Line profiles and Dopplergrams in active regions

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How do changes in shapes of line profiles (due to magnetic causes) affect measurements of Doppler shifts?

and

so how do they cause apparent 'helioseismic signatures'?

Since the physics of wave propagation in magnetic field (e.g., acoustic cut-off, field aligned propagation) is different from quiet Sun, answers to the above question depend on inter-connected set of physical, measurement and analysis issues.

Two main causes:

Radiative transfer & altered wave physics.

Height range of spectral line formation, i.e. response functions for Stokes profiles, is significantly extended over the tenuous magnetic atmosphere, and so phases of propagating waves sensitively depend on which part of Stokes profiles are used in Doppler measurements.

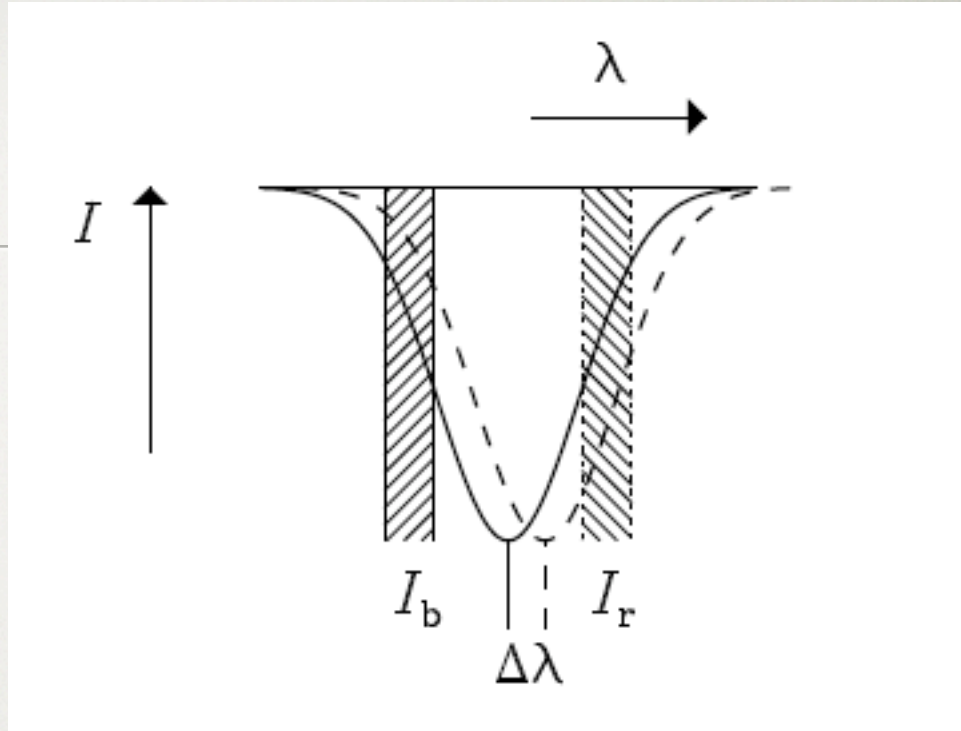
Artefacts due to measurement method

Changes in shapes due to Zeeman splitting

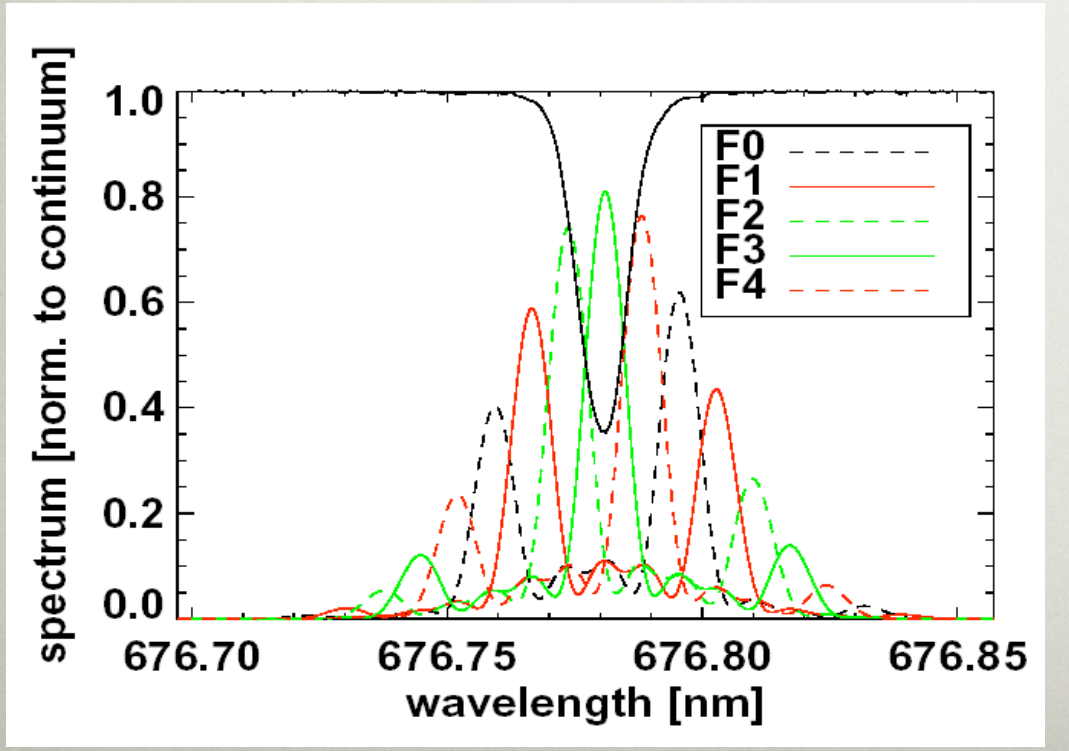
+

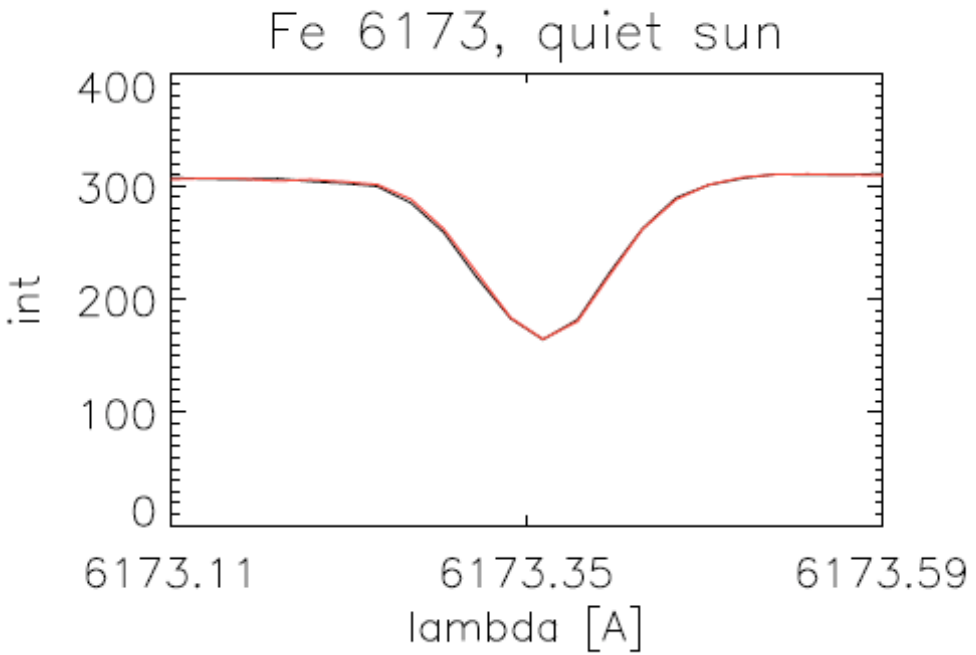
Fixed wavelength positions of filters in filtergraph instruments

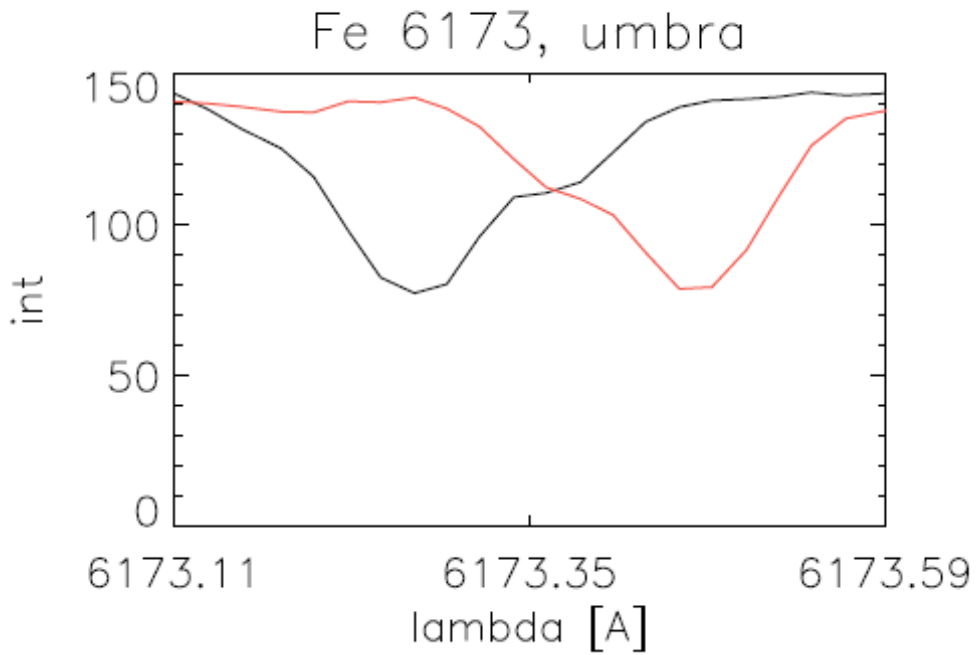
Simple Doppler shift measurements



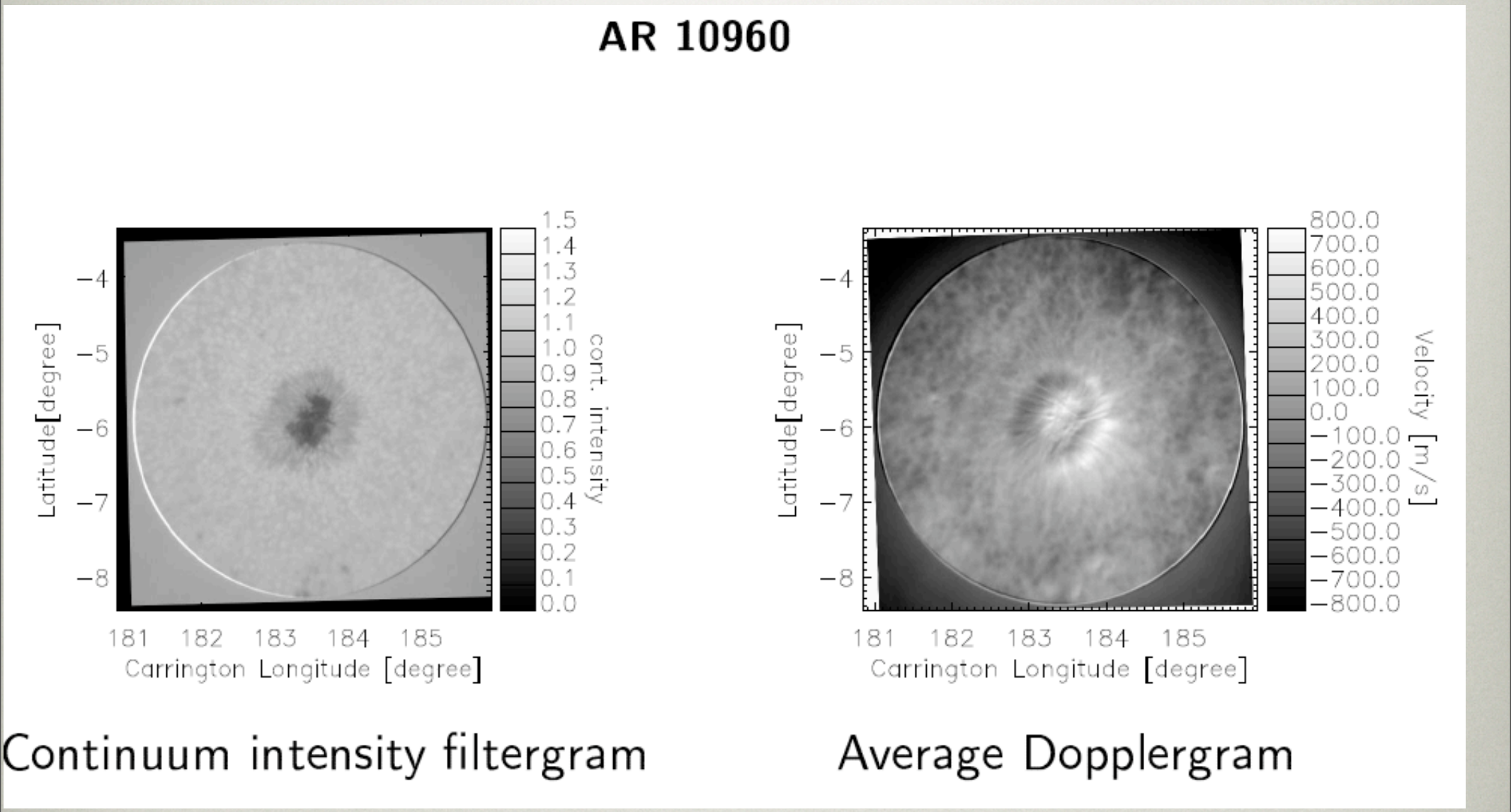
MDI / HMI




Fe 6173, quiet sun
400
300
200
100
0
int
6173.11
6173.35
6173.59
lambda [A]


Fe 6173, umbra
150
100
50
0
int
6173.11
6173.35
6173.59
lambda [A]

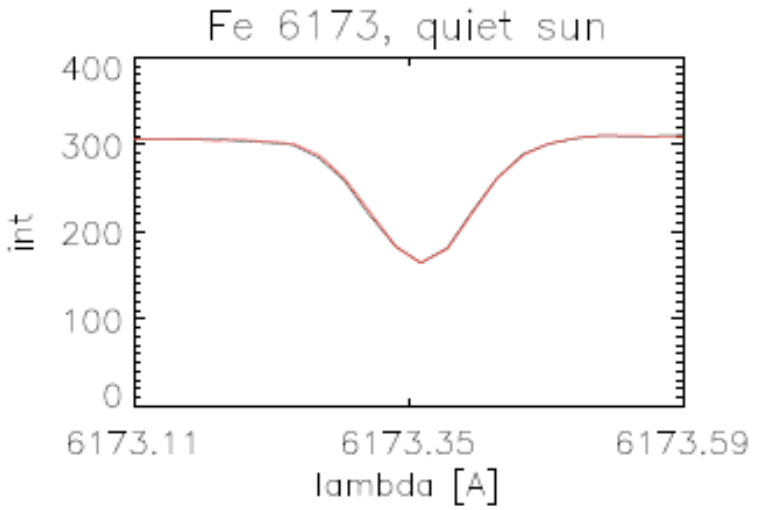
IBIS Observations

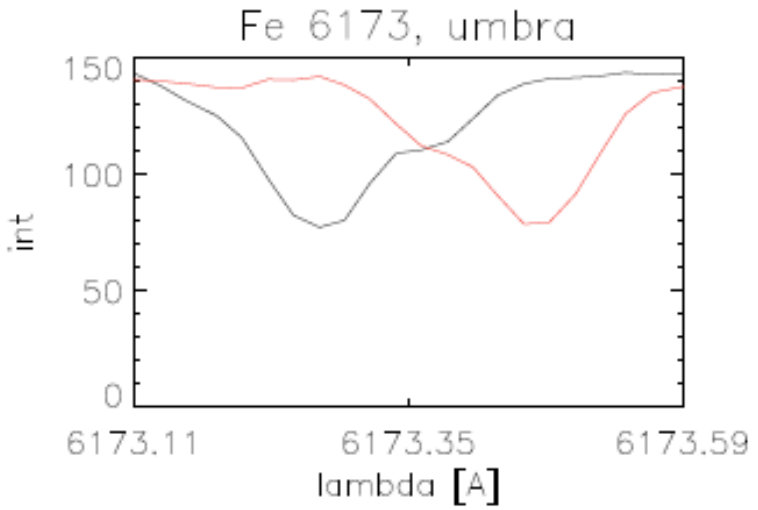


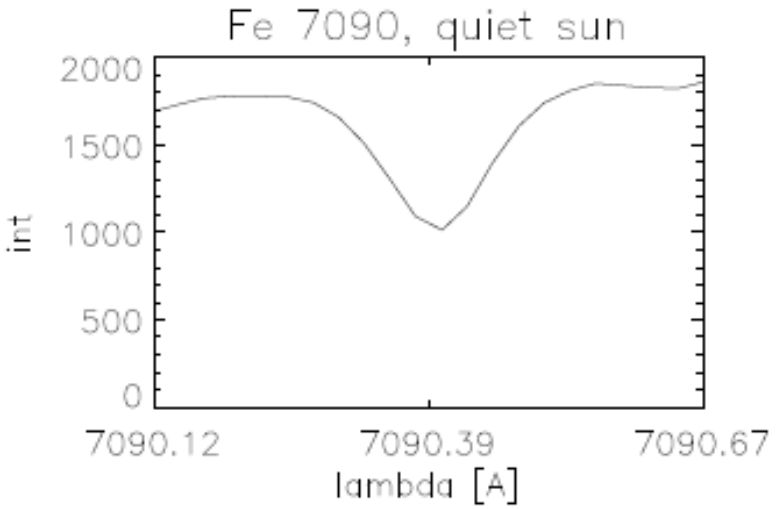
Continuum intensity filtergram

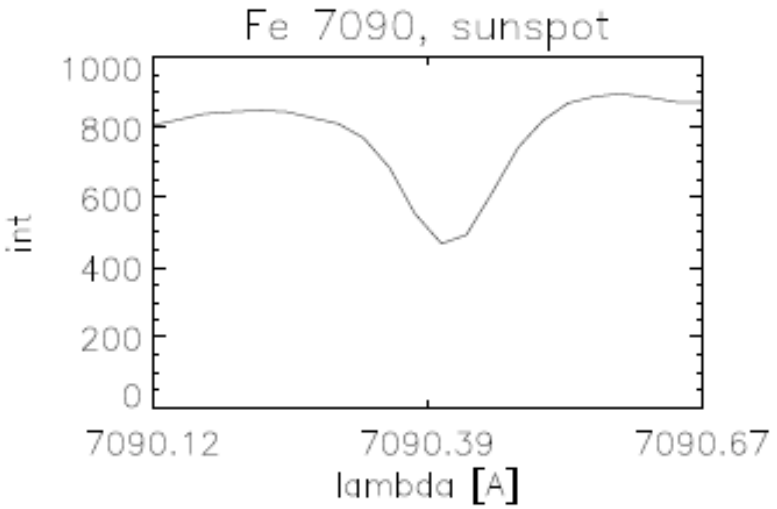
Average Dopplergram

Spectral scans

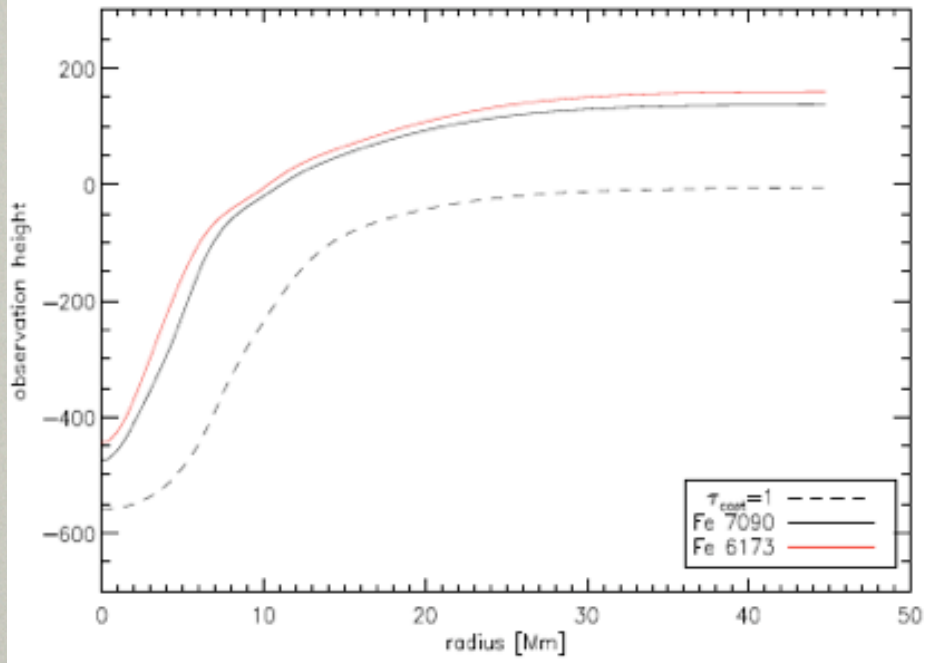


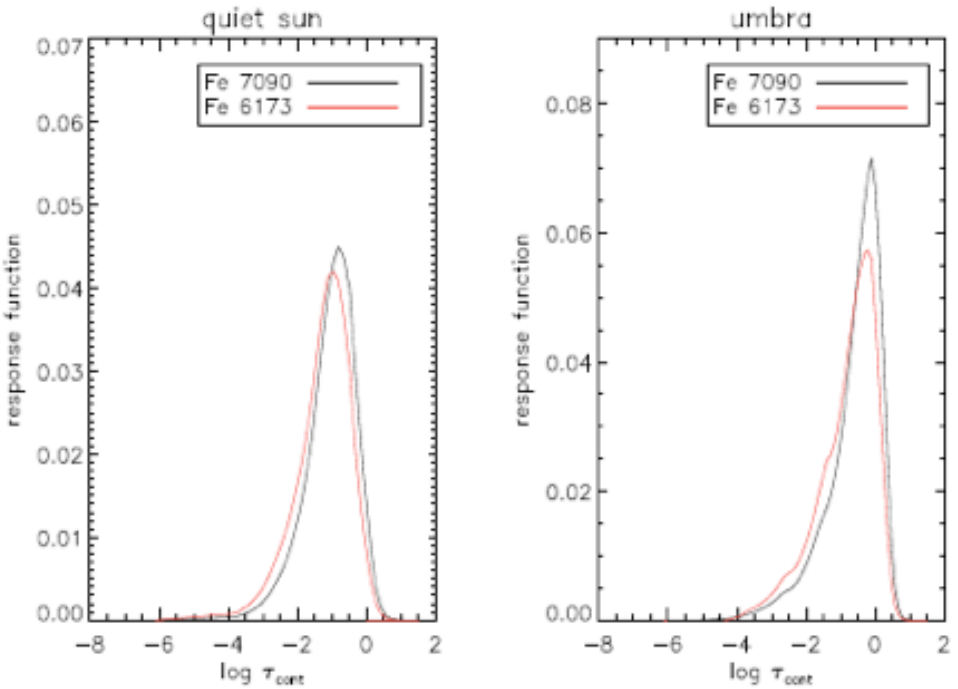






Observation height for Fe 6173 / Fe 7090





Observation heights

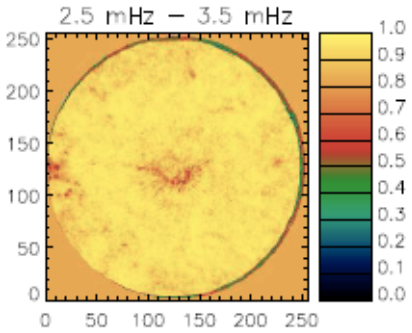
Response function (Maltby model)

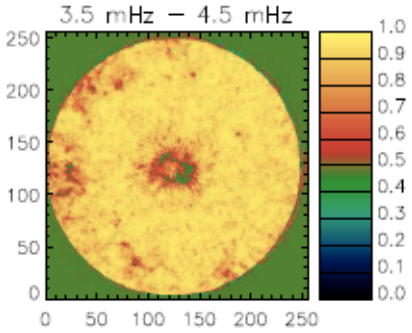
Method described in Wachter 2008, (Sol. Phys.)

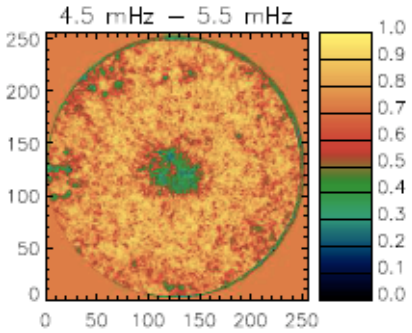
Phase differences between Fe 6173 and Fe 7090 oscillations; velocities derived from MDI algorithm.

Phase difference

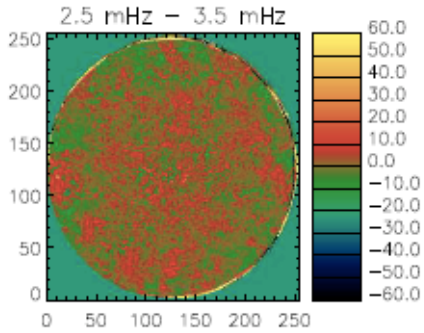
Correlation coefficients

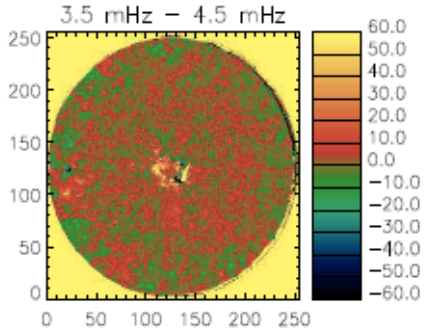


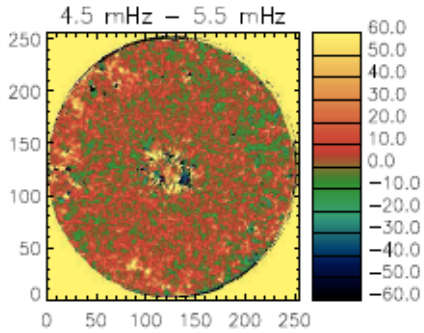




Phase shifts

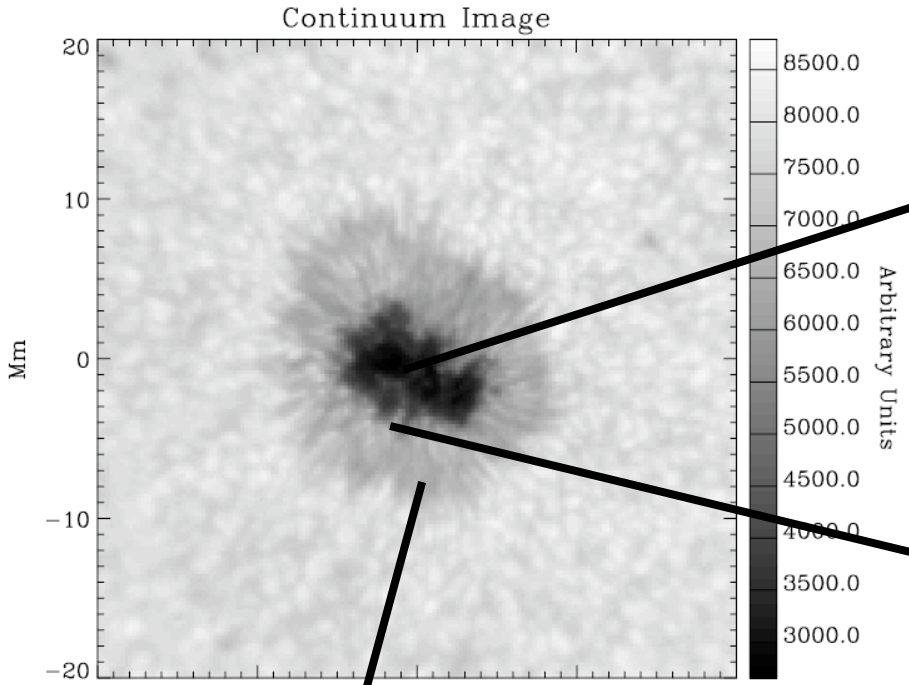


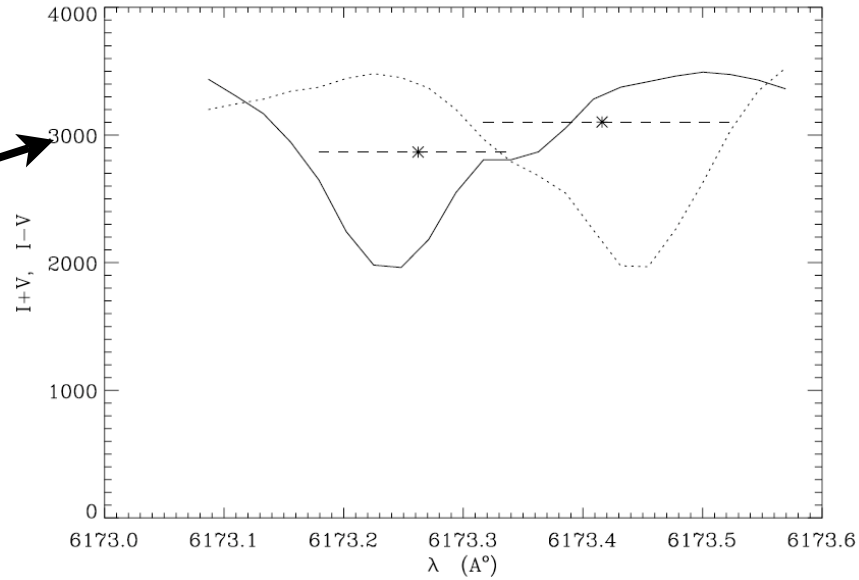


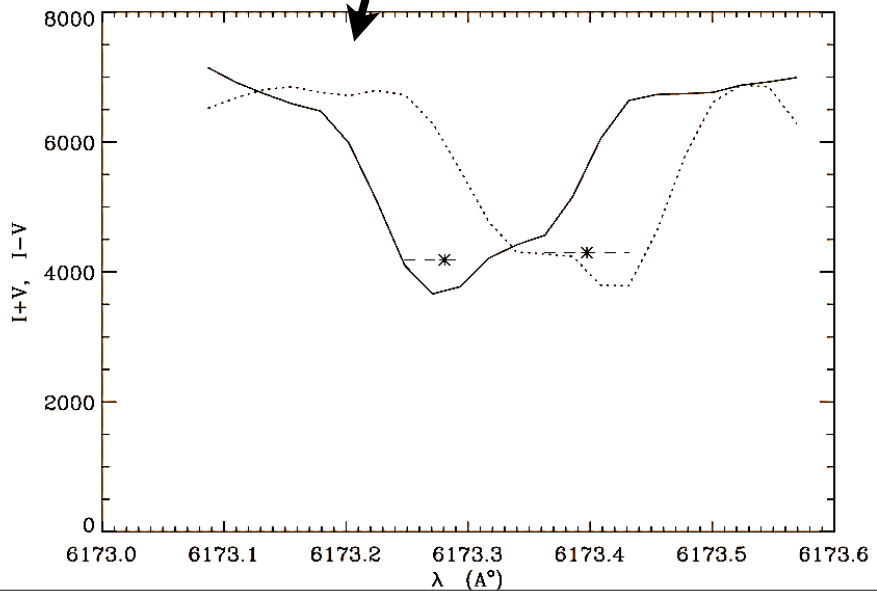


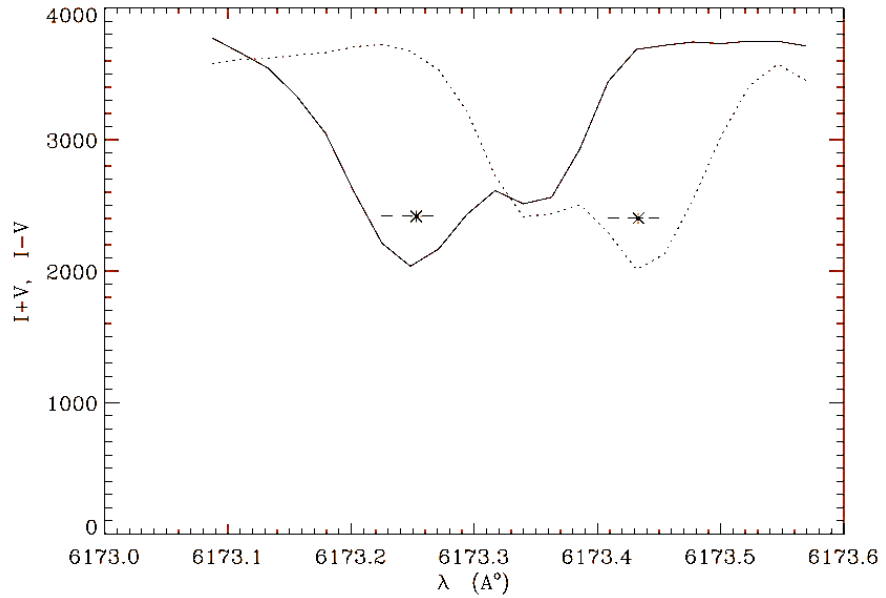
How can we utilise having all the filtergrams (6) available?

An analysis of phase shifts between bisector velocities of Fe I 6173 (magnetic) and Fe I 7090 (non-magnetic) lines

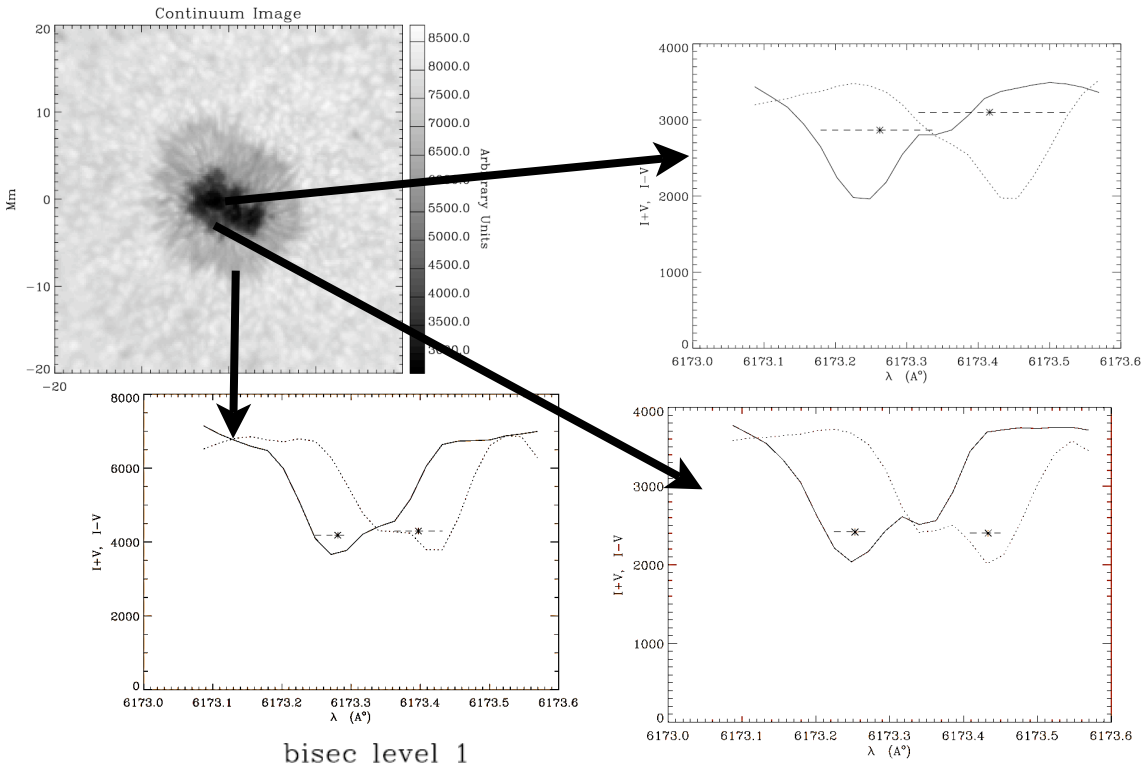


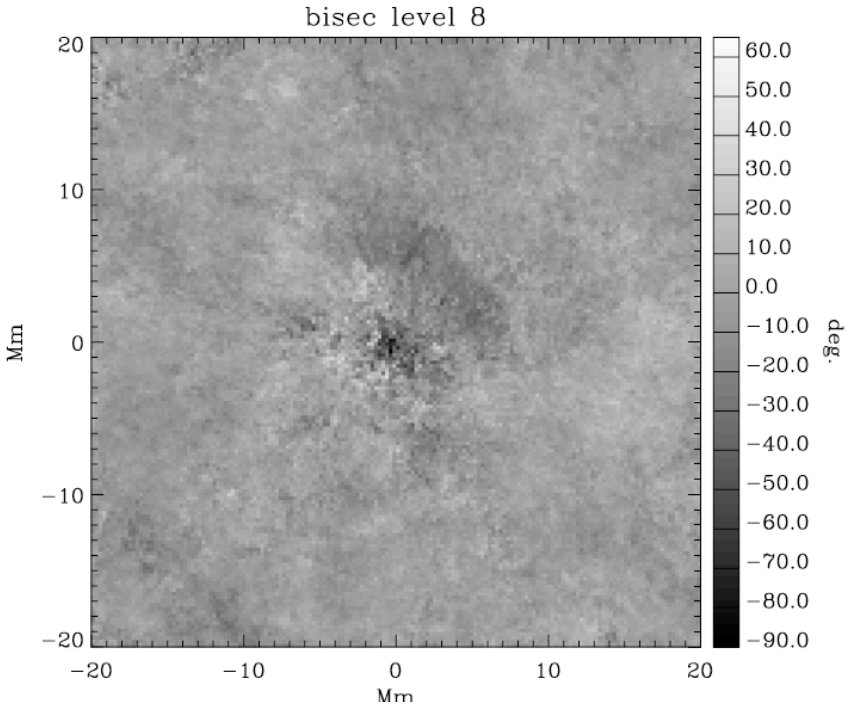


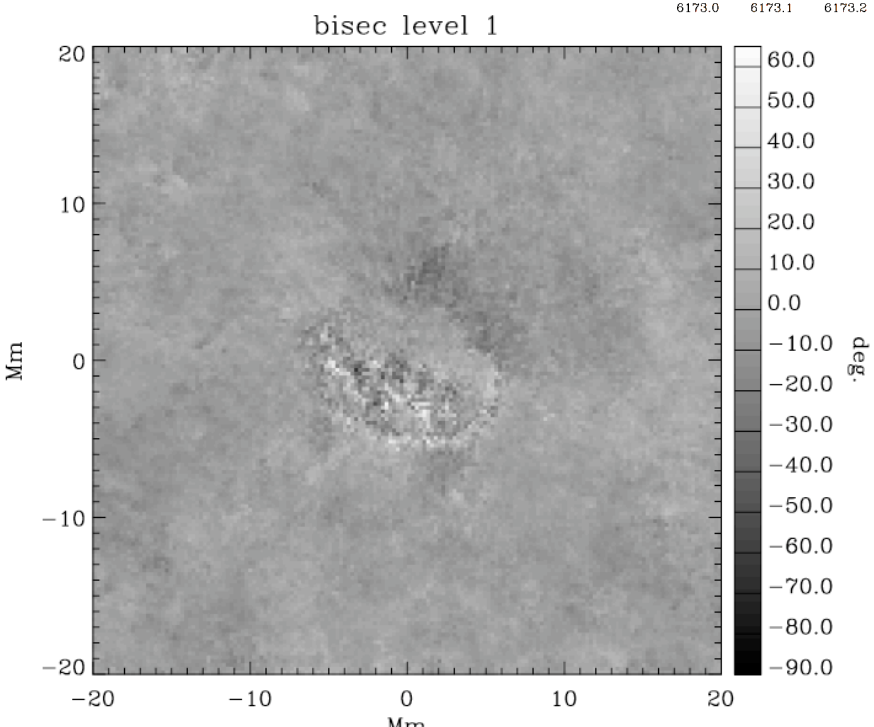


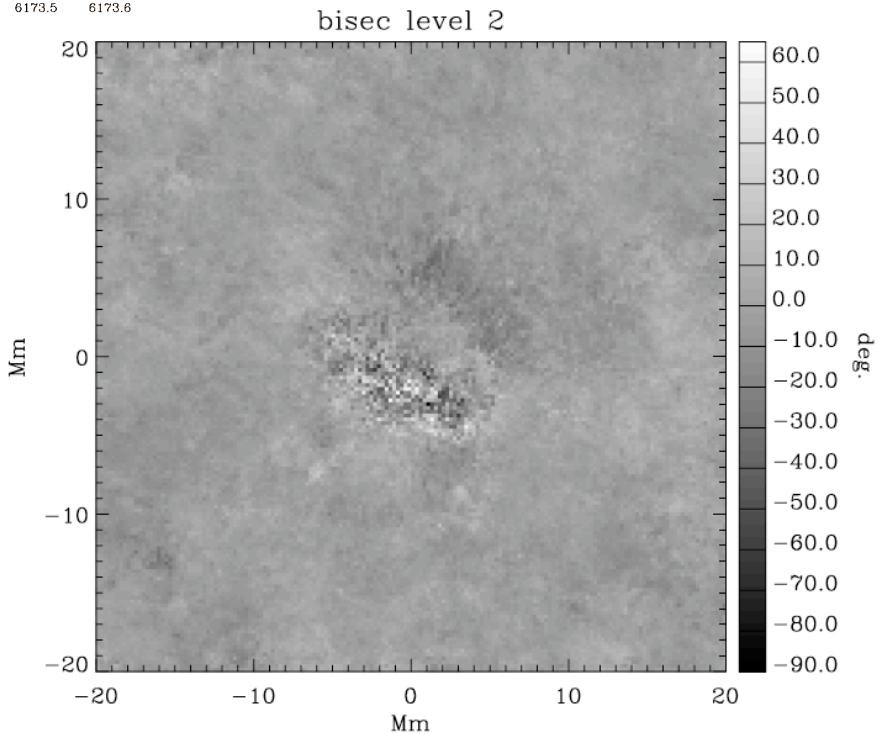


Phase shifts (artefacts) due to central Zeeman pi component in LCP and RCP profiles





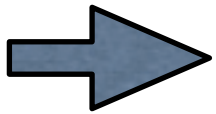




Phase differences between Fe 6173 and Fe 7090 oscillations (2.5 - 3.5 mHz)

Discussion and Conclusion

The progression of the central Zeeman pi component, in the LCP and RCP profiles, from the line core towards the wings as a function of magnetic field inclination to the LOS, i.e. from the penumbra to the umbra, is seen to be accompanied by spurious phase shifts in oscillations, with respect to the non-magnetic line (7090 A), as evidenced by the Doppler velocities derived from bisector positions that trace such changes in line shapes.



From information on the magnetic field orientations, one can choose filtergrams (from among the 6 available from HMI) that avoid the affected part of the line profile. So, in sunspot regions a better (for local helioseismology) estimation of Doppler velocities could just involve 2 filtergrams, one in the blue wing and the other in the red, that avoid the flattened or kinked part of the LCP and RCP profiles.