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

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Helioseismic and Magnetic Imager</th>
<th>Atmospheric Imaging Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral line</td>
<td>Fe I 6173 Å line</td>
<td>1600 Å passband</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(base of chromosphere/upper photosphere, Average response height ~ 430 km with width of 185 km)</td>
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<tr>
<td></td>
<td></td>
<td>1700 Å passband</td>
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<tr>
<td></td>
<td></td>
<td>(Photosphere, Average response height ~ 360 km with width of 325 km)</td>
</tr>
<tr>
<td>Observable</td>
<td>Velocity and Intensity continuum</td>
<td>Continuum</td>
</tr>
<tr>
<td>Cadence</td>
<td>45 Second</td>
<td>24 Second</td>
</tr>
<tr>
<td>Period of Analysis</td>
<td>1440 minutes on Jan 23, 2011</td>
<td>Duty cycle ~ 100%</td>
</tr>
</tbody>
</table>
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
\( \ell - v \) diagrams (HMI)

RD Technique

SHD Method

Low frequency noise in intensity ...granulation
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 $\ell = 360$
(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 $\ell = 360$
(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 $\ell = 320$

Ring-diagram Technique

Spherical Harmonic Decomposition Method
Power spectra at $\ell = 800$

Ring-diagram Technique

Spherical Harmonic Decomposition Method

![Graph of normalized power vs frequency for different continuum sources and HMI intensity.](image1)

![Graph of normalized power vs frequency for different continuum sources and HMI intensity.](image2)
Power spectra at $\ell = 1200$

Ring-diagram Technique

Spherical Harmonic Decomposition Method

Noise at low frequency frequencies in AIA data also increases at very high $\ell$. 

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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.