Cavity Magnetic Observations: A Survey using AIA and CoMP data

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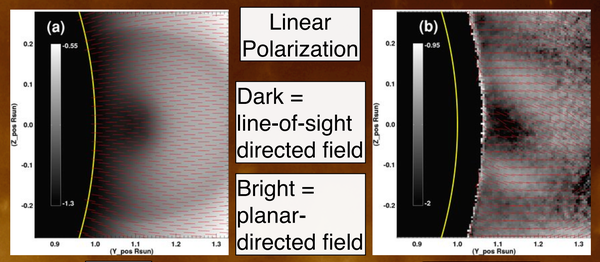
Abstract

The magnetic field of the corona is the predominate source of energy when it comes to coronal mass ejections (CME) and flares. Coronal prominence cavities are highly visible regions of rarified density when viewed off limb and can erupt into CMEs. Observing magnetic fields in the corona has always been difficult, but for the first time daily observations of linear polarization are being made by the Coronal Multichannel Polarimeter (CoMP). These observations of the optically-thin corona are ideal for studying structures such as cavities which extend along the line of sight. A survey was conducted over the last 6 months using the Atmospheric Imaging Assembly (AIA) instrument aboard the Solar Dynamics Observatory (SDO) satellite in order to create a working database of all visible cavities. These cavities were then compared to intensity and linear polarization images obtained by the CoMP telescope. The linear polarization images were examined for specific structures similar to those created using forward calculations of CoMP-like observables from magnetohydrodynamic models.

Background

The motivation for this REU project was to develop a means to locate and analyze images with the CoMP telescope. (Dove et. al. 2011) showed one example of a forward calculated magnetohydrodynamic model that was verified by observations. More generally this showed that forward calculations can be used to predict linear polarization in the corona. This was just one model and observation, so more observations are needed to further test this and other models.



Model

Linear Polarization

Dark = line-of-sight directed field

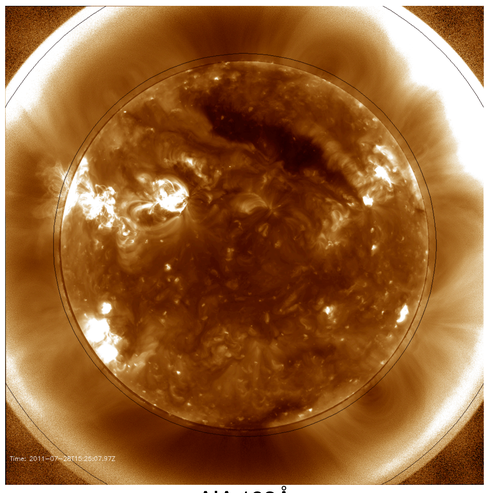
Bright = planar-directed field

CoMP Data

REU Project

The REU project had three objectives:

1. AIA Image Processing - The data from AIA was designed to look at the solar disk, so in order to use the data to look for cavities, the data had to be scaled in such a way as to make the off-limb corona more visible with as high contrast as possible.
2. Cavity Survey - Once the images were scaled correctly, 6 months worth were created and all that cavities throughout that time period were to be located and cataloged.
3. CoMP Data Analysis - Once the survey was complete, the cavities that had linear polarization CoMP data were analyzed, looking for similarities between them and the forward calculations.



AIA 193Å

Final result of exponentially fit image

64 cavities were catalogued over 6 months, Sample Database:

month	CoMP	Noticeable	cavity	location	start time	end time	hours visible	best time	height (Solar Radius)	width (Solar Radius)	shape	sharpness 1-3 3 is best	depletion 1-3 3 is best	eruption (time)
2011_06			18	NE	2011-06-10T0 1:30:08	2011-06-13T1 7:30:08	88	2011-06-11T0 2:00:08	.164 R	.112 R	elliptical	2	2	2011-06-12T0 3:30:08
			30	SE	2011-06-01T0 0:00:08	2011-06-04T0 0:00:08	72		-	-	elliptical	1	1	2011-06-05T1 7:00:08
2011_07			22	NE	2011-07-01T0 0:00:08	2011-07-04T2 2:00:08	94	2011-07-01T0 5:00:08	-	-	semicircle	1	1	no eruption
			59	NE	2011-07-06T1 0:00:08	2011-07-14T1 1:00:08	193	2011-07-10T1 1:30:08	.129 R	.106 R	elliptical	1	2	2011-07-14T1 1:00:08
			64	NE	2011-07-08T0 0:00:08	2011-07-10T0 0:00:08		None			elliptical			2011-07-10T0 0:00:08

eruption type	post eruption status	PCF or AR	prominence	CoMP online	cavity visible in CoMP I	cavity visible in CoMP POI	cavity visible in CoMP LOS velocity	comments
prominence eruption	visible cavity	unknown	yes, barely visible at the end of the time	yes, but not on the day of best visibility				
prominence eruption	no visible cavity	unknown	yes, there is a prominence but its not clear what its association is with the cavity	yes, partially	yes, 2011_06_01	yes		this would be an interesting time frame to look at comp data in, its hard to tell what actually erupts, but if its a cavity it is high up in the corona
		PCF	yes, the only defining characteristic of this cavity is the prominence	yes	no	no		this is a poor cavity making it very difficult to give any real measurements for its dimensions
prominence eruption	no visible cavity	unknown	yes, the prominence is sitting on the bottom of the cavity	yes	yes, 2011_07_08, 2011_07_09	no		more data from SDO is needed on the actual date of eruption and the time leading up to it
complete cavity	no visible cavity	unknown	this is very difficult to see, the cavity was found by working back from an eruption	yes	yes, 2011_07_08, 2011_07_10	possibly, 2011_07_10		

Results

Established technique of finding and analyzing CoMP images

- Image processing of AIA data
- Identification of corresponding CoMP cavities
- 78% of AIA cavities were observed by CoMP

Built and analyzed survey of AIA cavities

- Analyzed morphology of cavities
- Analyzed association with prominences and CMEs
- CME likelihood depended on cavity morphology

Acknowledgements

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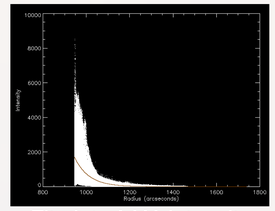
High Altitude Observatory, Boulder, Colorado
Laboratory for Atmospheric and Space Physics, Boulder, Colorado
University of Colorado, Boulder

References

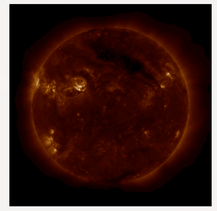
A Ring of Polarized Light, J. B. Dove et. al. 2011, The Astrophysical Journals Letters

Image Processing

Initially the most basic methods were used to process the data from AIA but it soon became apparent that a more custom scaling technique would be required in order to obtain the necessary result of a very high contrast corona. In order to achieve this, a exponential best fit was applied to the intensity plot of the images and then used to scale the data.



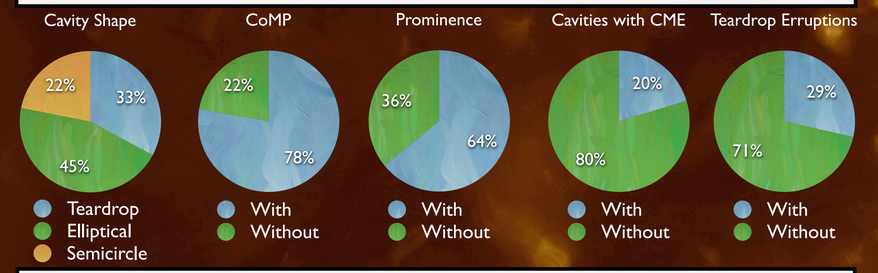
Fit plot of AIA intensity



Unprocessed AIA data

Survey

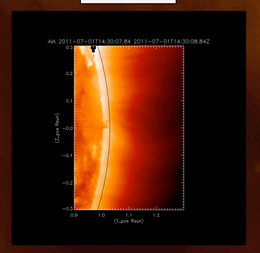
The purpose of the survey was to create a complete database from January , 2011 to July, 2011. It was very important that the database could be easily referenced and that the data give a good understanding of each cavity without any visual representation. Many different aspects were examined, but the most important characteristics were the prominence association, CME eruptions, shape and the presence of CoMP data for the particular time period that each of the cavities were visible.



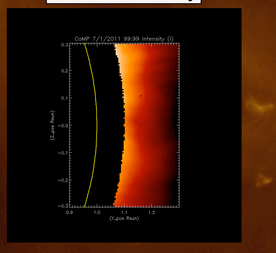
CoMP Analysis

Once the cavities were catalogued, their corresponding CoMP images were processed in order to analyze for structures similar to those created using forward calculations. After analyzing three months of data and finding 9 ideal candidates, no clear pattern was found in the CoMP data. This may be due to a reduced field of view in the CoMP data. Fortunately these are the early stages of CoMP analysis and there is much more to be done in the future.

AIA 193Å



CoMP Intensity



CoMP Linear Polarization