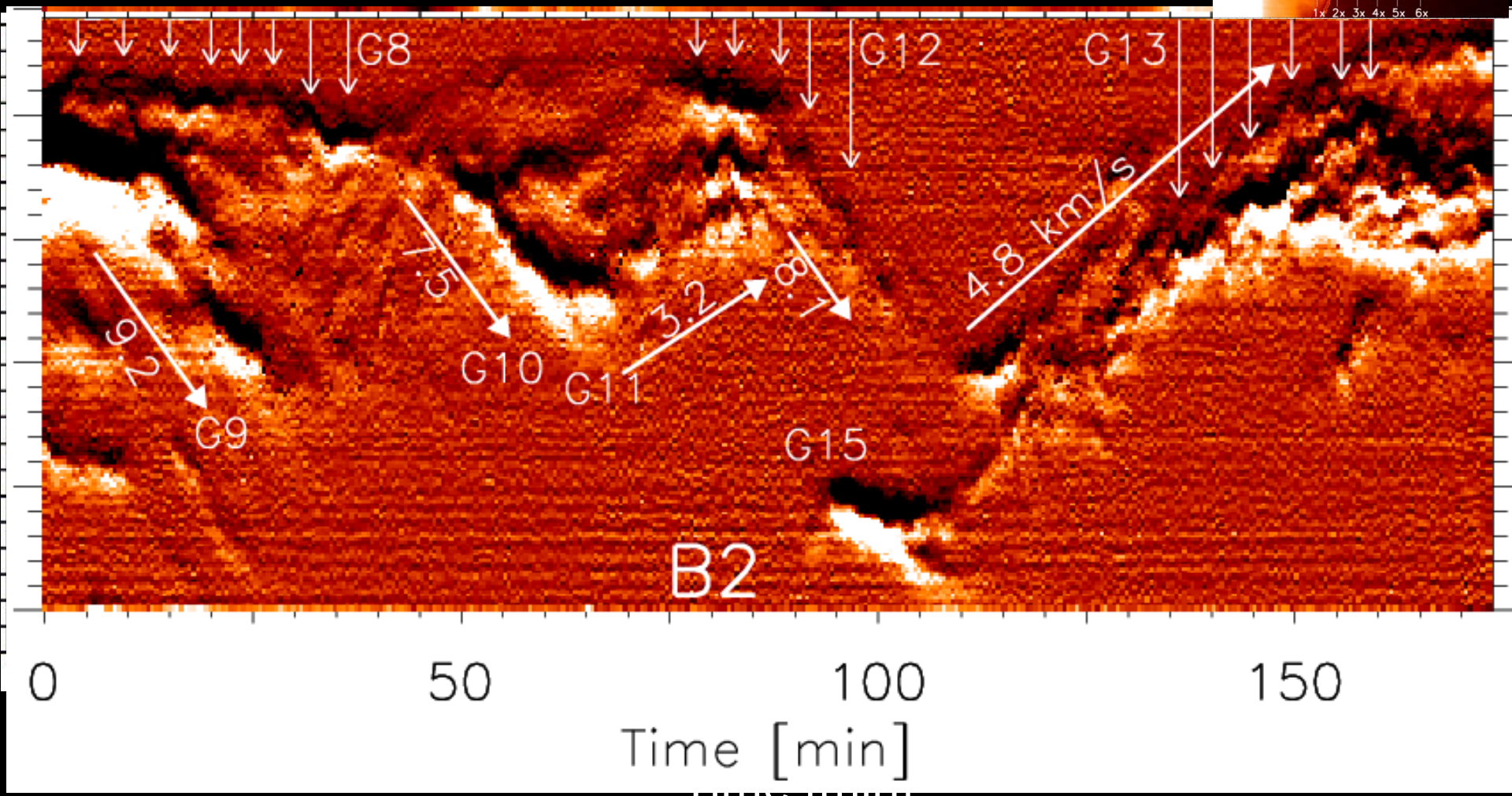
2008 Jan.15 prominence



Time-distance maps

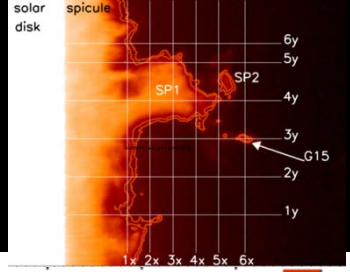
Oscillations on pro. surface +thread

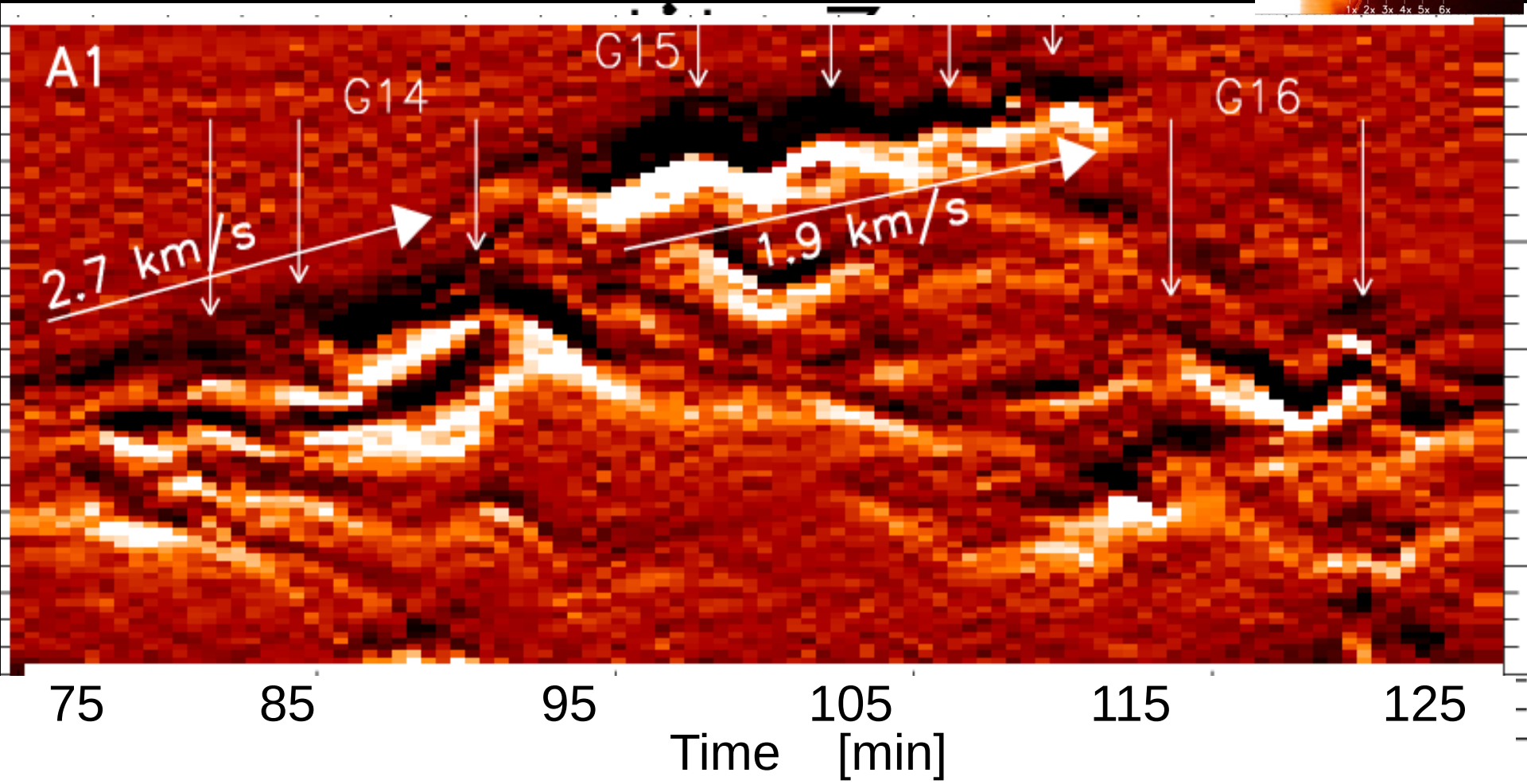




Ning et al. 2009

Time-distance maps





A&A 499, 595–600 (2009)
DOI: 10.1051/0004-6361/200810853

Astronomy & Astrophysics

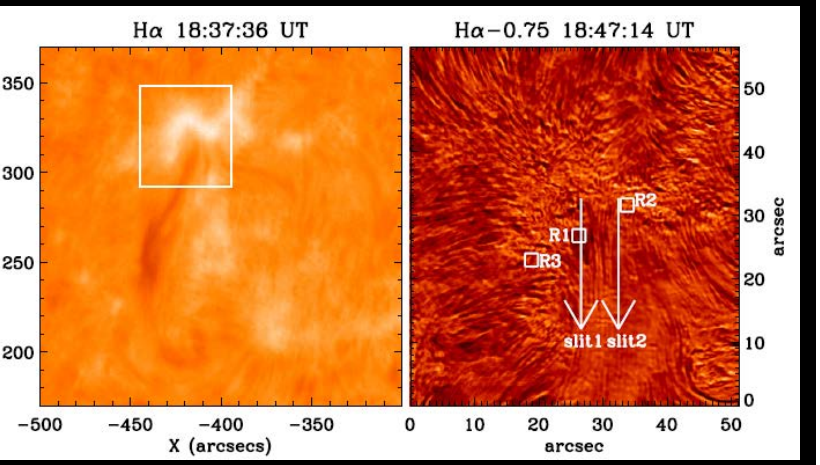
Small-scale oscillations in a quiescent prominence observed by HINODE/SOT

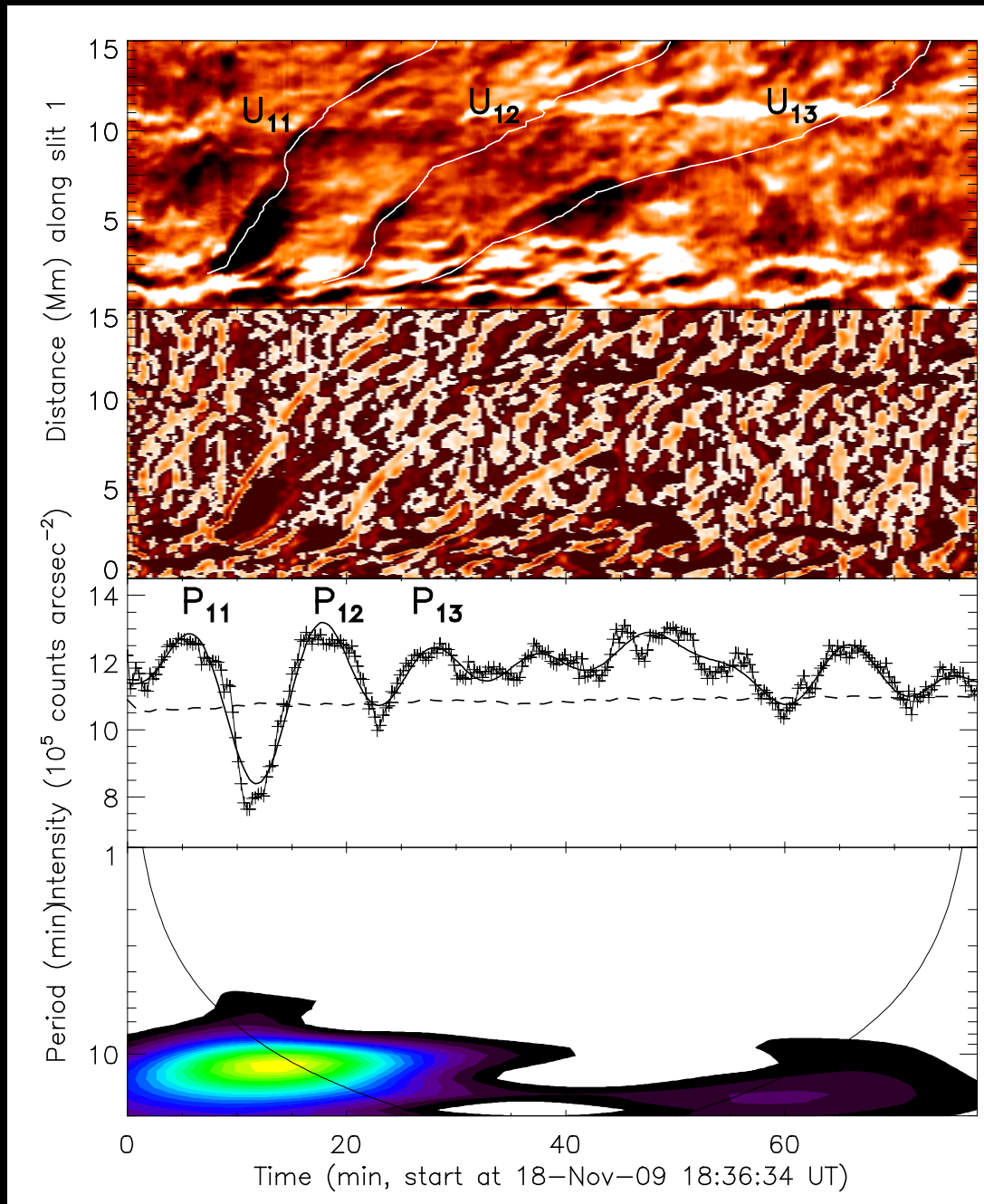
Prominence oscillations

Z. Ning[1], W. Cao[2], T. J. Okamoto[3], K. Ichimoto[3,4], and Z. Q. Qu[5]

[1] Purple Mountain Observatory, Nanjing 210008, PR China
e-mail: ningzongjun@pmo.ac.cn
[2] Center for Solar Terrestrial Research, New Jersey Institute of Technology, Newark, NJ 07102, USA
e-mail: wcao@bbso.njit.edu
[3] National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan
e-mail: joten.okamoto@nao.ac.jp
[4] Kwasan and Hida Observatories, Kyoto University, Yamashina, Kyoto 607-8471, Japan
e-mail: ichimoto@kwasan.kyoto-u.ac.jp
[5] Yunnan Astronomy Observatory, Kunming 650011, PR China

Oscillations in a filament





THE ASTROPHYSICAL JOURNAL LETTERS, 719:L95–L98, 2010 August 10 doi:10.1088/2041-8205/719/1/L95

EVIDENCE OF FILAMENT UPFLOWS ORIGINATING FROM INTENSITY OSCILLATIONS ON THE SOLAR SURFACE

WENDA CAO[1,2], ZONGJUN NING[2,3], PHILIP R. GOODE[1,2], VASYL YURCHYSHYN[2], AND HAISHENG JI[3]
[1] Center for Solar-Terrestrial Research, New Jersey Institute of Technology, 323 Martin Luther King Blvd., Newark, NJ 07102, USA; wcao@bbso.njit.edu
[2] Big Bear Solar Observatory, 40386 North Shore Lane, Big Bear City, CA 92316, USA
[3] Purple Mountain Observatory, Nanjing 210008, China
Received 2010 May 20; accepted 2010 July 6; published 2010 July 26

ABSTRACT

A filament footpoint rooted in an active region (NOAA 11032) was well observed for about 78 minutes with the 1.6 m New Solar Telescope at the Big Bear Solar Observatory on 2009 November 18 in Hα $\pm$0.75 Å. This data set had high cadence ($\sim$15 s) and high spatial resolution ($\sim$0.″1) and offered a unique opportunity to study filament dynamics. As in previous findings from space observations, several dark intermittent upflows were identified, and they behave in groups at isolated locations along the filament. However, we have two new findings. First, we find that the dark upflows propagating along the filament channel are strongly associated with the intensity oscillations on the solar surface around the filament footpoints. The upflows start at the same time as the peak in the oscillations, illustrating that the upflow velocities are well correlated with the oscillations. Second, the intensity of one of the seven upflows detected in our data set exhibits a clear periodicity when the upflow propagates along the filament. The periods gradually vary from $\sim$10 to $\sim$5 minutes. Our results give observational clues on the driving mechanism of the upflows in the filament.

Summary

- Oscillations of prominence or filament threads.

- The physics is open.