Search for High Frequency Waves in the Solar Atmosphere

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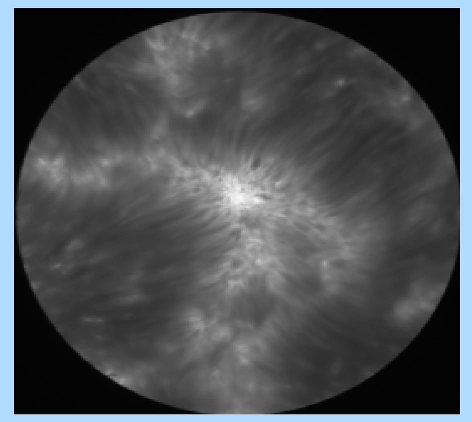
Abstract

High frequency waves were searched for in the solar atmosphere to corroborate or falsify an earlier marginal measurement. Image sequences taken using IBIS, a scanning narrow band pass imager, were converted into Dopplergrams and Fourier transformed to obtain an energy spectrum. High frequency waves were expected to show up as bright ridges in the k-ω diagram. While there is some structure in the 100mHz range, there are no discernible ridges present and further analysis of the other data sets will be necessary to obtain conclusive results.

Image Processing

Raw Data Images



Images were taken using IBIS, a narrow band pass imager (FWHM ~0.1 Å) located at the National Solar Observatory. Images were taken as the filter scanned across Ca-II (8542 Å) and Na-D (5896 Å) absorption lines. Data sets were taken for both lines in regions of quiet sun, a coronal hole, and a pore. The Ca-II pore data was chosen to be analyzed first since the air turbulence in this data set was best corrected by the adaptive optics system. The properties of the Ca-II spectrum produced unforeseen complications in later analysis.

Flat-fielding

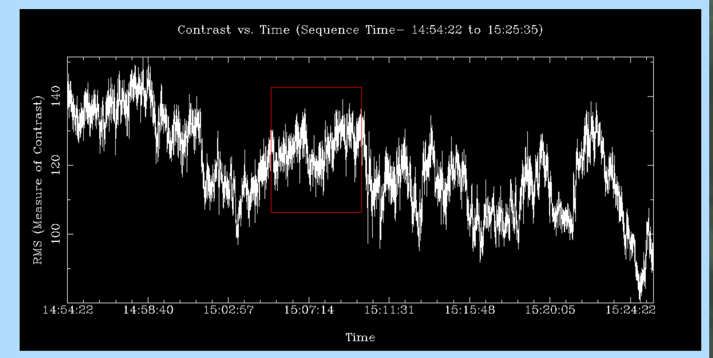
The images were adjusted to account for the background noise of the detector and for the varying sensitivity of the detector across the image plane.

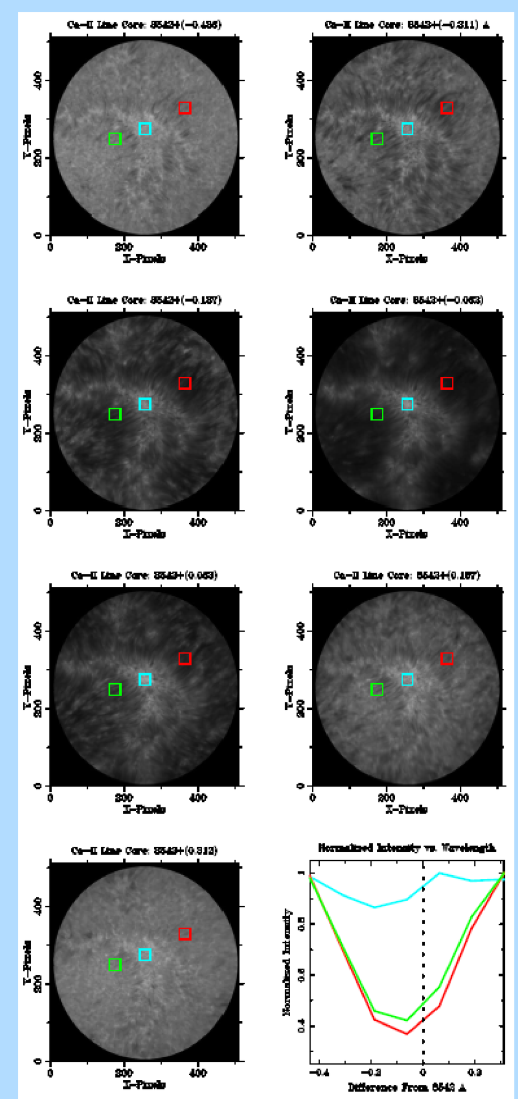
Destretching and Aligning

The image pixels were realigned to compensate for jitter in image caused by atmospheric turbulence.

Dopplergrams

A 5 minute segment of the Ca-II sequence centered around a pore was chosen to be analyzed based on relatively constant seeing conditions.





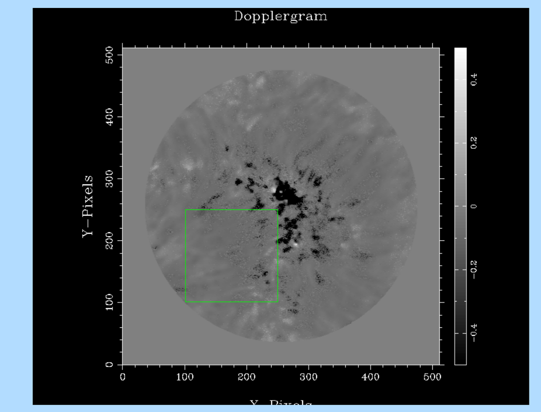
Dopplergrams were created by fitting an intensity plot for each pixel within a certain distance from the center of the image

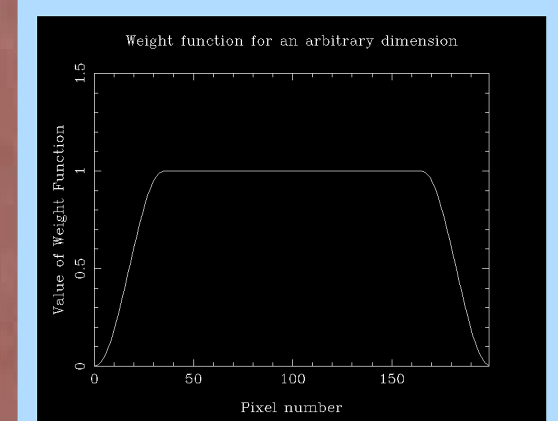
For each pixel in a given radius:

- An intensity plot was created for that pixel location over the 7 image scan.
- A negative going parameterized Gaussian was fit to the intensity plot.
- The offset of the minimum from the line core was recorded

Fourier Transform

After recording the offsets for each pixel, the image of the offsets provides the Dopplergram. The region indicated was chosen for its proximity to the center (where seeing is optimal) and for its lack of misfit plots (dark black regions on image) throughout the 5 minute sequence of images.



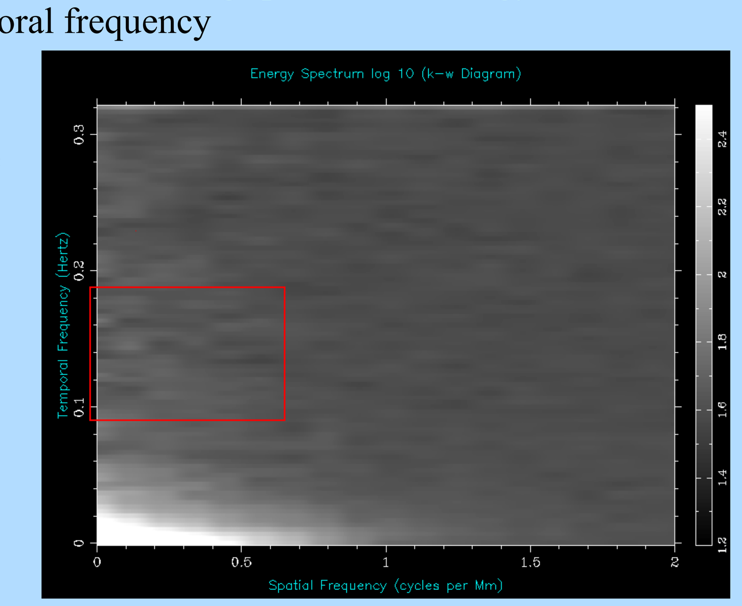


The Dopplergrams were stacked to form a cube with two spatial dimensions and a time dimension.

The cube of data was apodized and the Fourier transformation of the data was taken.

The resulting cube of data contains two spatial frequency dimensions and a temporal frequency dimension. Since it is assumed that these waves propagate isotropically in the plane of the image, the data was averaged in the theta direction to produce the following spectrum of energy vs. radial spatial frequency and temporal frequency

Between the range of 100 and 200 mHz there is some structure that suggests that waves may be present, but ridges can not be clearly distinguished above the noise level and so wave presence can not be confidently verified or falsified.



Background and Motivation

•In November of 2004 Craig DeForest published a paper entitled “High-Frequency Waves Detected in the Solar Atmosphere”

• Ridges were detected in the energy spectrum produced by Fourier transformation of sequential TRACE intensity images taken at 1600 Å. These ridges correspond to waves in the 100mHz range (a 10 second period)

• Due to the low signal to noise ratio, the presence of these waves are to be re-examined by Fourier transformation of Dopplergrams instead of intensity images.

Acknowledgments:

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References:

Deforest, C.E. 2004 High-Frequency waves detected in the solar atmosphere. ApJ Vol. 617 Pg L90

Conclusions

While some interesting structure exists around the frequency of 100 mHz, the signal to noise ratio is still too low to state confidently the presence of waves. Due to the nature of the Ca-II line and the fine structure found in scans close to the line core, it does not make it an optimal data set to analyze based on the errors associated with the fitting of the Gaussian. These misfit curves show up as dark black in the center region of the Dopplergrams. This in turn led to taking the Fourier transform of data towards the edge of the image plane where the seeing is less well compensated by the adaptive optics system, but where there are virtually no misfit intensity plots. Analysis of the Na-D data sets will not only provide better seeing conditions but will most likely provide better fits in the Dopplergrams, leading to a better over all signal to noise ratio in the Fourier transform. Wave presence could not be verified nor conclusively falsified by the results of the Ca-II data set, but it is possible that the Na-D data set will provide more conclusive results.