

Multi-wavelength study of the dynamics of sunspot and it's surroundings

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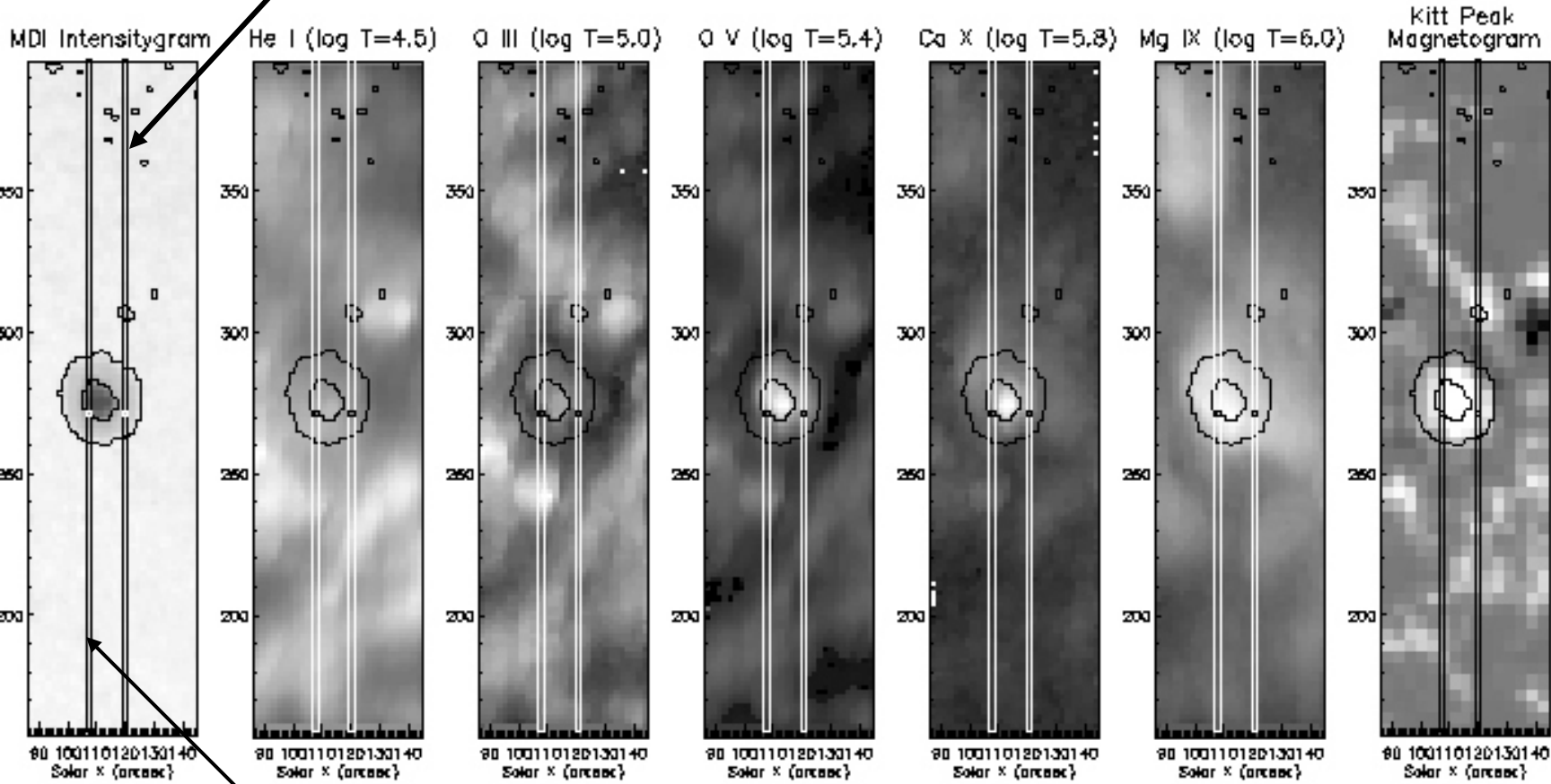


Chin-Hsien Lin (Yale)

E.O'Shea & J.G.Doyle (Armagh)

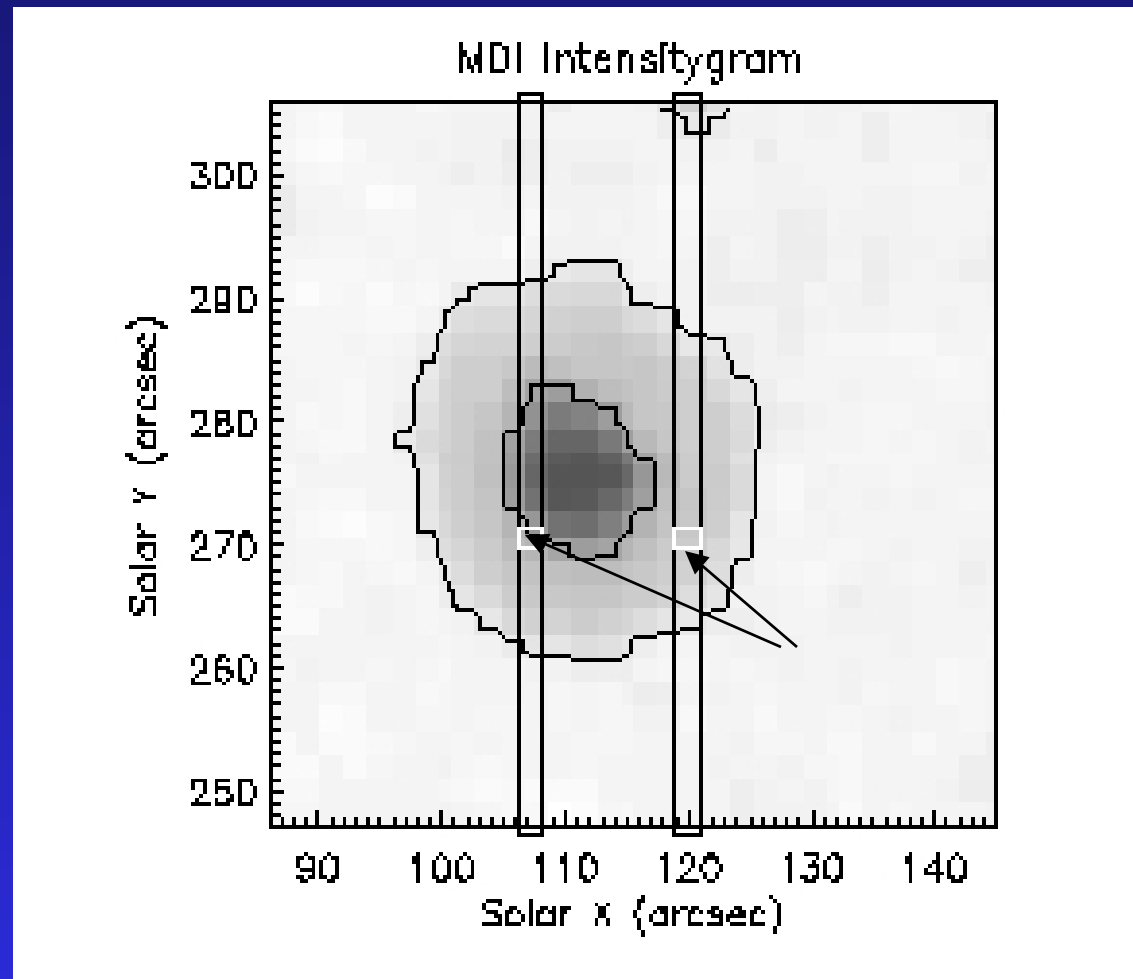


Initial location of the CDS slit

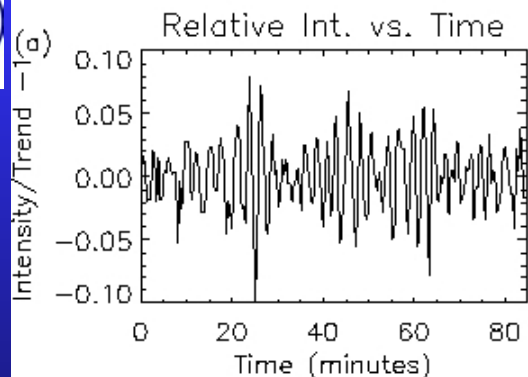


Final location of the CDS slit

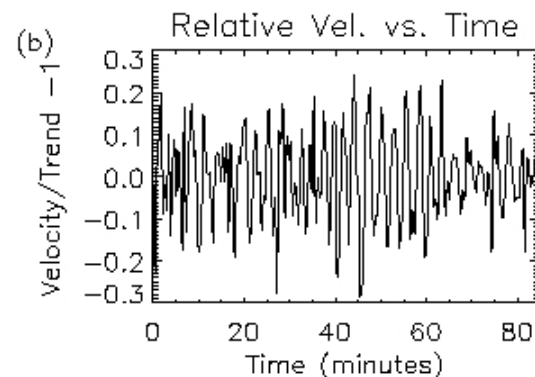
Position of the slit with respect to CDS rasters and magnetograms



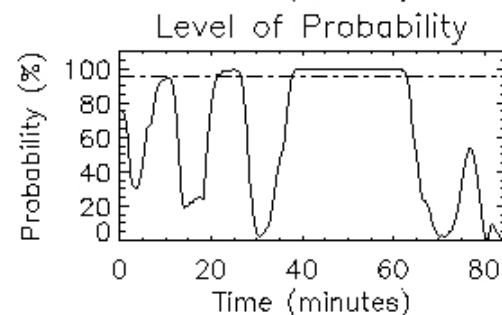
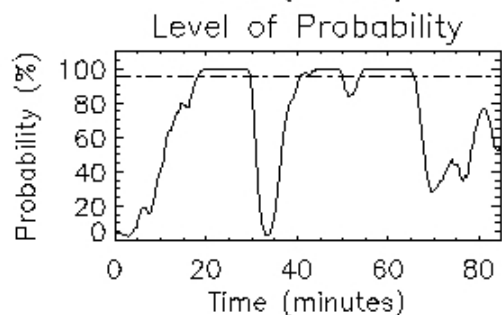
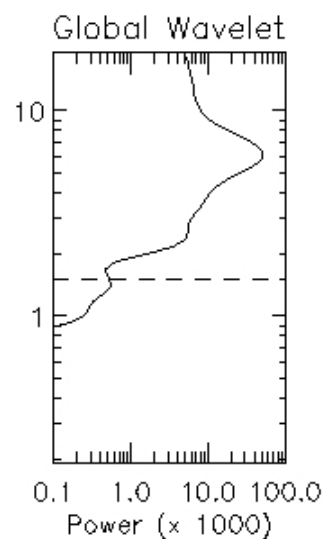
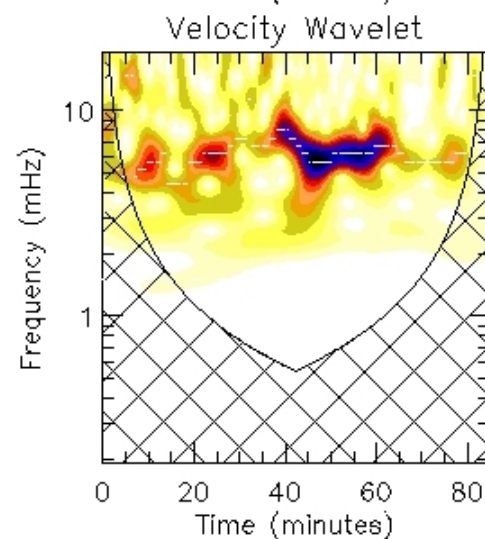
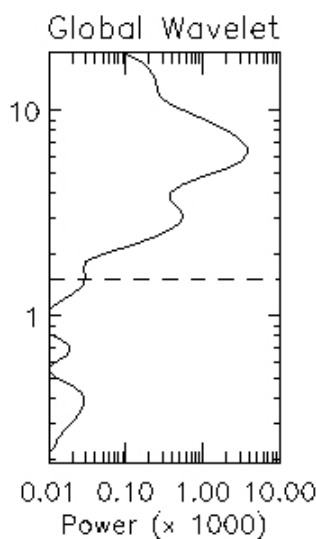
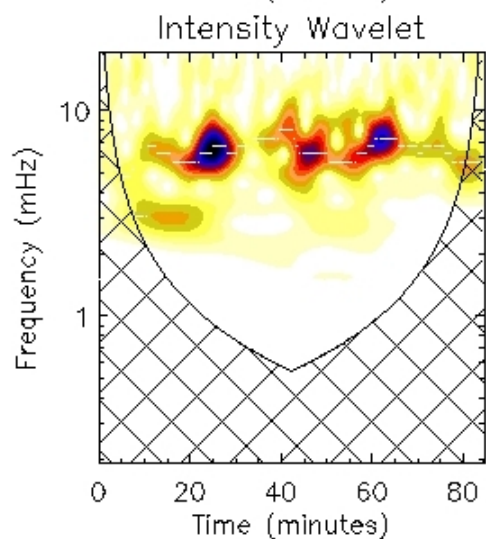
The location of the CDS slit, over-plotted on MDI. Contours of Umbra and Penumbra shown



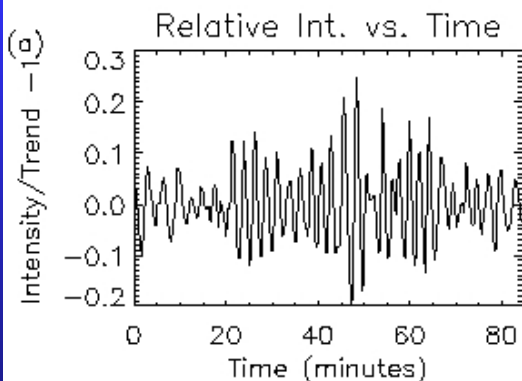
Global freq. at max.
power (> 1.5 mHz)
= 6.2 mHz
Prob. level: 99-100%



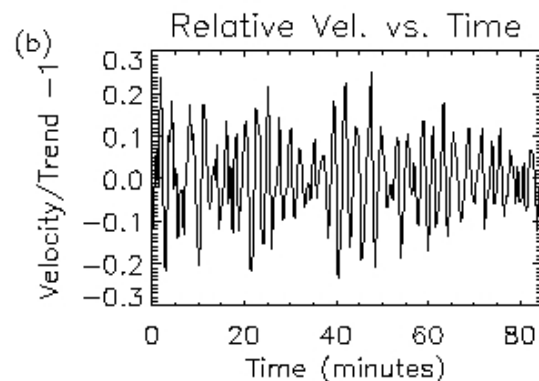
Global freq. at max.
power (> 1.5 mHz)
= 6.2 mHz
Prob. level: 99-100%



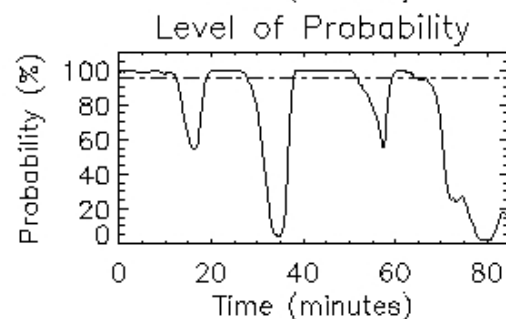
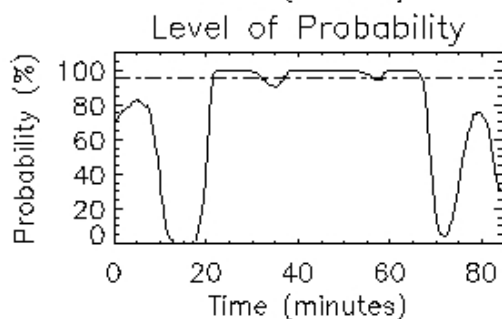
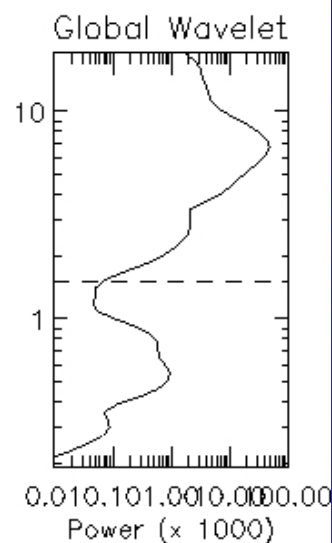
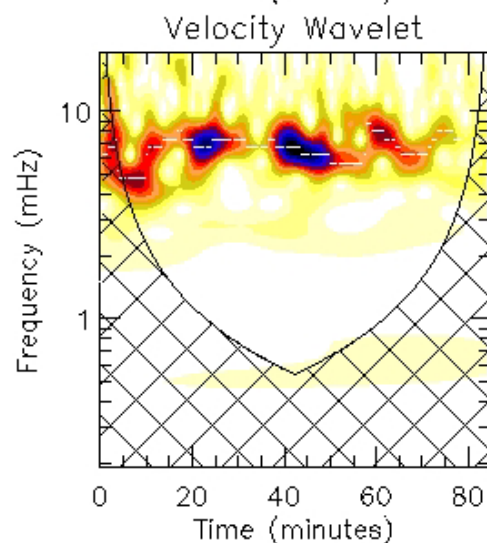
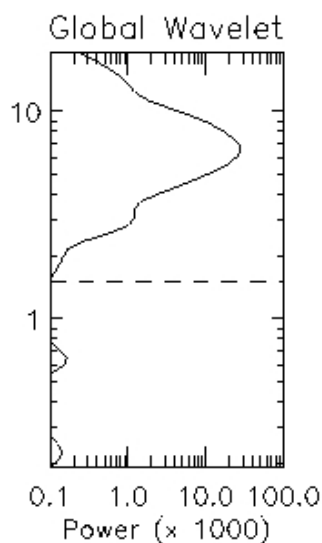
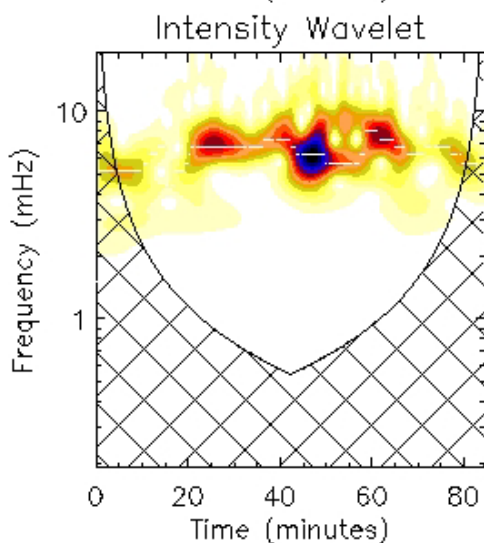
Wavelet results for He I 584 A



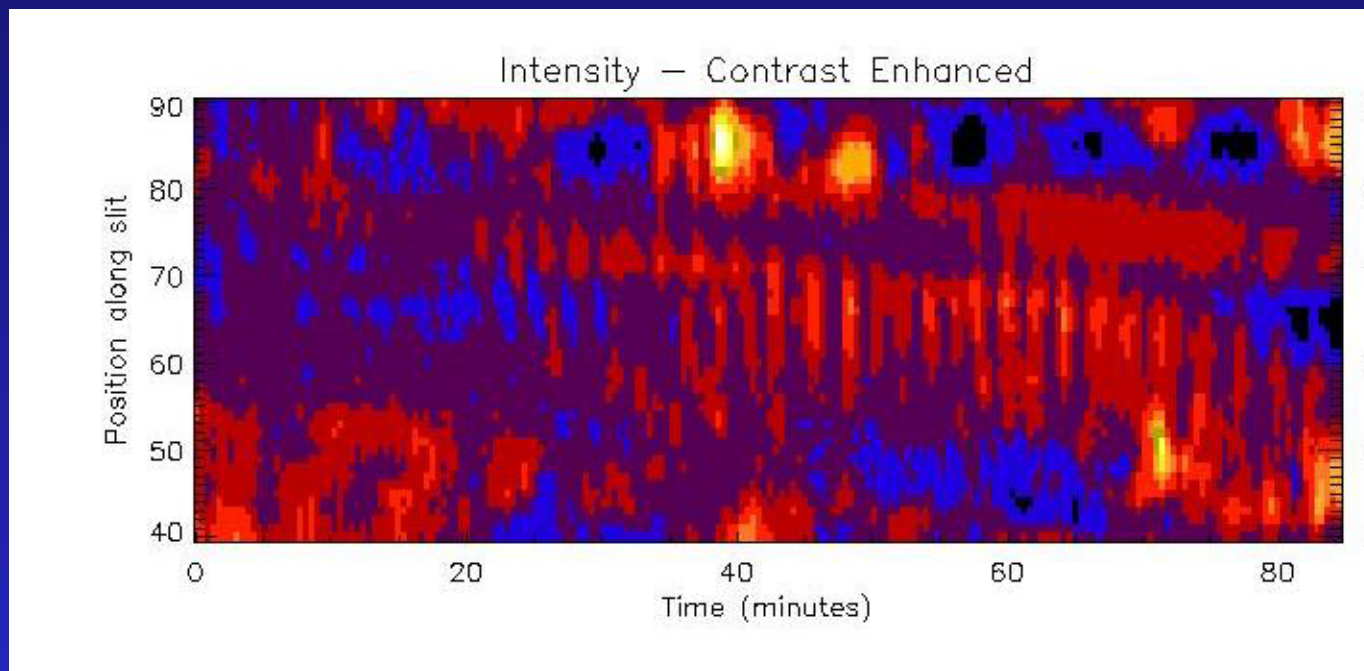
Global freq. at max.
power (> 1.5 mHz)
= 6.7 mHz
Prob. level: 99-100%



Global freq. at max.
power (> 1.5 mHz)
= 6.7 mHz
Prob. level: 99-100%



Wavelet results for OV 629 A



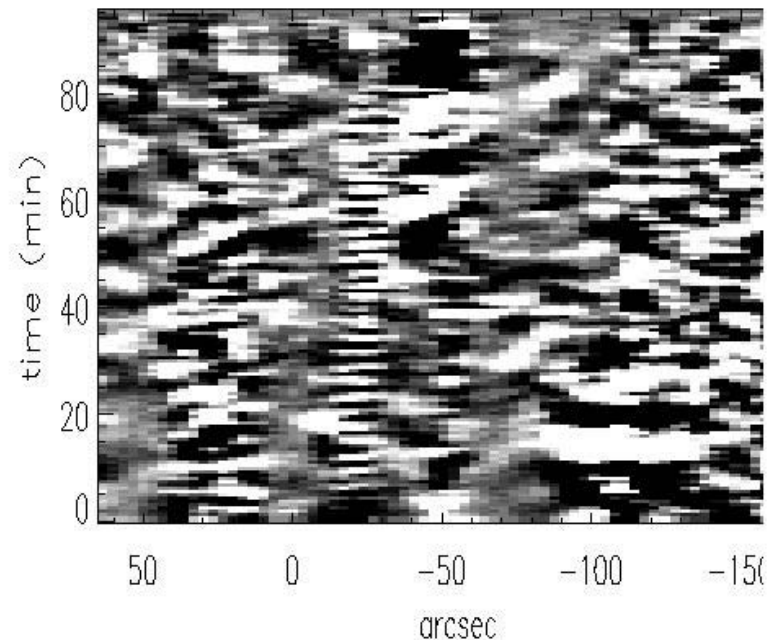
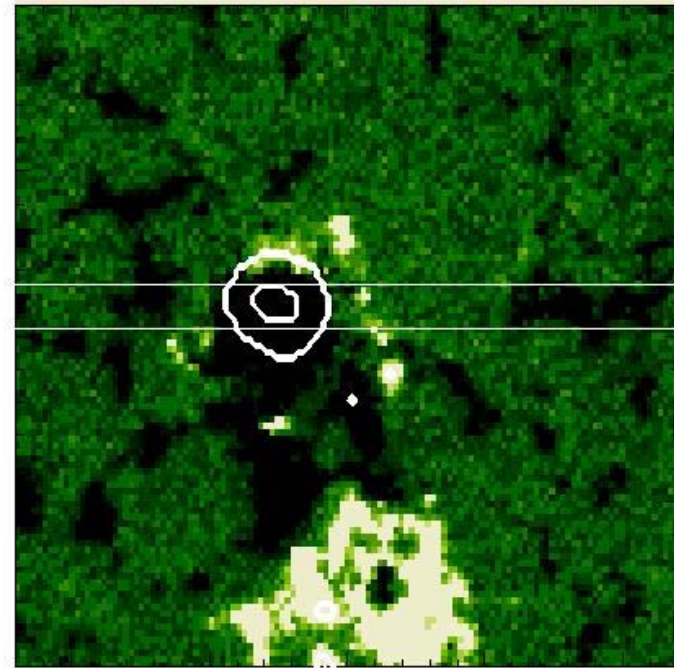
Space time diagram

These results were published in Banerjee et al. 2002, A&A



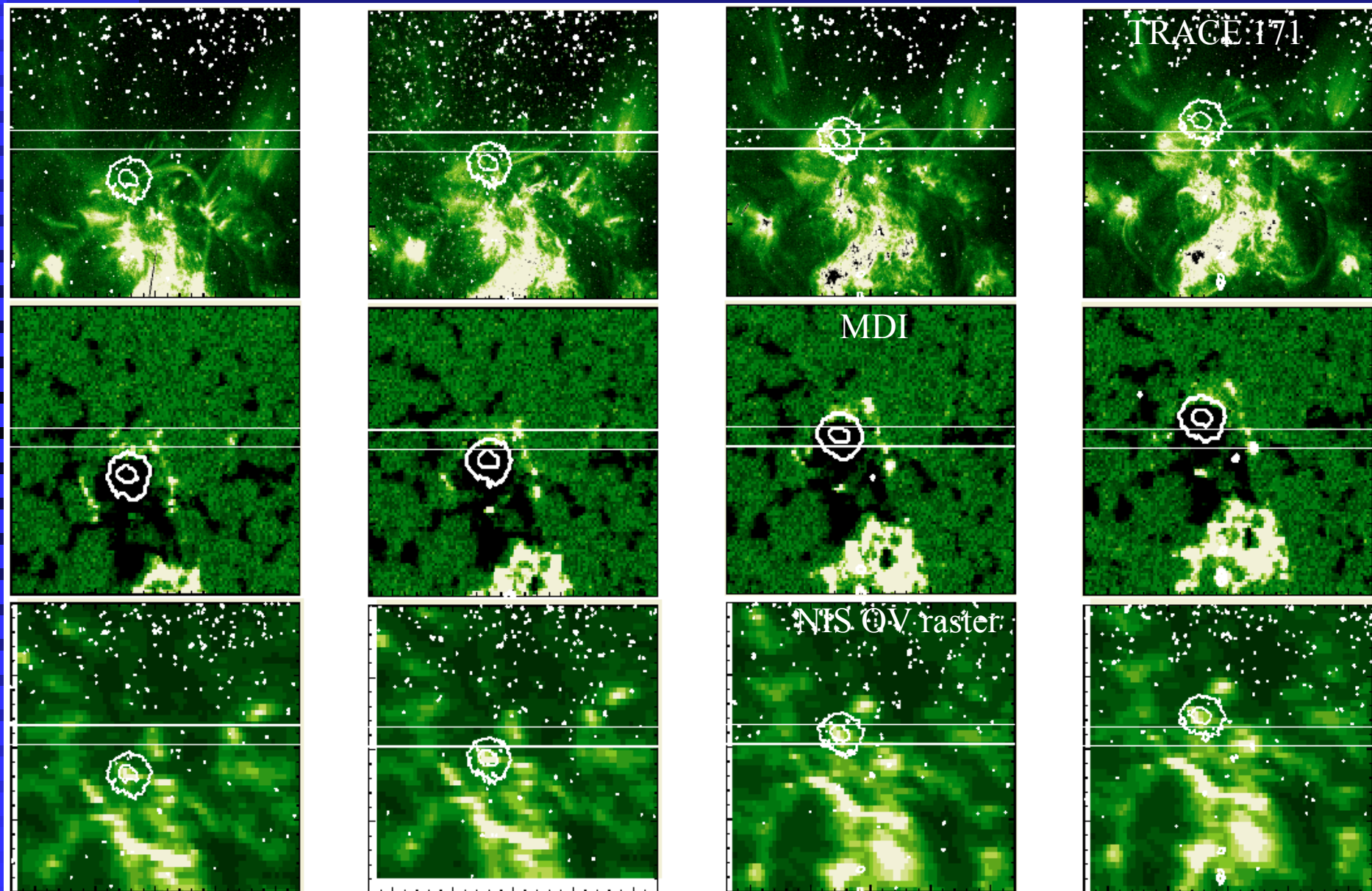
- New set of observations:
- Feb 12-15, 2004
- CDS (raster and temporal series)
- TRACE (171 Å and 1600 Å)
- MDI Magnetograms
- EIT He II 304 Å

Unfiltered oscillations





Feb, 15th 2004



7:37

9:13

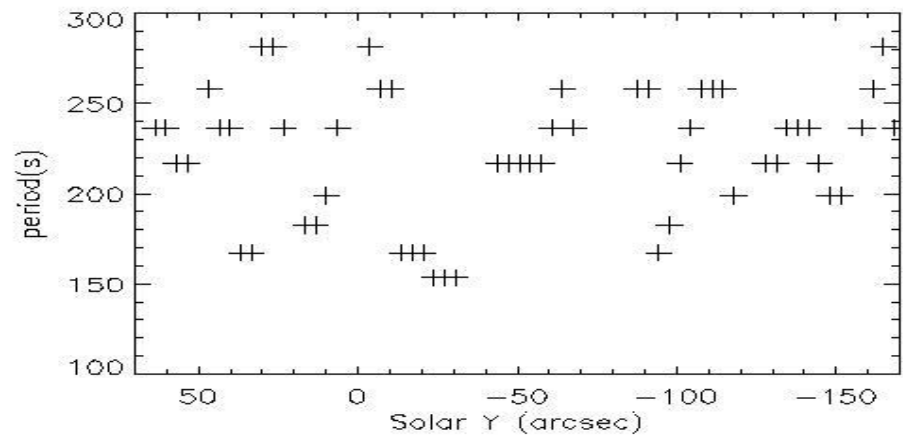
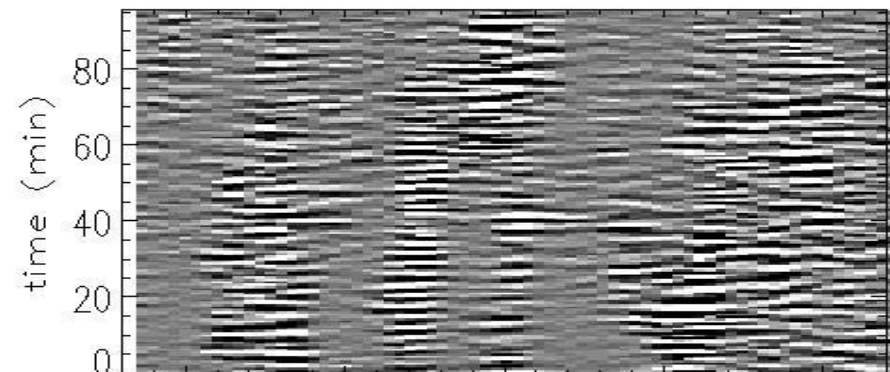
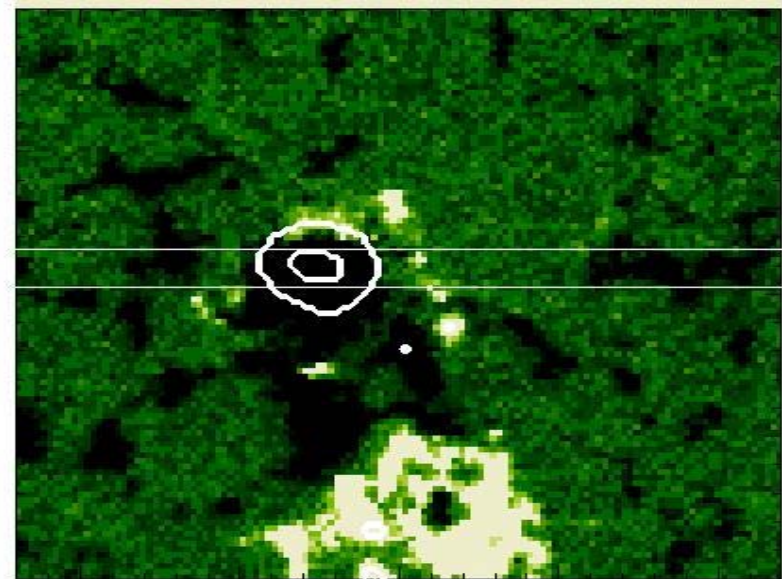
10:49

12:25



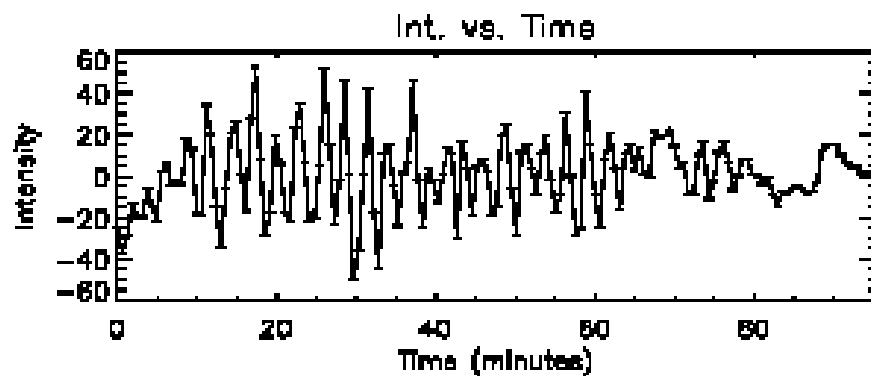
3-min oscillations outside the umbra

Detection of 3 minute oscillations
And possible link with magnetic
Field concentrations as recorded
By MDI

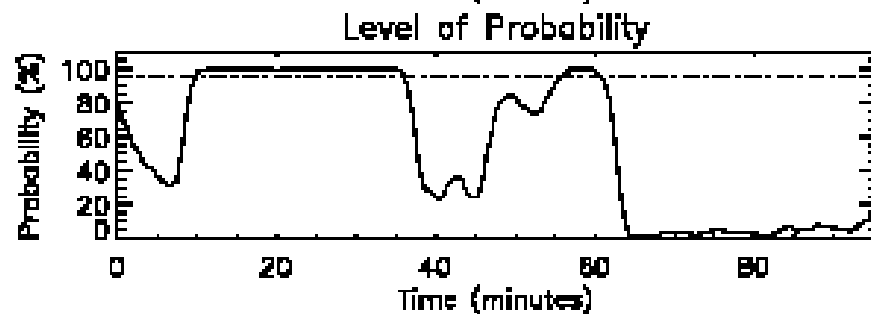
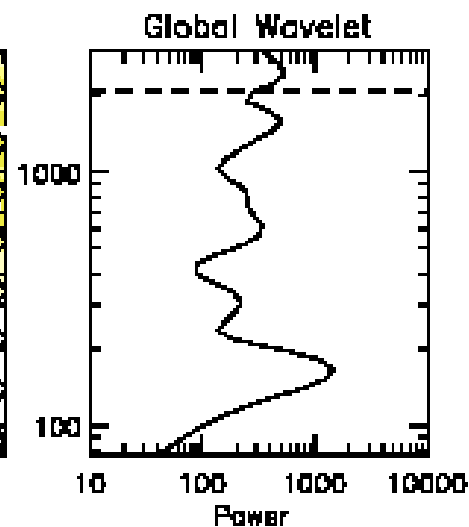
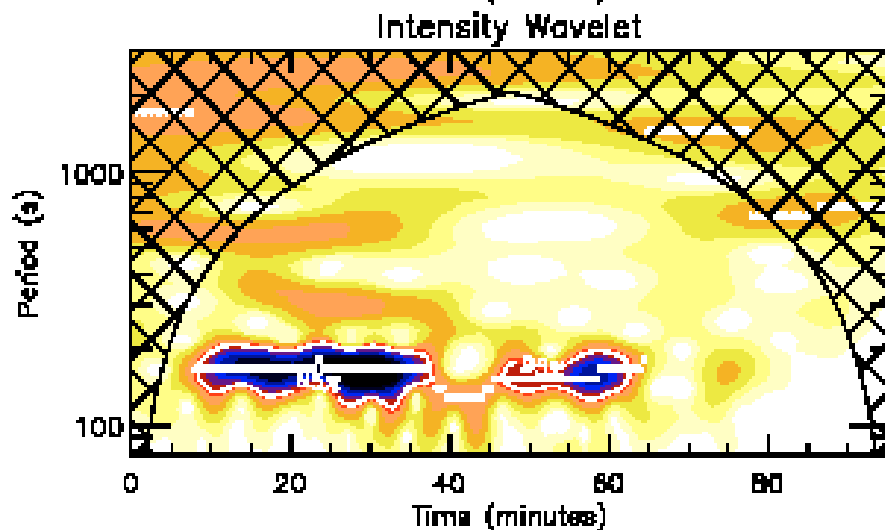




Oscillations inside the umbra



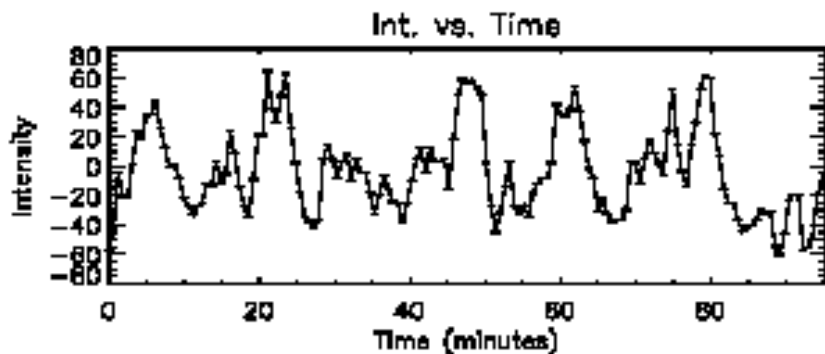
DV 10:49:44 @ -20.3 arcsec
Global Period at max.
power (< 2088.0 sec.)
■ 167 sec.
Prob. level: 99.5%



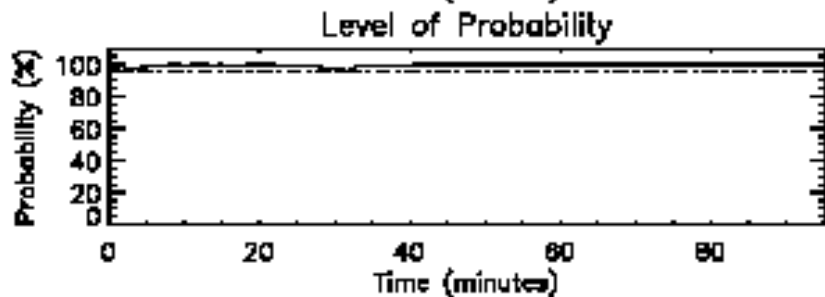
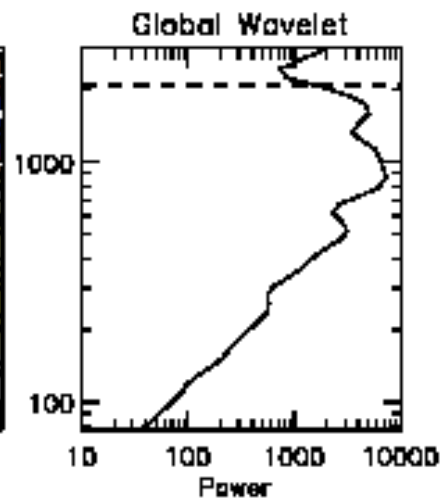
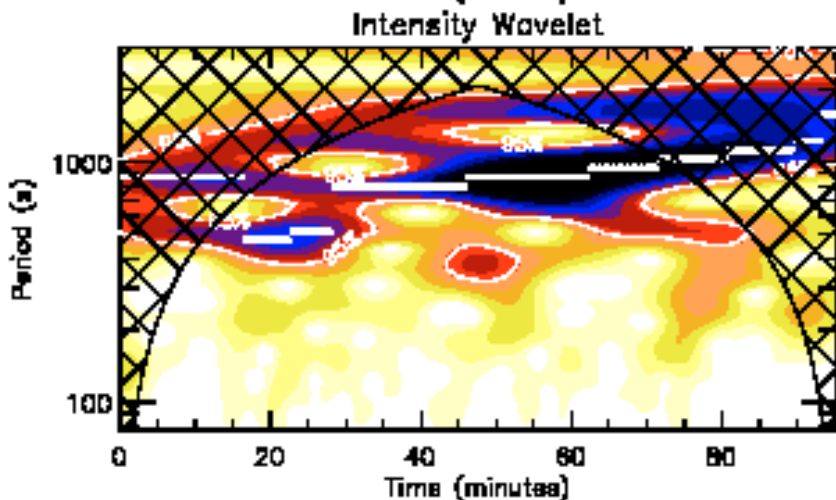
1st Period = 167 ; $(1-p) = 0.995000$



Outside the umbra



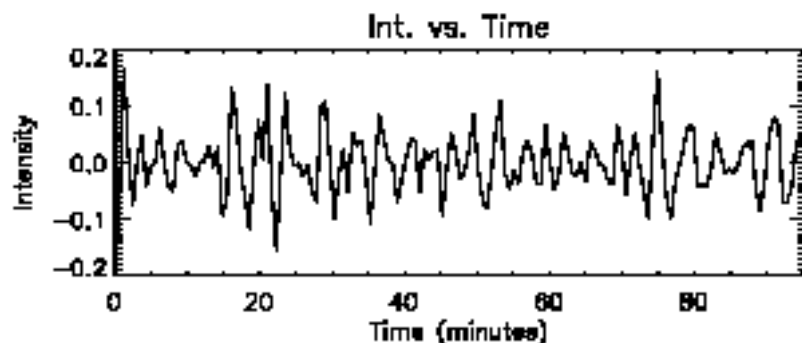
OV 07:37:29 @ -111 arcsec
Global Period at max.
power (< 2089.6 sec.)
= 868 sec.
Prob. level: 99-100%



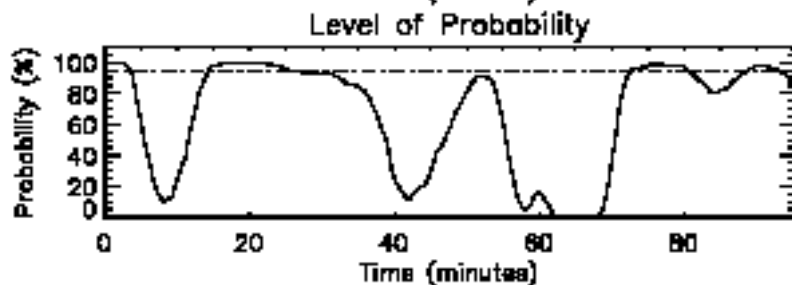
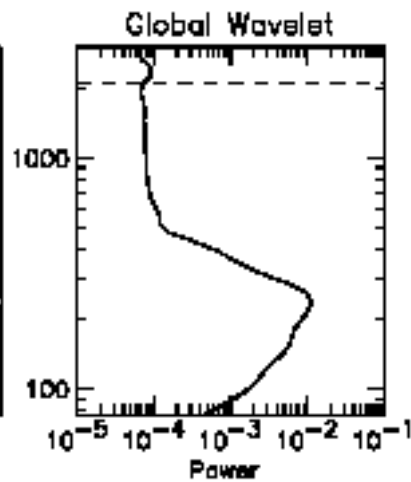
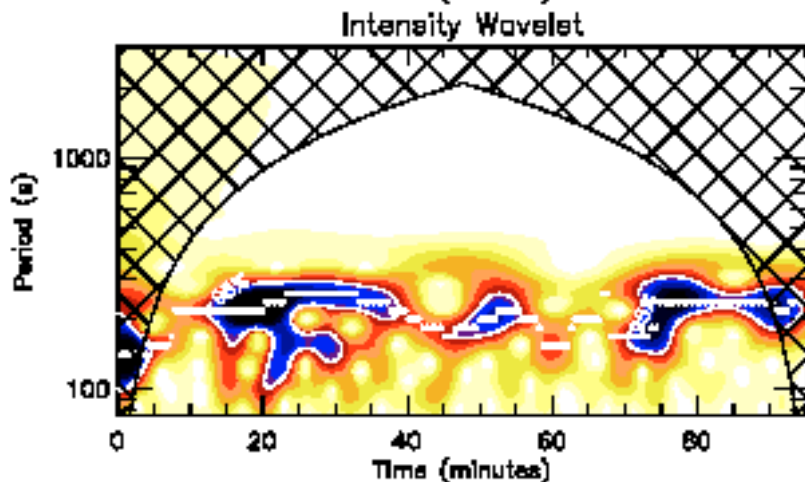
1st Period= 868 ; (1-p)= 1.00000



Filtered relative oscillations (non-sunspot region)



Rel. Osc. $P < 300s$ @ -111 arcsec
Global Period at max.
power (< 2089.6 sec.)
= 236 sec.
Prob. level: 98.5%



1st Period = 236 ; $(1-p) = 0.985000$



NIS OV raster image

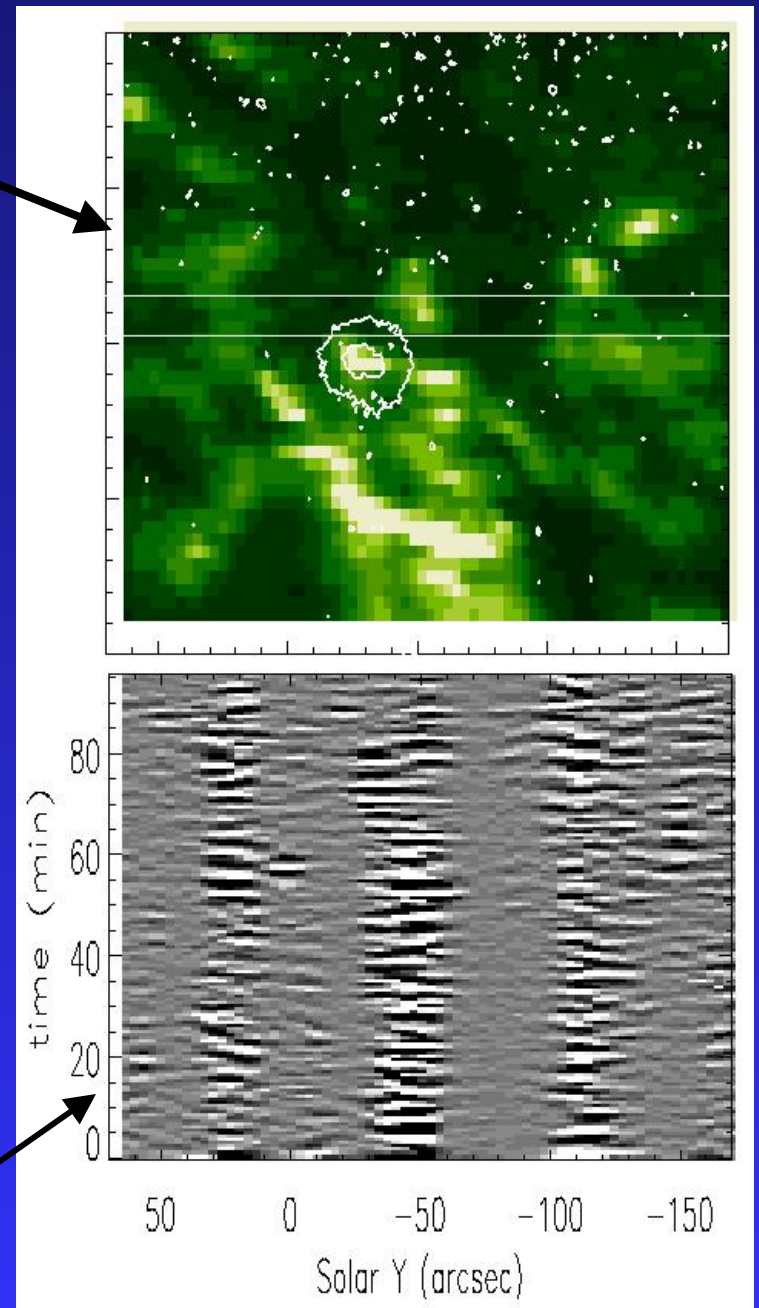
Appearance of oscillation stripes

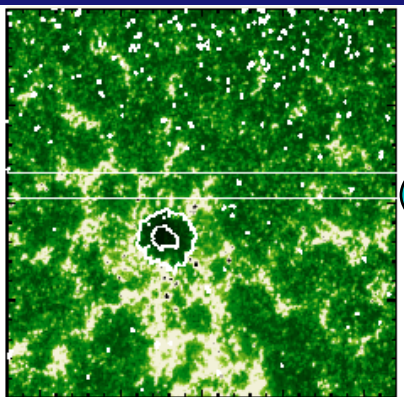
- **indication of fine structures**

Multi-thread oscillations

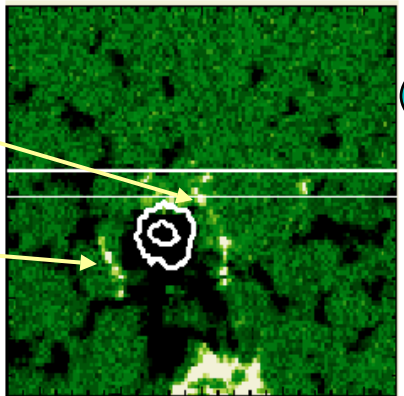
- **indicating multi-loop structures**

OV X-T slice from time-series



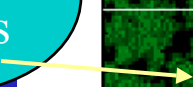


TRACE 1600 A

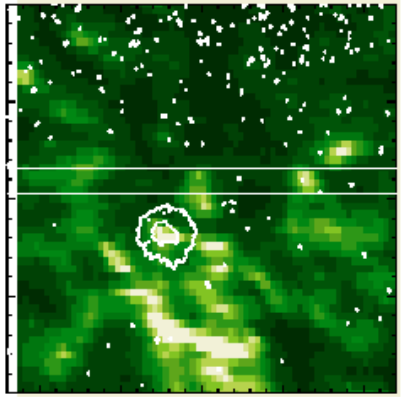


MDI magnetogram

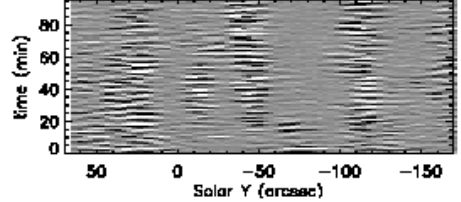
White dots
MMFs



MMFs in the supergranulation
Cell boundaries, as revealed from
TRACE image co-alignment



CDS OV raster image



P300 filtered X-T slice

Lin, Banerjee, O'shea, Doyle, A&A, 2006 (Dec issue)



Summary

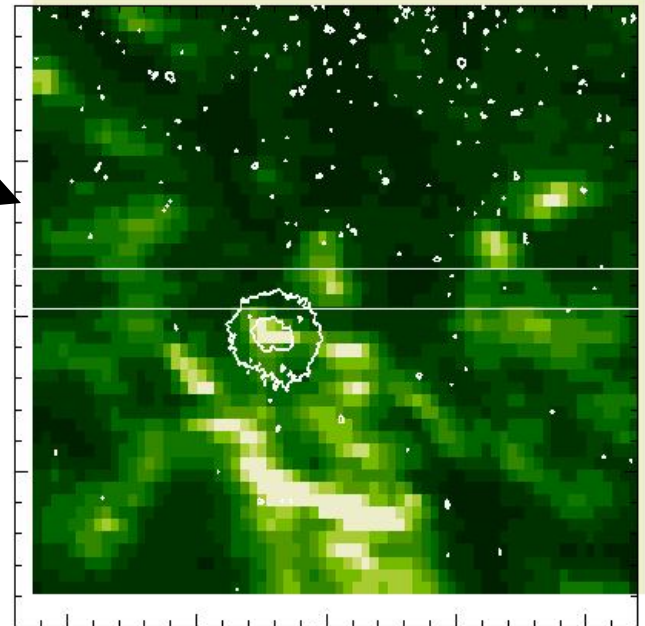
Oscillations with range of frequencies were found in regions with strong magnetic strength

- Oscillations of different frequencies can exist in various magnetic structures
- Different modes are enhanced by different structures
- Vertical, concentrated magnetic structures enhance 3-min oscillations while suppress longer-period oscillations.
- 3-min oscillations in these non-sunspot locations last for about 20 mins, this could be due to the size of the oscillation regions

Oscillations can resolve finer features than intensity images.

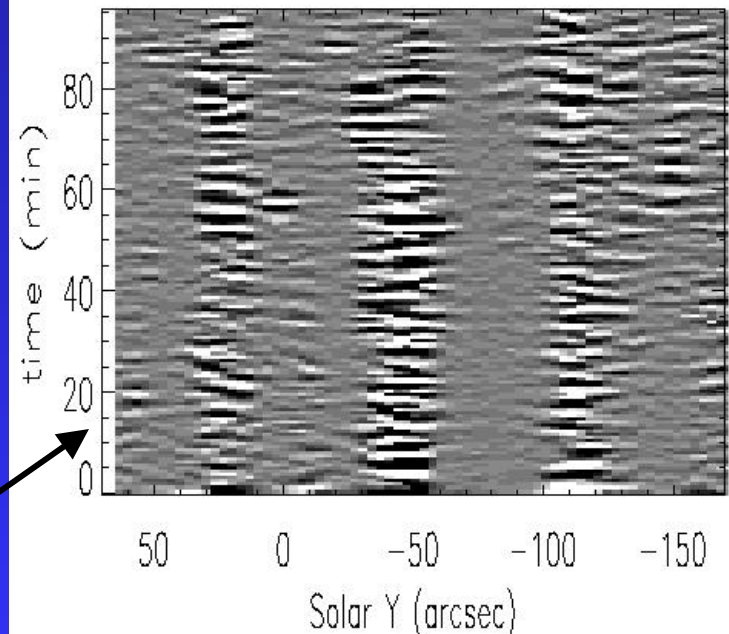


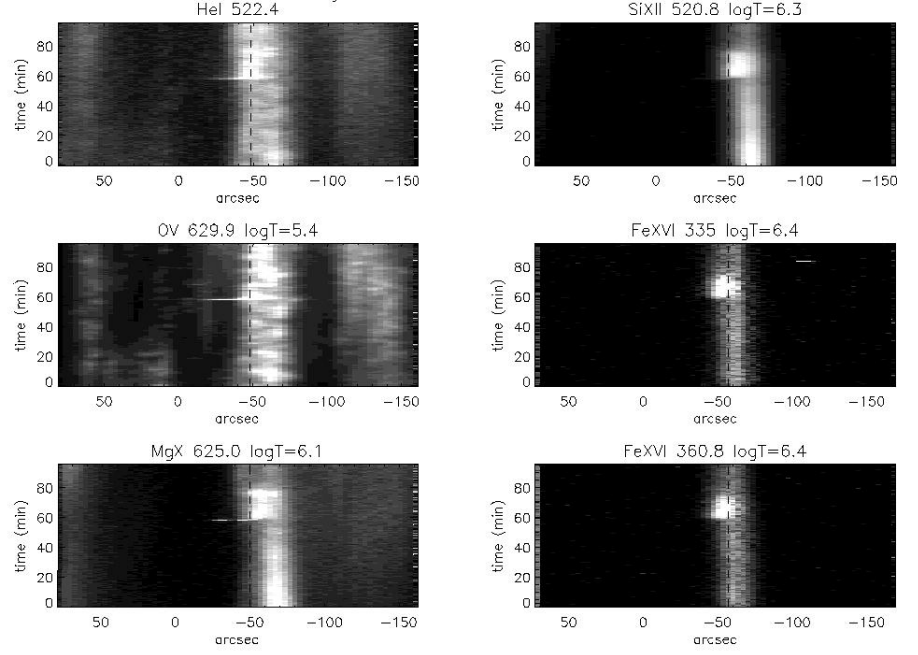
NIS OV raster image



Oscillations can resolve finer features than intensity images

OV X-T slice from time-series





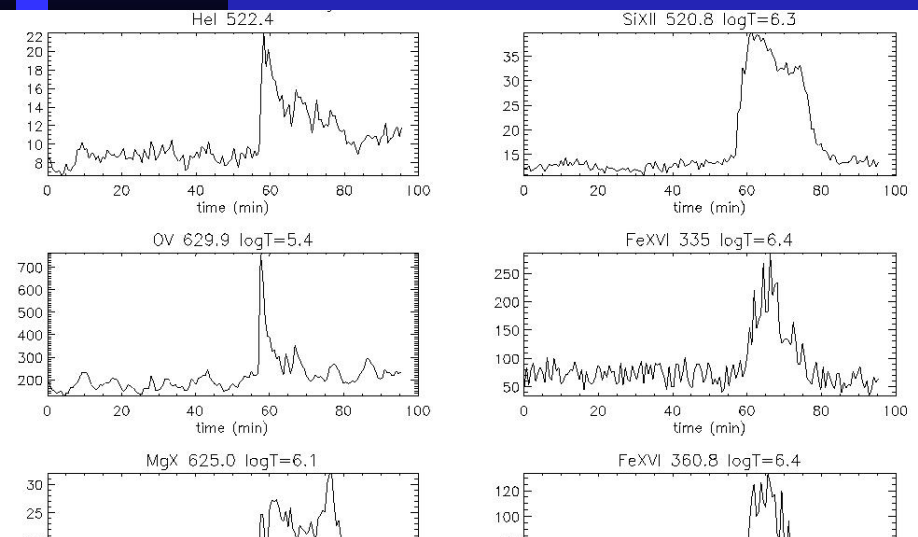
High-speed EUV jets:

- We detected an eruptive event with velocities 230 – 320 km/s at temperatures $\sim 2.5 \times 10^5$ K, where the local adiabatic sound speed is ~ 80 km/s.

- Such velocities are comparable to the jet velocities detected in X-ray

- The event can be explained by the X-ray jet model

- Fast magnetic reconnection



Multi-wavelength study of a high velocity event near a sunspot
Chia-Hsien Lin, D. Banerjee, E. O'Shea and J.G. Doyle, 2006, A&A, [450, 1181](#)