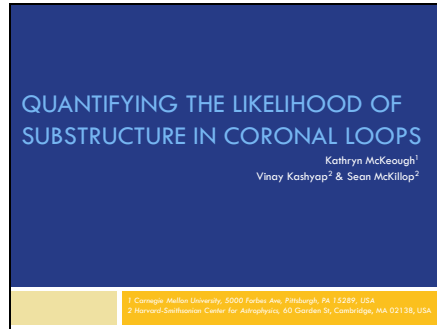


Slide 1



What can we see at very small spatial scales that help constrain the theories of coronal heating

Temperature range of Corona

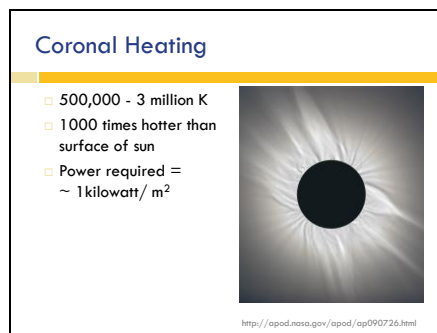
Temperature of AIA

How far the sun is from earth

What wavelength AIA we are looking at (HiC is same)

Radius of the sun

Slide 2

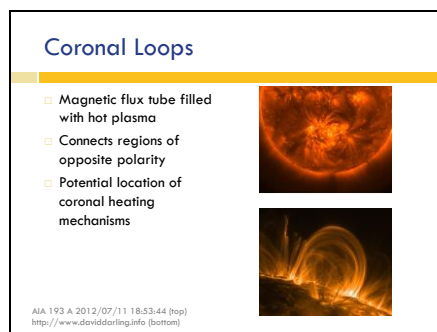


Surface area of the sun  $6.09 \times 10^{12} \text{ km}^2$

Corona, transition, chromosphere, photosphere....

where energy is coming from how it is being deposited (understandable because corona is lower density)

Slide 3



Slide 4

### Coronal Heating -Solutions

Nanoflares	Alfven Waves
<ul style="list-style-type: none"><li>□ <i>Small scale</i></li><li>□ Small consecutive bursts of energy that contributes to heating</li><li>□ Magnetic reconnection induced by stresses from footpoint motions causing braids in flux tubes</li></ul>	<ul style="list-style-type: none"><li>□ <i>Large scale</i></li><li>□ Alfven waves dissipate energy into plasma through turbulence</li><li>□ Waves propagate along flux tubes</li></ul>

two types small scale v. large scale  
Nanoflares – small compared to across the loop

Alfven Waves- long compared to the length of the loop

-propagate from center, but can be reflected back

- Not all energy caused by turbulence

- AW 0.08 m

footpoint= where loop enters chromosphere

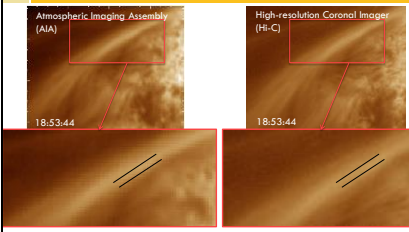
Slide 5

### Goal

By identifying the substructure of coronal loops, we determine dominant spatial scales and constrain theories of coronal heating.

Slide 6

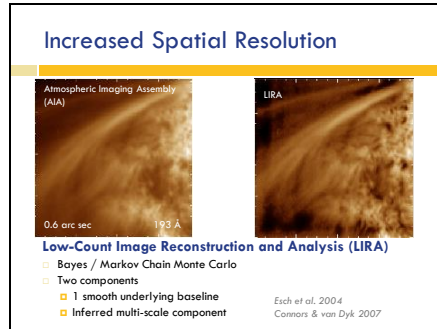
### Increased Spatial Resolution



The slide shows a comparison of two coronal loop images. The top left image is labeled 'Atmospheric Imaging Assembly (AIA)' and the top right image is labeled 'High-resolution Coronal Imager (HIC)'. Both images show a coronal loop with a red box highlighting a specific region. Below each image is a zoomed-in view of the highlighted region, showing the difference in spatial resolution between the two instruments. The HIC image shows much finer detail than the AIA image. The timestamp '18:53:44' is visible on both images.

Model smooth variations of image  
Bayesian multiscale method that uses MCMC  
AIA on SDO since 2010

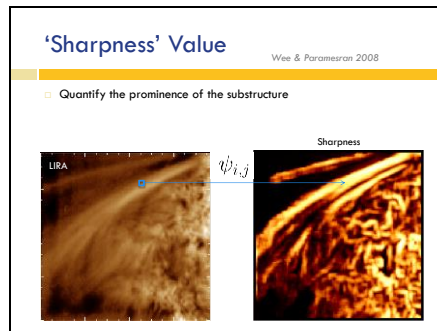
Slide 7



Model smooth variations of image  
Arc second resolution of each  
AIA is 1.3 arc min (77 arc sec) across  
Bayesian multiscale method that uses  
MCMC

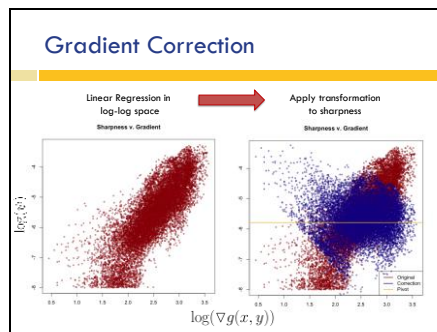
----- Meeting Notes (8/13/14 12:06) -----  
Forward modeling process (start with  
source, push through instrument to  
compare to data)

Slide 8



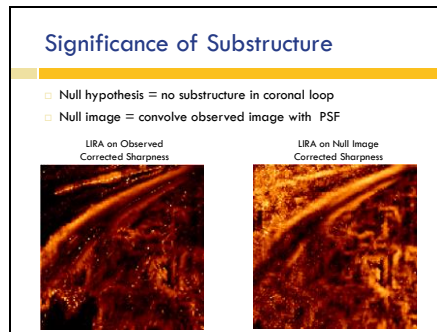
----- Meeting Notes (8/13/14 12:06) -----  
retitle LIRA on... --> sharpness  
qualitatively explain sharpness value

Slide 9

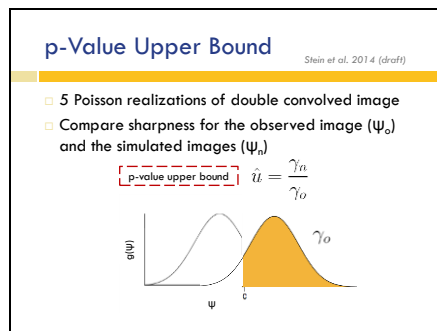


Detecting too many edges  
Pivot data about horizontal using  
function of gradient & linear regression  
fit of sharpness v gradient in log-log  
space

Slide 10



Slide 11



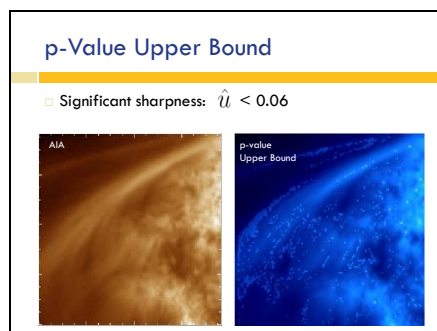
QUESTION

Adjacent sharpness are correlated  
P-value test is independent?

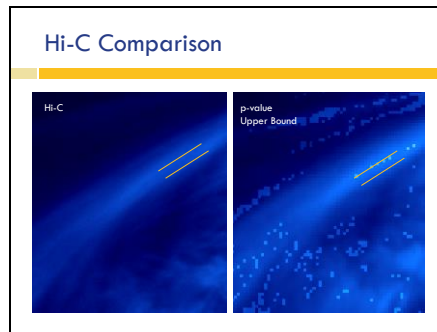
Draw gamma\_o curve

what we chose for gamma\_n (=0.05)

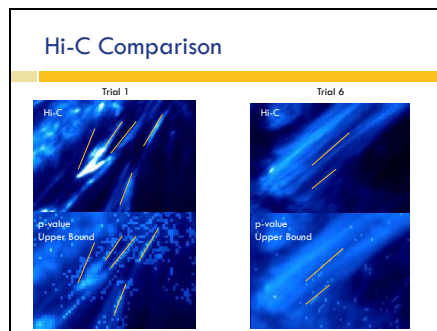
Slide 12



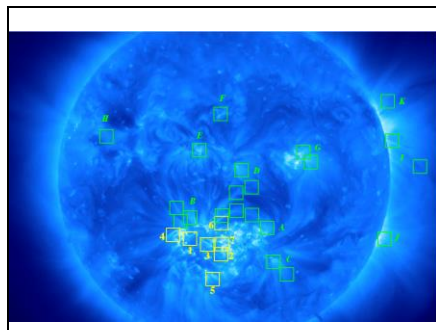
Slide 13



Slide 14



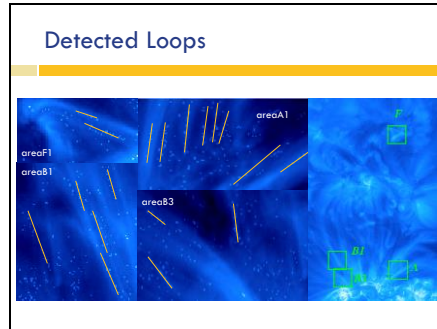
Slide 15



For each of the loops, we are able to see if there is substructure  
If all loops come up with substructure – strands everywhere (low lying, upper corona etc.)

Apply to different regions of the sun to determine where along the loops substructure exists and therefore where we expect to see these coronal heating phenomena.

Slide 16



Those that don't may have not been detected  
those that do have strong indication of substructures  
More likely to be heated by nanoflares in future

Slide 17

### Summary

- Developed method to search for substructure in solar images
- Found evidence for substructure in AIA images that we observe in Hi-C
- Similar evidence of substructure in AIA loops outside of Hi-C region:
  - Loops with strands appear to be ubiquitous
  - Supports nanoflare model
- Not all loops found to have substructure – unclear if statistical or physical explanation
- Isolated points possibly result of Poisson artifacts

Slide 18

### Future Work

- Results are preliminary
  - Quantify false positives and non-detections
  - Increasing power could expand detection regions
- Understand implications of results
  - Relation between bright points and detections – compare significant pixel light curves
  - Why some loop complexes show no detections

quantify= poisson artifacts  
Power = simulations

Slide 19




### Acknowledgements

We acknowledge support from AIA under contract SPQ2H17018 from Lockheed-Martin to SAO.

We acknowledge the High resolution Coronal Imager instrument team for making the flight data publicly available. NASA/NASA led the mission and partners include the Smithsonian Astrophysical Observatory in Cambridge, Mass.; Lockheed Martin's Solar Astrophysical Laboratory in Palo Alto, Calif.; the University of Central Lancashire in Lancaster, England; and the Lebedev Physical Institute of the Russian Academy of Sciences in Moscow.

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We thank David van Dyk and Nathan Stein for useful comments and help with understanding the output of URA.



Slide 20

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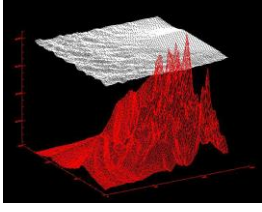
Slide 21

### Extra Slides

Slide 22

### Baseline Model

1. Begin with max
2. Correct using min curvature surface through convex hull
3. Iterate until surface lies below data



A 3D plot showing a red surface being iteratively corrected to fit data points. The surface is shown in a perspective view, with the data points represented as a grid of small cubes. The surface is initially flat and then corrected to follow the shape of the data points.

Correction never more than 5%

----- Meeting Notes (8/13/14 12:06) -----

BYE BYE SLIDE

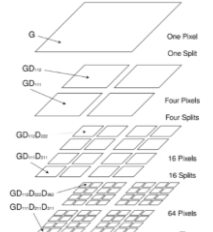
Slide 23

### LIRA Operations

INPUT	OUTPUT
<ul style="list-style-type: none"><li>□ Point Spread Function (PSF)</li><li>□ Observed Image (<math>2^n \times 2^n</math>)</li><li>□ Baseline Model</li><li>□ Prior &amp; Starting Image</li></ul>	<ul style="list-style-type: none"><li>□ MCMC iterations of Multi-scale Counts</li><li>□ Posterior distribution of departures from baseline</li><li>□ De-convolution</li></ul>

Slide 24

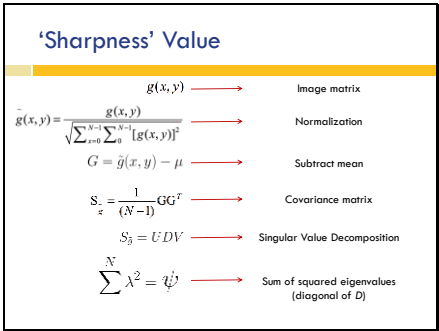
### Multi-scale Representation



A diagram illustrating the multi-scale representation of an image. It shows a hierarchy of splits and pixels. The top level is a single pixel, which is split into four pixels. This process is repeated, showing a grid of 16 pixels, then 64 pixels, and finally 256 pixels. The diagram is labeled with 'One Pixel', 'One Split', 'Four Pixels', 'Four Splits', '16 Pixels', '16 Splits', and '64 Pixels'.

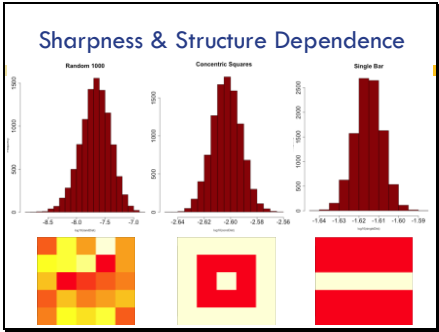


Slide 25



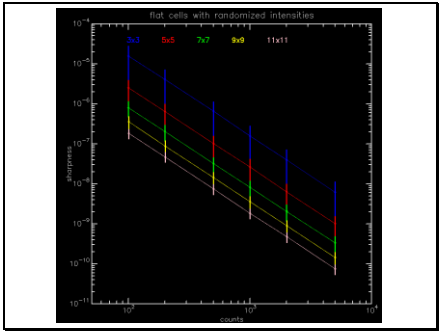
----- Meeting Notes (8/13/14 12:06) -----  
EXTRA SLIDE

Slide 26



Random, X and randomized

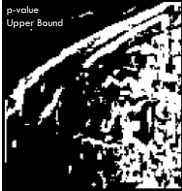
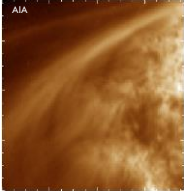
Slide 27



Slide 28

### Edge Detection

□ Gradient steepest along edges → edge detection



Slide 29

### Gradient Correction

$$\psi' = 10^{\log(\psi) - (a \times \log(\nabla g) - \nabla g)}$$
$$\log(\psi) = a \times \log(\nabla g) + b$$
