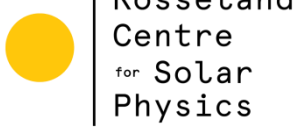
Sunspot waves at high resolution

Diego Prado Barroso, Shahin Jafarzadeh, Luis Vieira, Alisson dal Lago.

ESPM-16

09/09/2021



Waves in Sunspots

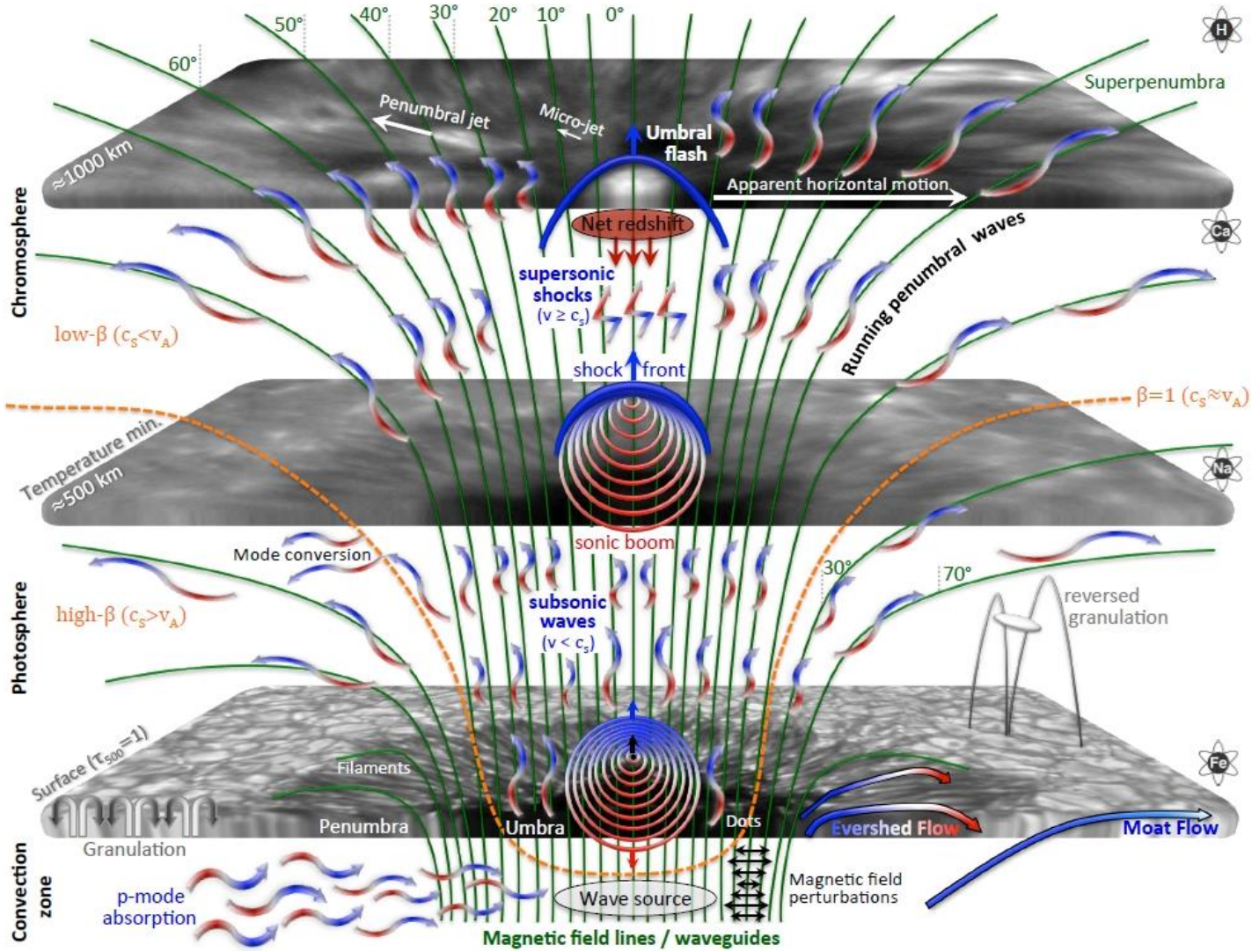


Image courtesy: LÖHNER-BÖTTCHER, J. **Wave phenomena in sunspots.** 214 p. PhD Thesis – Albert-Ludwigs Universität, Freiburg, 2015.

Observational data

Swedish 1-m Solar Telescope (SST), La Palma.
Image courtesy: Christoffer H. Stoele.

Active Region AR12533

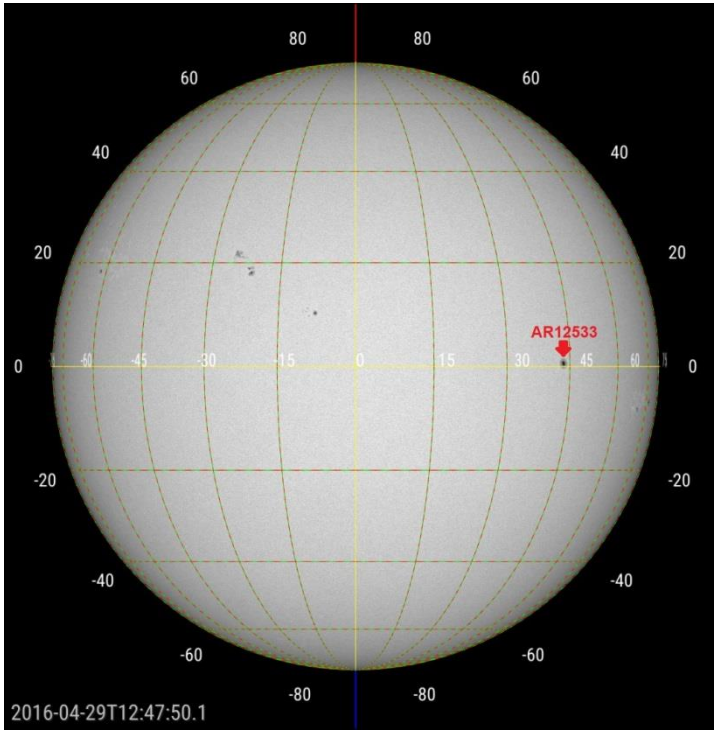
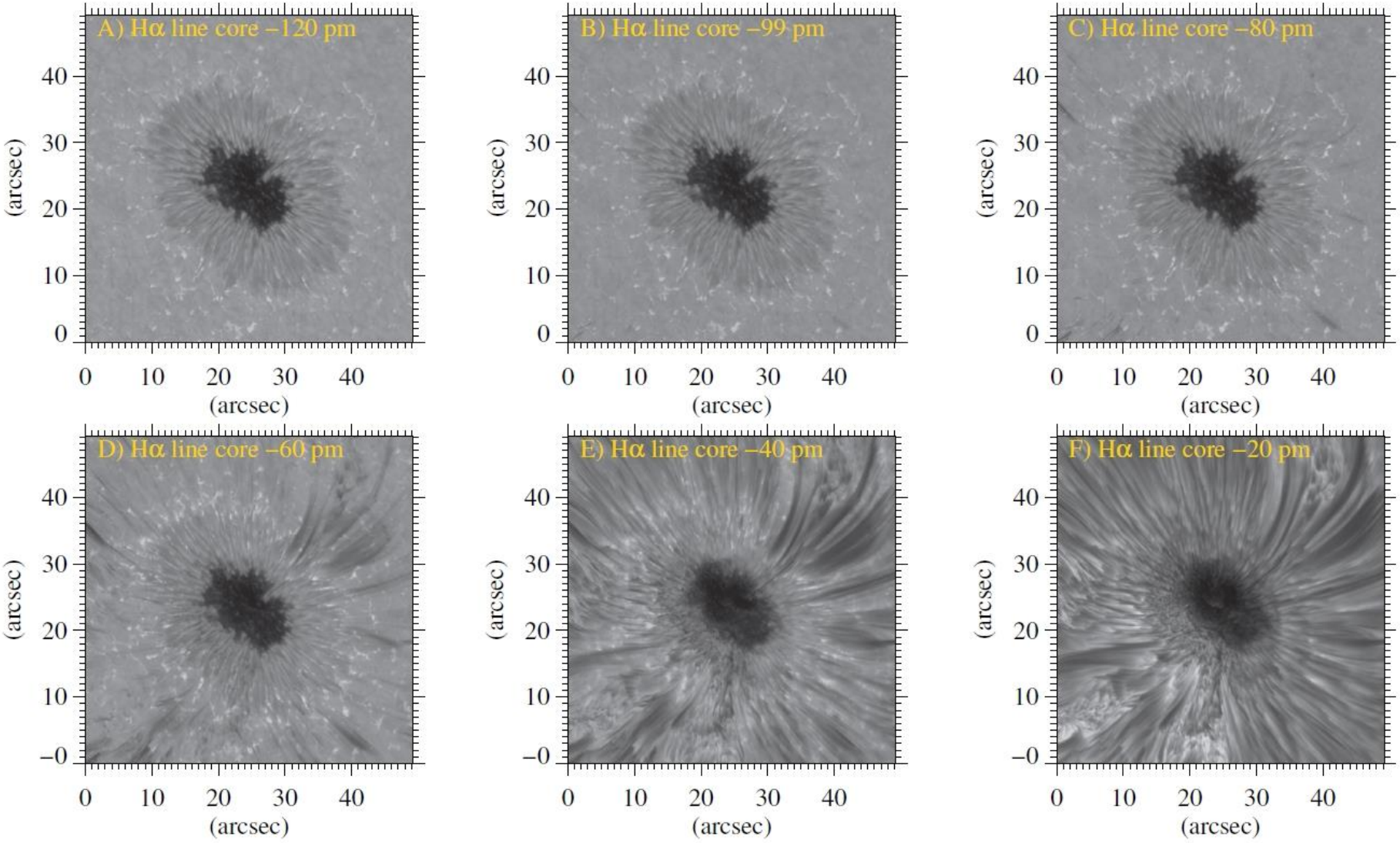


Image obtained from Jhelioviewer software.

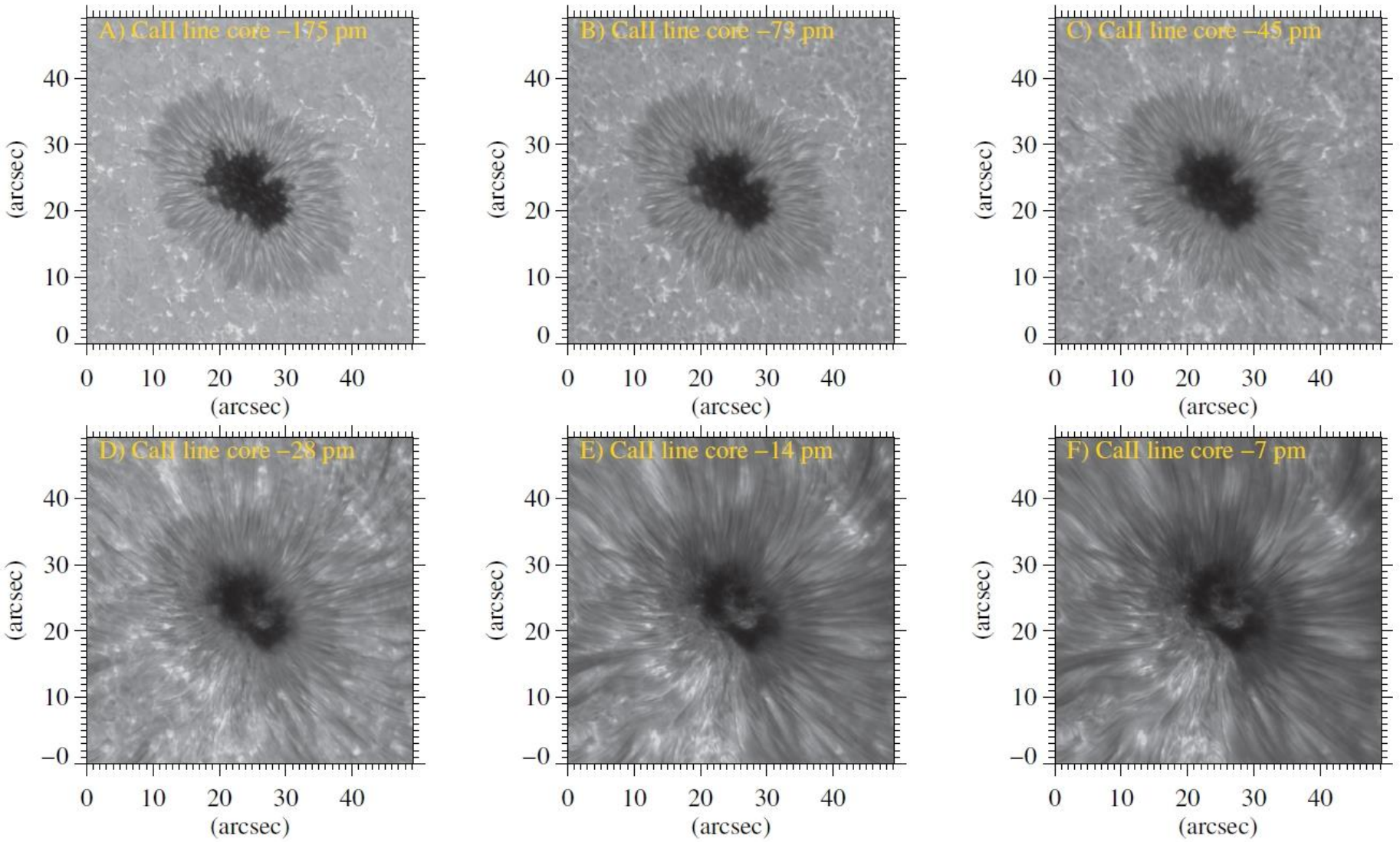
Observing Date	April 29, 2016
Solar heliocentric coordinates	(x,y) = (623,19) [arcsec]
Cosine of Heliocentric angle	$\mu = \cos\theta = 0.75$ ($\theta = 42.9^{o}$)
Observing time	09:42:51 - 12:08:32 UTC
Lenght of Observation	02:25:40 (hours:min:sec)
Observing rate	30.8 frames/s
Cadence of Time Series	20.3s
Instrument used	CRISP
Number of Scans	431
Image Scale	0.059 [arcsec/pix]
Size of field-of-view	54" x 54"

	Hα 656.3 nm	**Ca II 854.2 nm**
Line center	656.28 nm	854.21 nm
Spectral resolution	61.3 mÅ	106.6 mÅ
Nº. of wavelength Positions	15	21
wavelength positions offset from line core	± (0, 200, 400, 600, 800, 1000, 1200, 1500) mÅ	± (0, 70, 140, 210, 280, 350, 455, 595, 735, 945, 1750) mÅ
Number of exposures	8	6
Diffraction limits	$1.22\frac{\lambda_{H\alpha}}{D} \approx 0.170''$	$1.22\frac{\lambda_{H\alpha}}{D} \approx 0.221''$
Spectropolarimetry	No (only intensity)	Yes (full Stokes)

Observational data

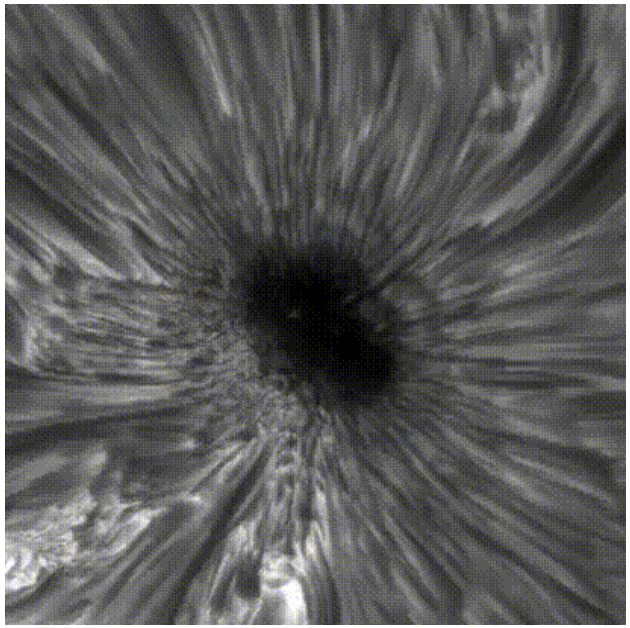


Observational data

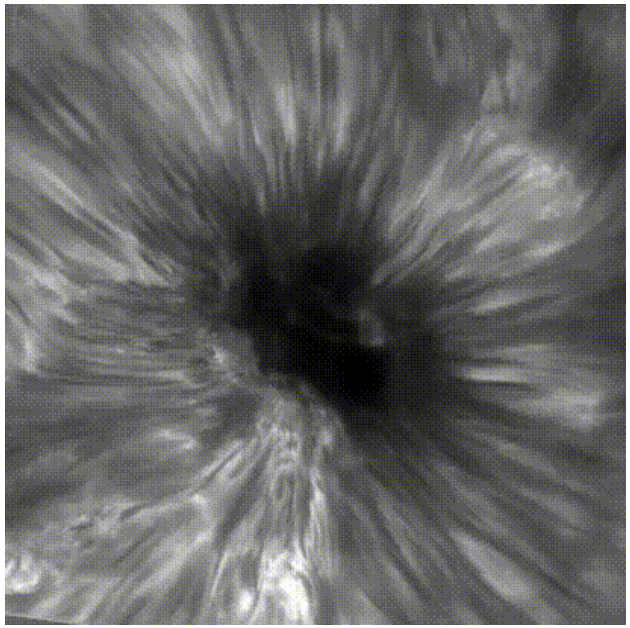


Observational data

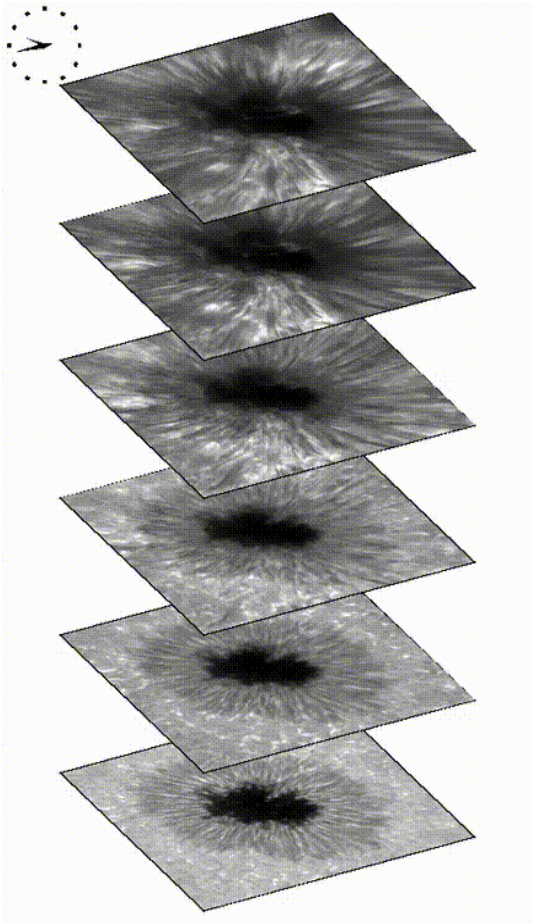
Hα Line (Minimum Spectra)



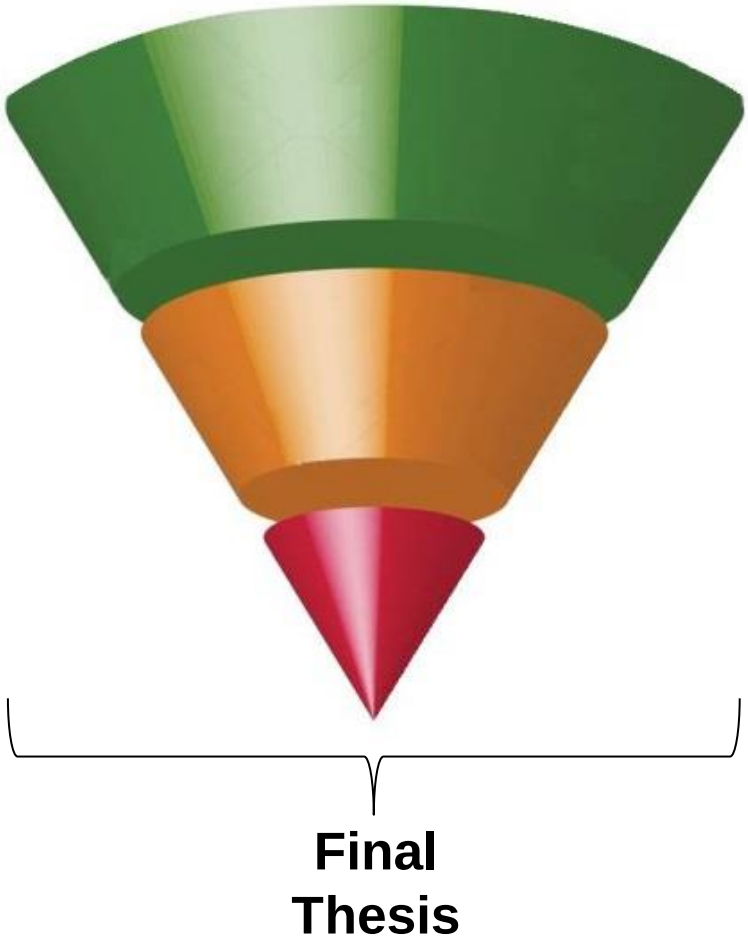
Ca II Line (Minimum Spectra)



Ca II Line
in different heights



Overall Approach



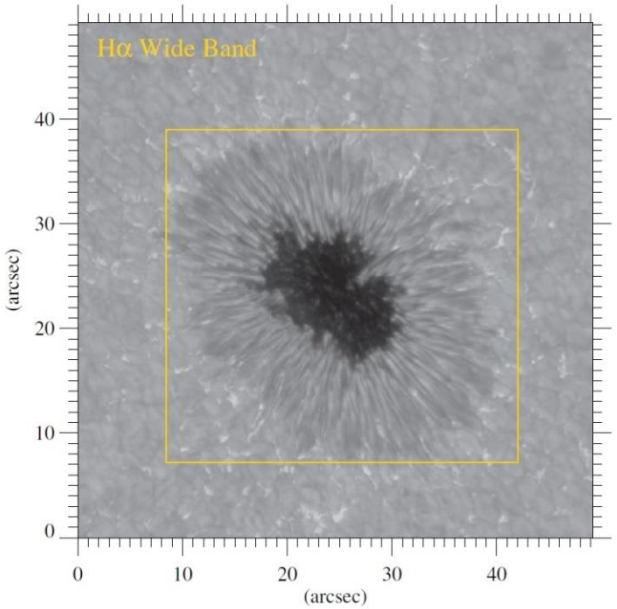
Project 1 : Overall oscillation phenomena analysis

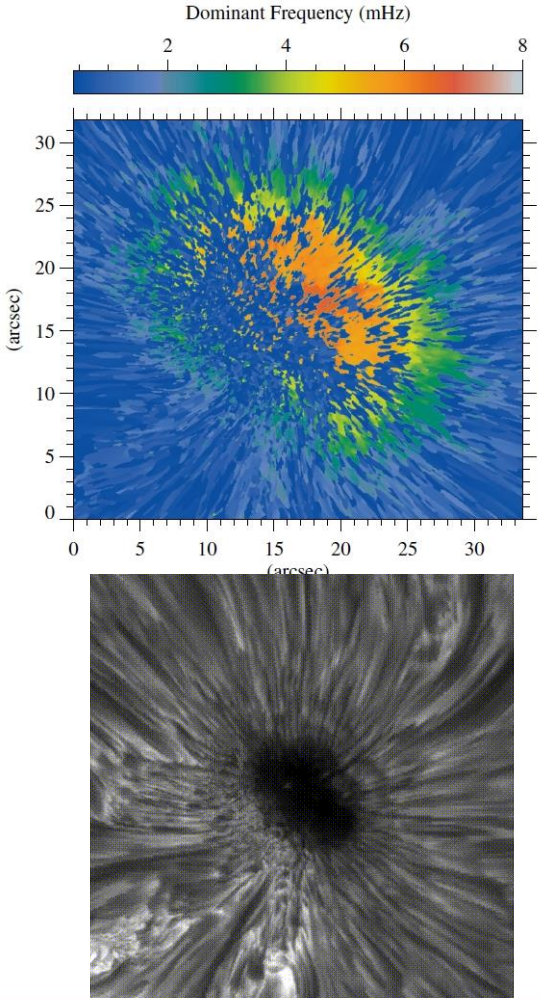
Project 2 : Magnetic field perturbation analysis

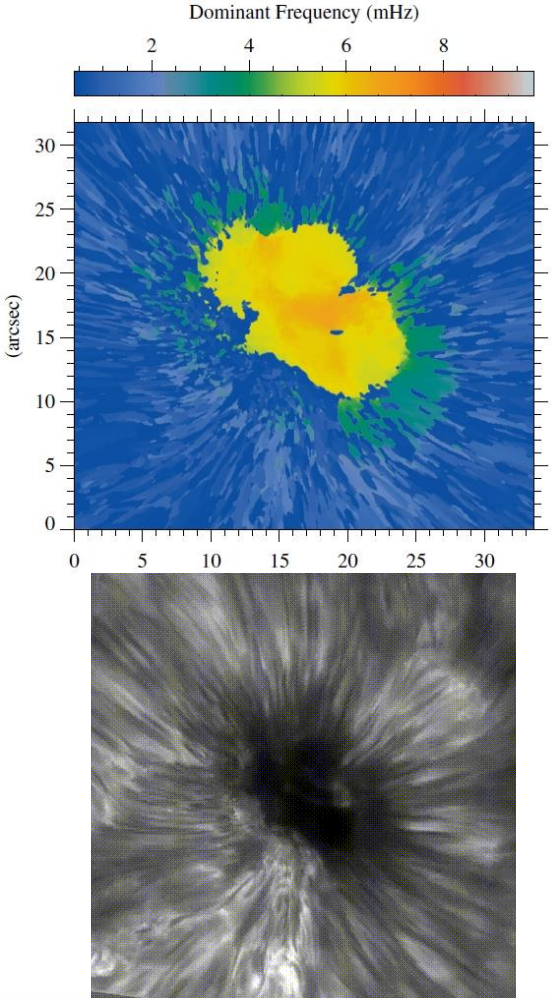
Project 3 : Detailed wave modes analysis

Preliminary Results

Dominant Frequency (Hα / Ca II)







Concluding remarks

- High values of dominant frequencies were observed over umbra and penumbra region in both spectral lines. Uncertainty of each pixel will be analyzed.

- Further analysis are projected considering the magnetic field in order to disentangle the wave modes, as the subprojects advance.

Thank you.

Acknowledgments

- This research counts with funding and support by CAPES, an entity of the Brazilian Government dedicated to the formation of human resources.

- It is part of the PhD post-graduation program in Space Geophysics of Brazilian National Institute for Space Research.

- Supports from the University of Oslo and the Research Council of Norway through its Centres of Excellence scheme, Rosseland Centre for Solar Physics (project No. 262622) are acknowledged.

- The Swedish 1-m Solar Telescope is operated on the island of La Palma by the Institute for Solar Physics of Stockholm University in the Spanish Observatorio del Roque de los Muchachos of the Instituto de Astrofísica de Canarias.

- **WaLSA** is an international science team with a focus on wave activity in the lower atmosphere of the Sun. Its supports are acknowledged.

diego.barroso@inpe.br