Local Helioseismology with AIA

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Primary Goal

To exploit the potential of high cadence and high resolution observations from AIA for *local* helioseismic studies.

Why do we want to use AIA data?

Simultaneous observations in solar atmosphere at different heights will allow us to investigate

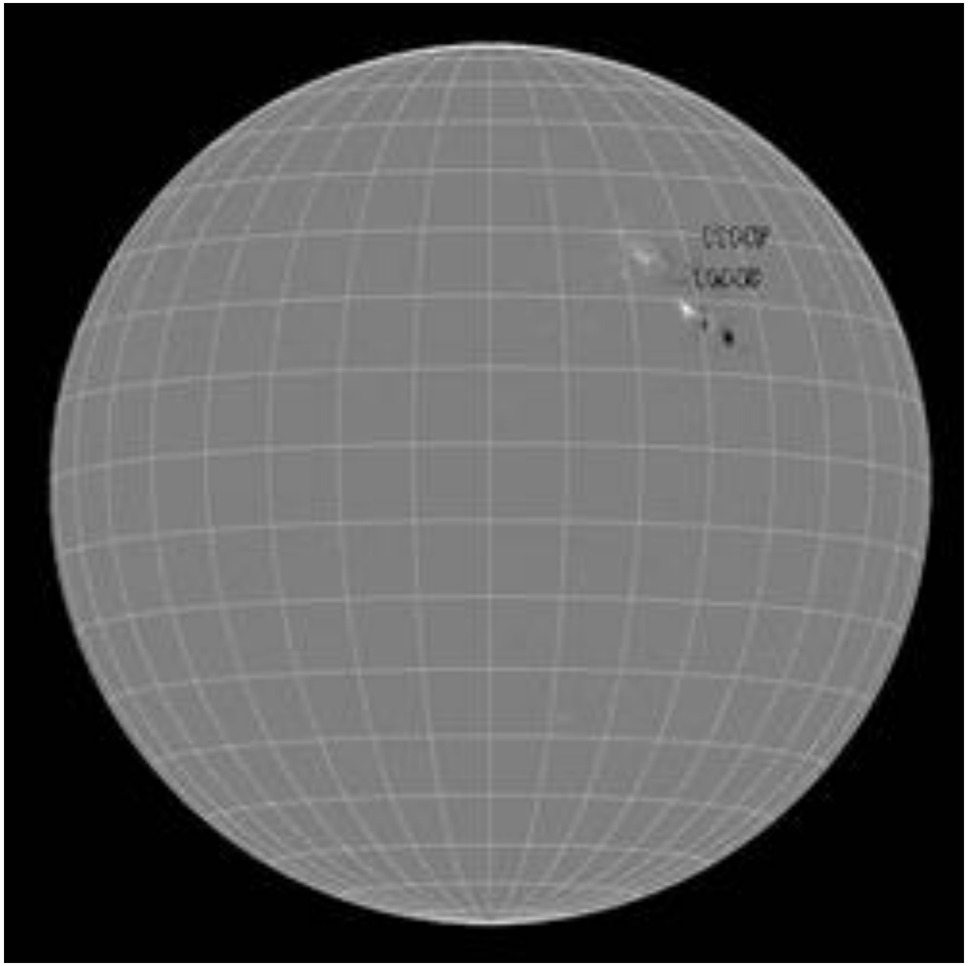
- ✓ how acoustic waves are propagated in solar atmosphere and test the models of wave propagation,

- ✓ how results from helioseismology are affected by the choice of observable and the height of formation of the spectral line in solar atmosphere.

Data

Instrument	Helioseismic and Magnetic Imager	Atmospheric Imaging Assembly
Spectral line	Fe I 6173 Å line	1600 Å passband (base of chromosphere/upper photosphere, Average response height ~ 430 km with width of 185 km) 1700 Å passband (Photosphere, Average response height ~ 360 km with width of 325 km)
Observable	Velocity and Intensity continuum	Continuum
Cadence	45 Second	24 Second
Period of Analysis	**1440 minutes on Jan 23, 2011 Duty cycle ~ 100%**	

Sample magnetogram from GONG

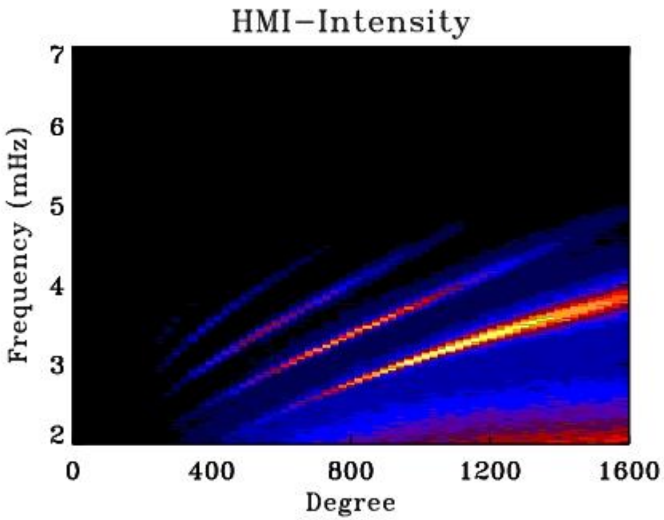


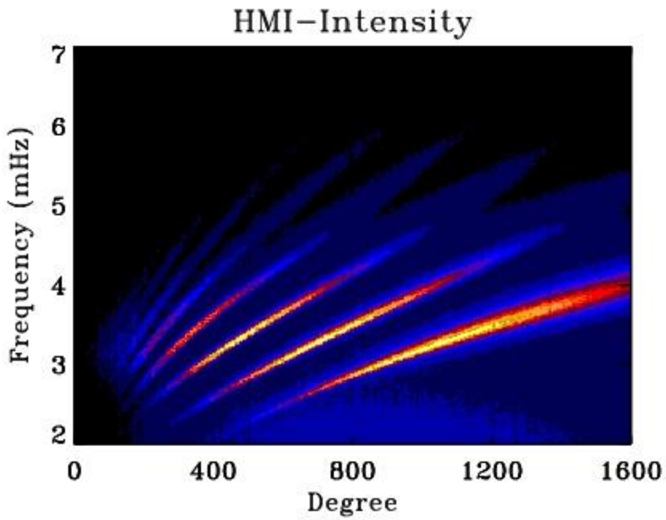
Techniques

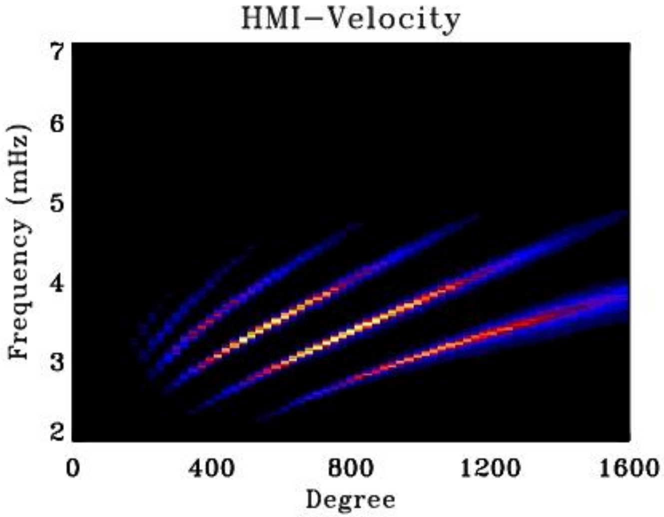
- **Ring-diagram (RD) analysis - GONG pipeline**
  - ✓ 15°x15° patch at the disk center (quiet region)
  - ✓ tracked for 1440 min at Snodgrass rate
  - ✓ Temporal resolution : 11.57 μHz
  - ✓ Spatial resolution: 0.0324086 Mm^{-1}
- **Spherical Harmonic Decomposition (SHD) Method**
  - ✓ 45°x45° patch at the disk center (quiet region)
  - ✓ Temporal resolution : 11.57 μHz

ℓ-ν diagrams (HMI)

RD Technique | **SHD Method**



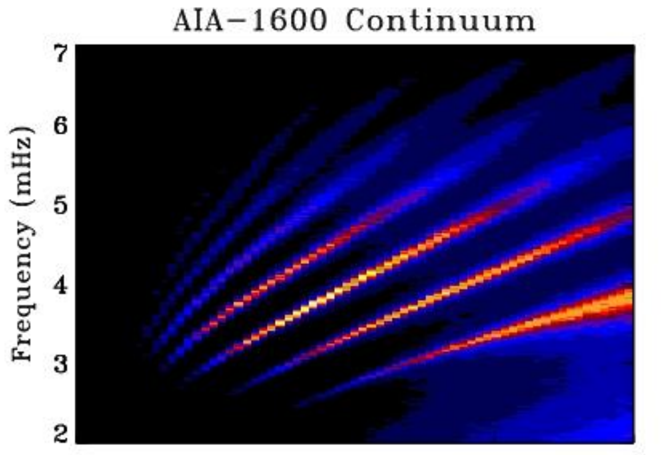




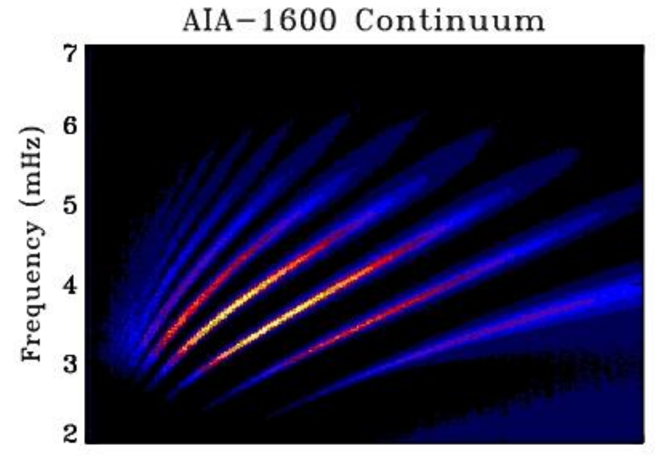
Low frequency noise in intensity ….granulation

ℓ-ν diagrams (AIA Continuum)

RD Technique

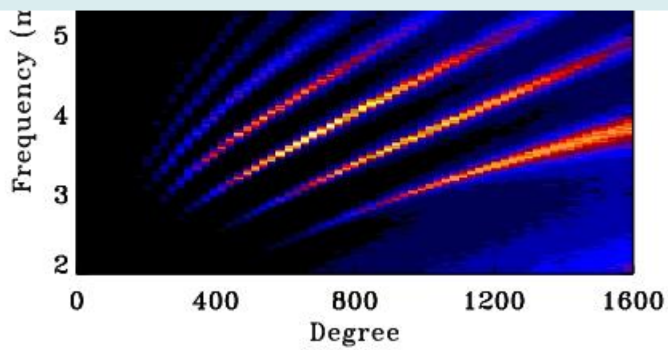


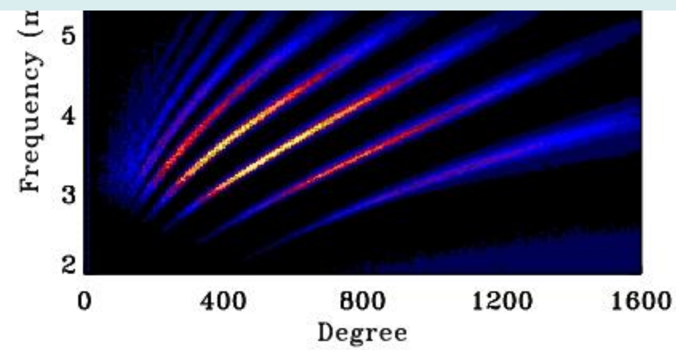
SHD Method



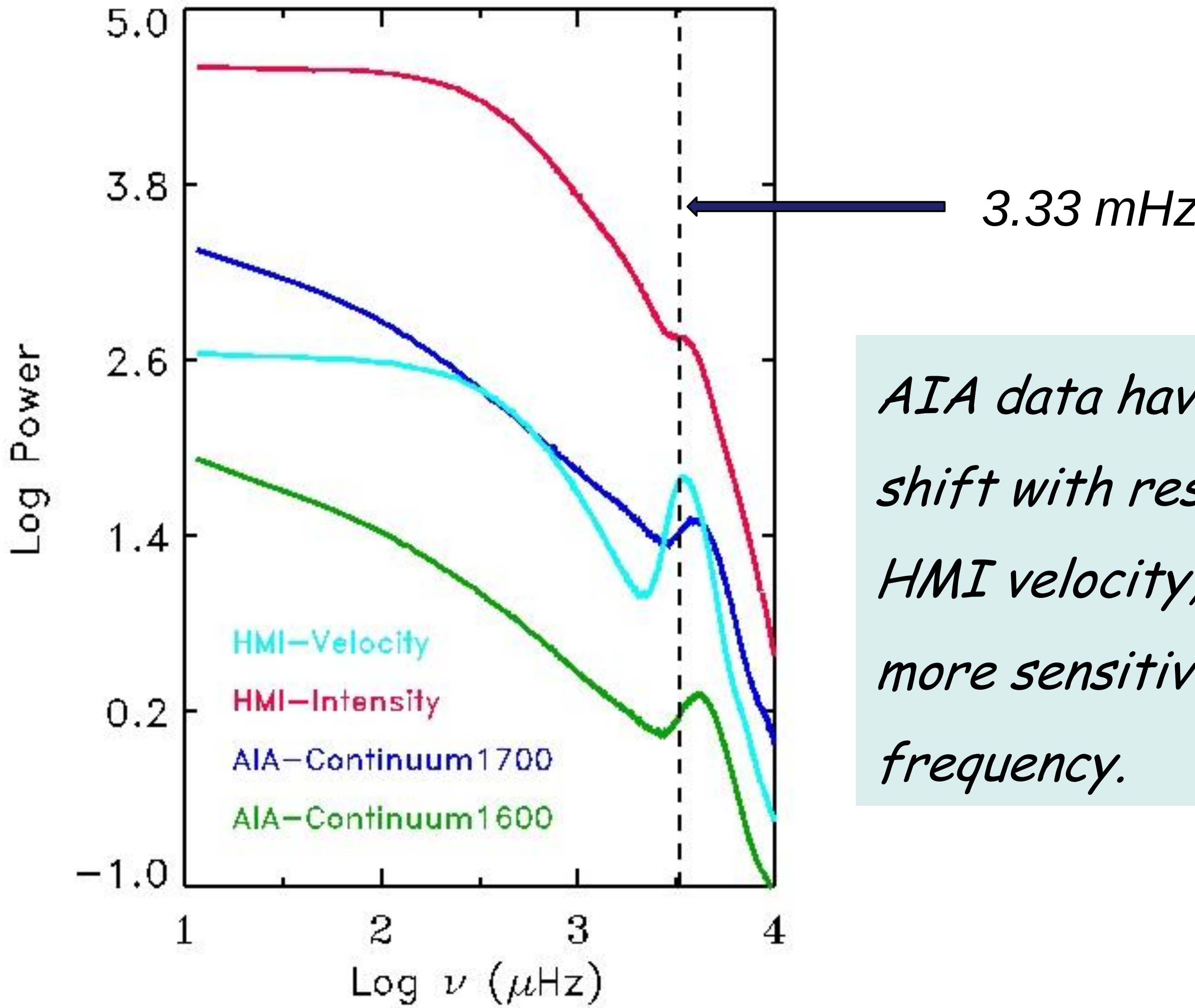
There is strong signal of 5 minute oscillations in AIA data.

Power at higher frequency increases and low frequency noise decreases with increasing height of observation.



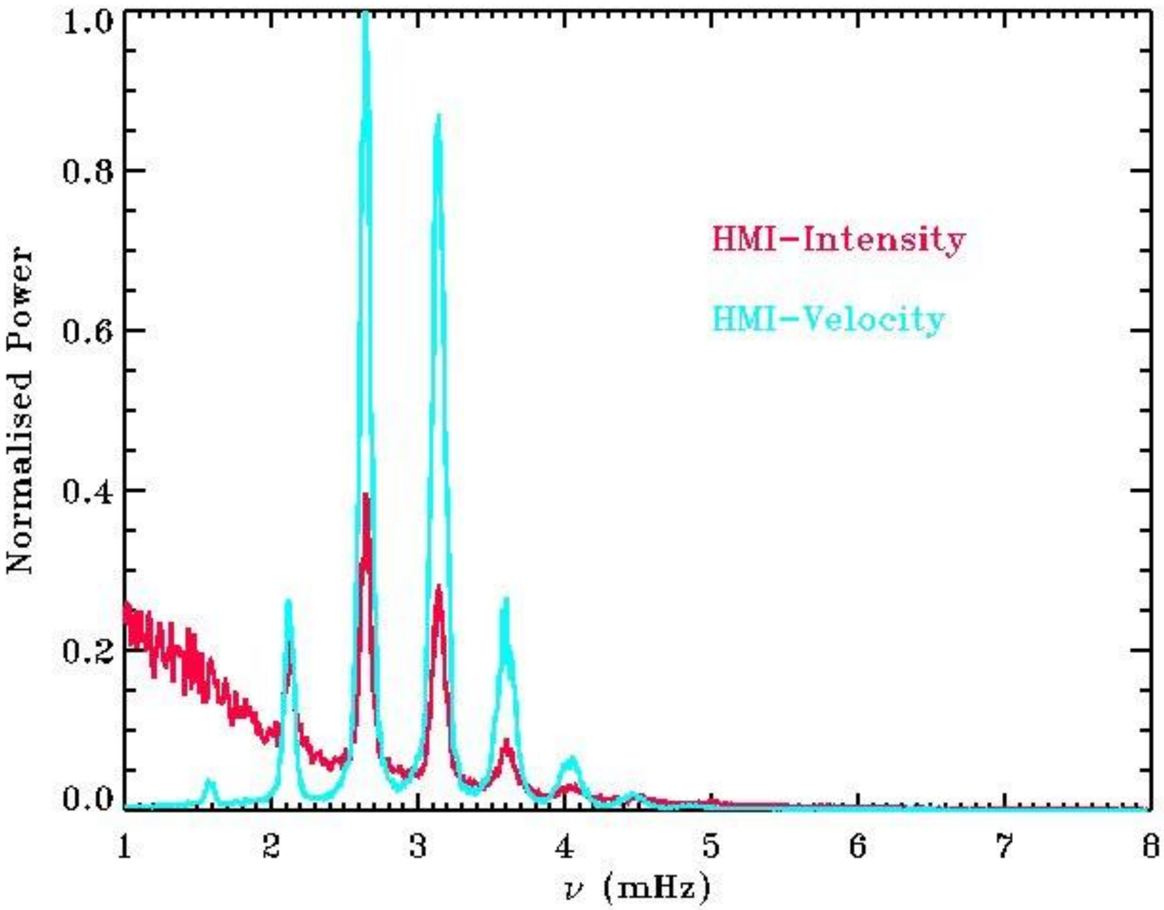


k-averaged power spectra



AIA data have phase shift with respect to the HMI velocity, and show more sensitivity to high frequency.

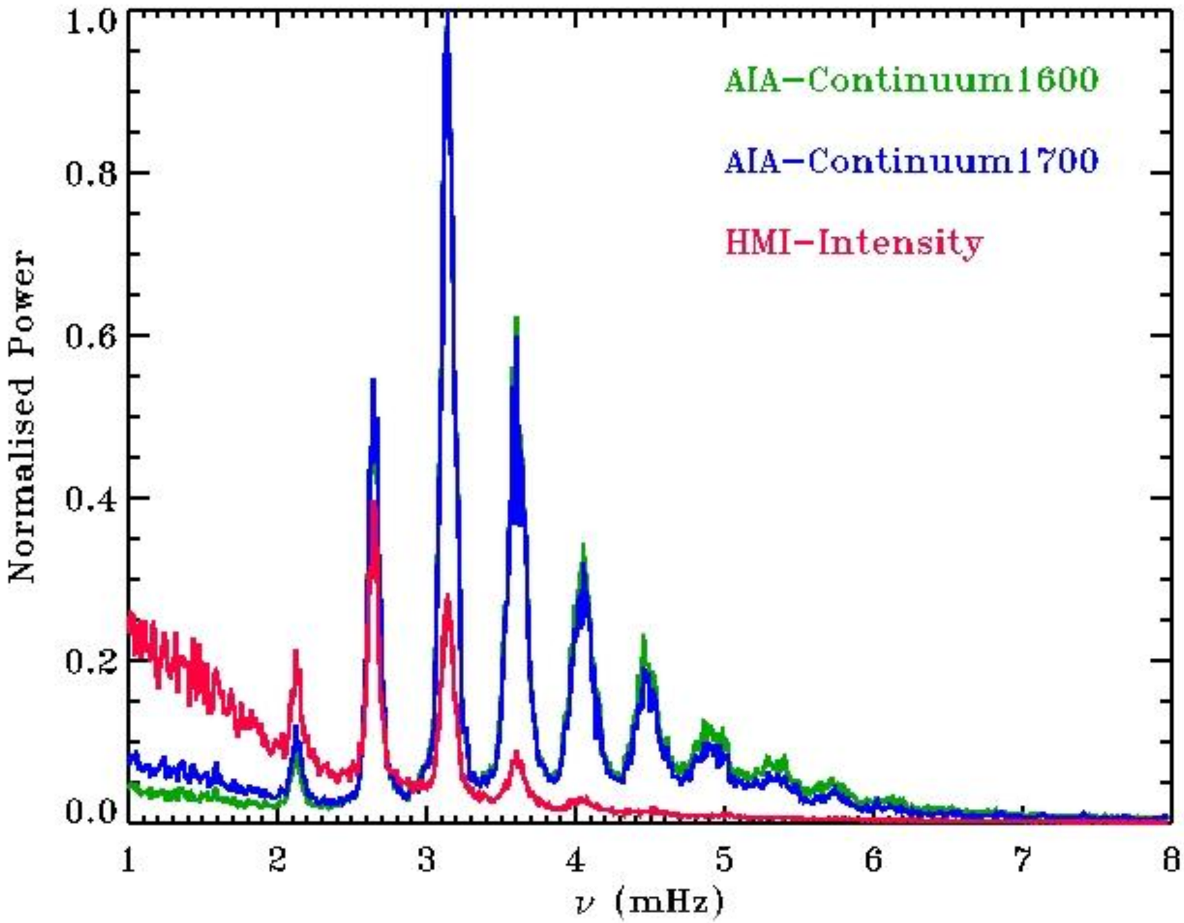
Power spectra at ℓ = 360
(Ring-diagram Technique)



Velocity data has higher signal-to-noise ratio than the intensity.

Low frequency power spectrum in intensity is dominated by granulation noise.

Power spectra at ℓ = 360
(Ring-diagram Technique)

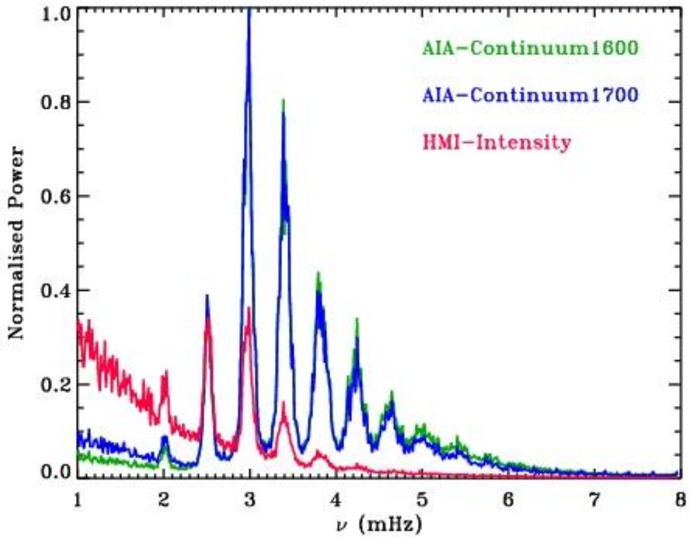


Granulation noise in low frequency power spectrum decreases with increasing height of observation.

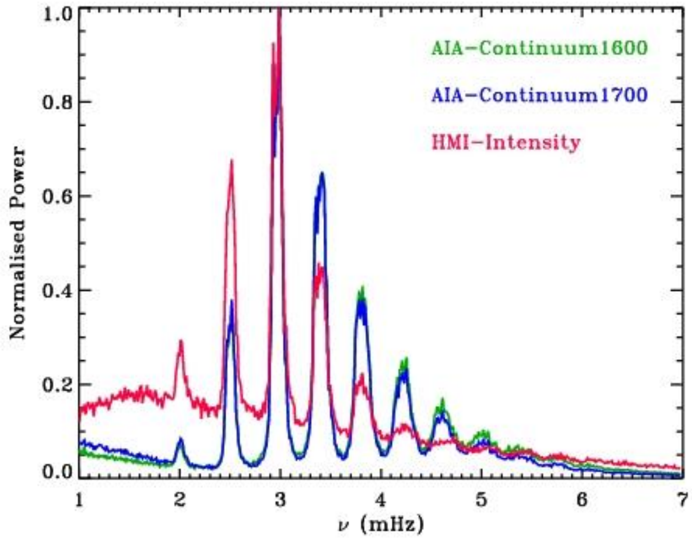
Signal-to-noise ratio also increases with increasing height.

Power spectra at ℓ = 320

Ring-diagram Technique

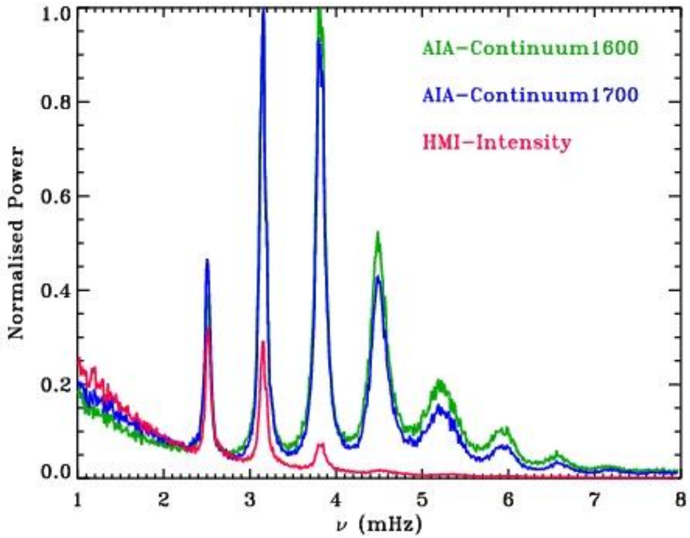


Spherical Harmonic Decomposition Method

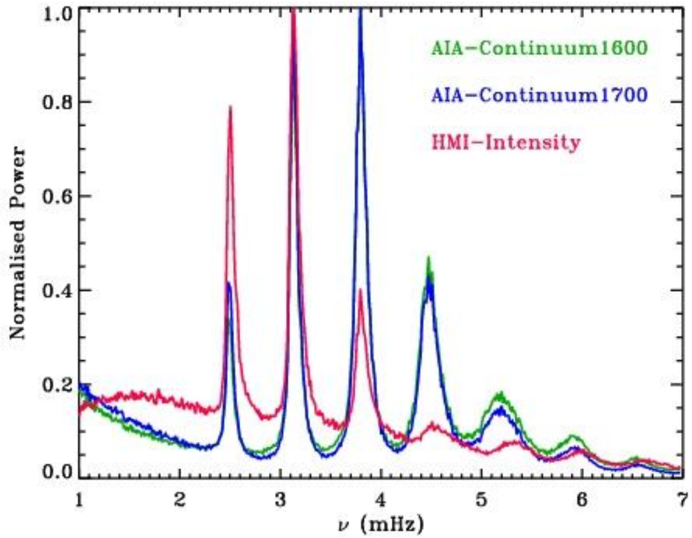


Power spectra at ℓ = 800

Ring-diagram Technique

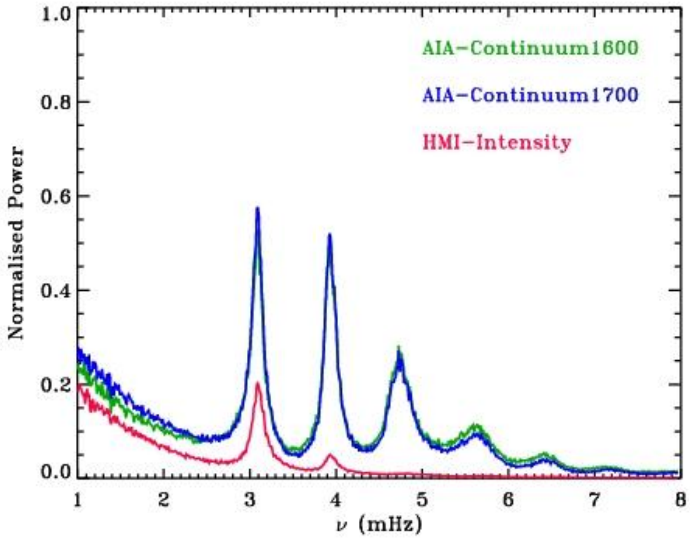


Spherical Harmonic Decomposition Method

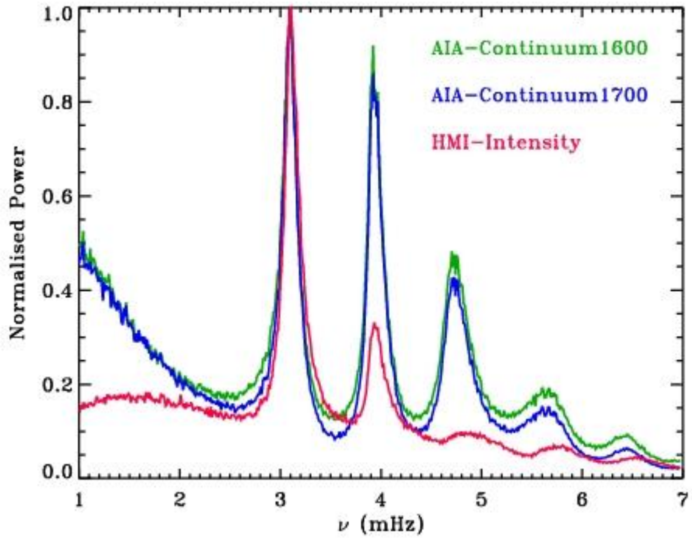


Power spectra at ℓ = 1200

Ring-diagram Technique



Spherical Harmonic Decomposition Method



Noise at low frequency frequencies in AIA data also increases at very high ℓ.

Summary

- ✓ The 1600 and 1700 Å passbands of AIA have strong 5-minute oscillation signal with low granulation noise, hence can be used for helioseismic studies.
- ✓ The 5-minute signals in AIA continuum and HMI velocity data are comparable.
- ✓ The AIA data show more sensitivity to high-frequency.
- ✓ The power in HMI intensity decreases sharply with increasing frequency.
- ✓ The AIA data can be used to study modes at high frequencies.
- ✓ These bands are sensitive to flare activity…. Need to test for regions with such activity.