Hi-C Observations of Penumbral Bright Dots

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Introduction

- While looking at images from the High Resolution Coronal Imager (Hi-C), we found transient, radially oscillating bright dots in a sunspot penumbra
- Hi-C provided the highest resolution images of the solar corona ever seen, explaining why these dots were not found before (Hi-C resolved features 150km in size, 12 times more powerful than previous instruments)
- Dots are potentially related to transition region (TR) penumbral bright dots seen with Interface Region Imaging Spectrograph (IRIS) telescope by Tian et al. (2014)
- Our purpose is to measure the properties of the Hi-C dots and compare with the IRIS dots; if we can find the cause of these brightenings we may find clues to a coronal heating mechanism

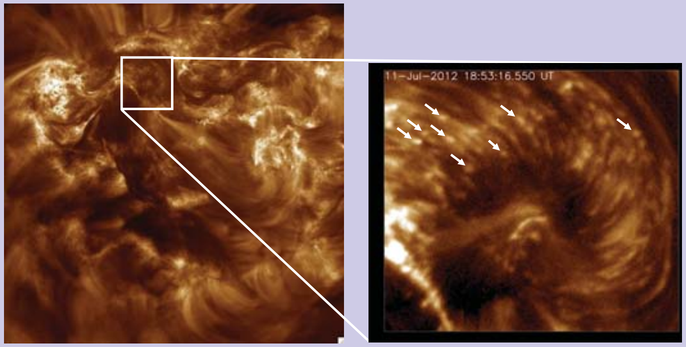

Figure 1. (Left) Still image of the Hi-C telescope's full field of view. Hi-C observed at 193Å/19.3nm. (Right) Still image of the sunspot we studied, shown as an inset of the full field of view. The penumbra is the outer, brighter region that is twisted counter-clockwise from radial symmetry. Our bright dots are the circular regions of plasma brighter than the background; several are indicated with arrows.

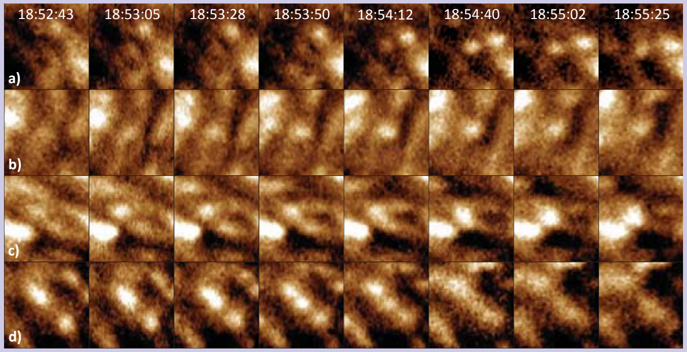

Figure 2. A sequence of four different dots/dot groups evolving in time, giving examples of how they behave. a) a single moving dot; b) a single stationary dot; c) a pair of dots, joining together to form a larger, brighter dot; d) a group of three dots. The top and middle dot form from the split of a larger, brighter dot. The middle and bottom dot later join, but fade, instead of forming a larger, brighter dot.

Data

- Calculated dot size, lifetime, speed, and intensity enhancement using the same methods as Tian et al. (2014) so that comparisons are rigorous and reliable
- In order to better see the dots while making measurements, we performed a Gaussian smoothing regime and subtracted the smoothed image from the origin
- Used Hi-C data almost exclusively, complemented with data from the Solar Dyna Observatory's (SDO) Atmospheric Imaging Assembly (AIA) when calculating dot lifetime that outlasts Hi-C's observing time
- Made lightcurves by measuring the light emitted over time from the same dot ar but in different layers of the solar atmosphere (used SDO AIA data)

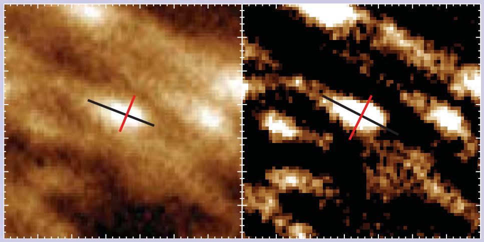

Figure 4. A 7-by-7 arcsecond (~25,000 km²) snapshot showing how dot size is measured. Two cuts are made across dot center when dot is at max brightness: length (black), pointing to sunspot center, and width (red), perpendicular to length cut. Left image is normal; right has Gaussian filter.

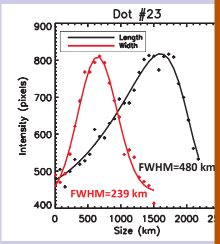

Figure 5. Length and width cuts o dot at left. A Gaussian is fit to the points and full width at half maxi (FWHM) is determined to be dot s

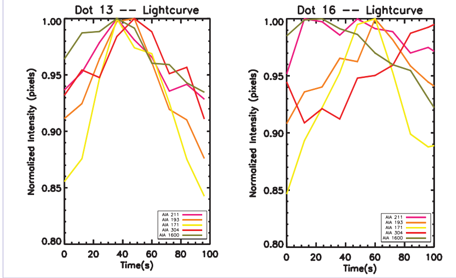

Figure 3. Lightcurves of dots showing their brightness over time in different wavelengths; the legend is in order of decreasing height in the atmosphere. Left shows peak brightness at similar times across the wavelengths; right shows discrepancies between the peaks.

	Tian et al. (IRIS)	This research (Hi-C)
Length (km)	439.0	557.7
Width (km)	352.3	472.4
Lifetime (s)	41.3	268
Speed (km/s)	N/A	5.8
Intensity Enhancement (%)	319.4	188

Figure 6. Comparison between our dots and those of Tian et al (2014). Their speed is N/A because they measured velocity instead of absolute speed (included dot direction in or out from the center).

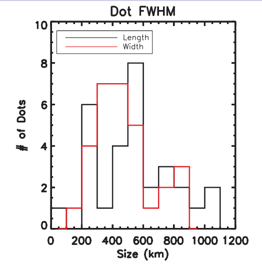

Figure 7. Histograms of dot lengths and widths.

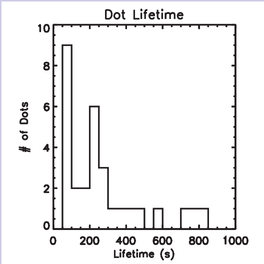

Figure 8. Histogram of dot lifetimes.

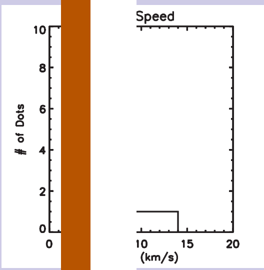

Figure 9 of dot speeds.

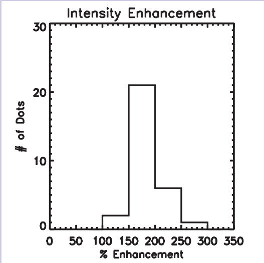

Figure 10. Histogram of intensity enhancement (ratio of dot brightness to background brightness).

Results

- Hi-C dots are larger, slower, longer-lasting, and less bright than IRIS dots
- A few lightcurves reach peak brightness in all wavelengths at the same time, but r not

Conclusions

- Hi-C dots are probably a similar origin or mechanism to the IRIS dots, but on the e end
- Same peaking time of lightcurves in AIA channels indicate dots originate in TR; ori ose with unmatched peaks is unclear
- Possible physical mechanisms are: plasma downflow (similar to coronal rain), repe onnection in the lower atmosphere, or reconnection induced by penumbral waves
- Future work includes using a hydrodynamic numerical model to test possible mec

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