

Analyses of Erupting Prominences with Emphasis on their Helicity

Olga Panasenco, Helio Research

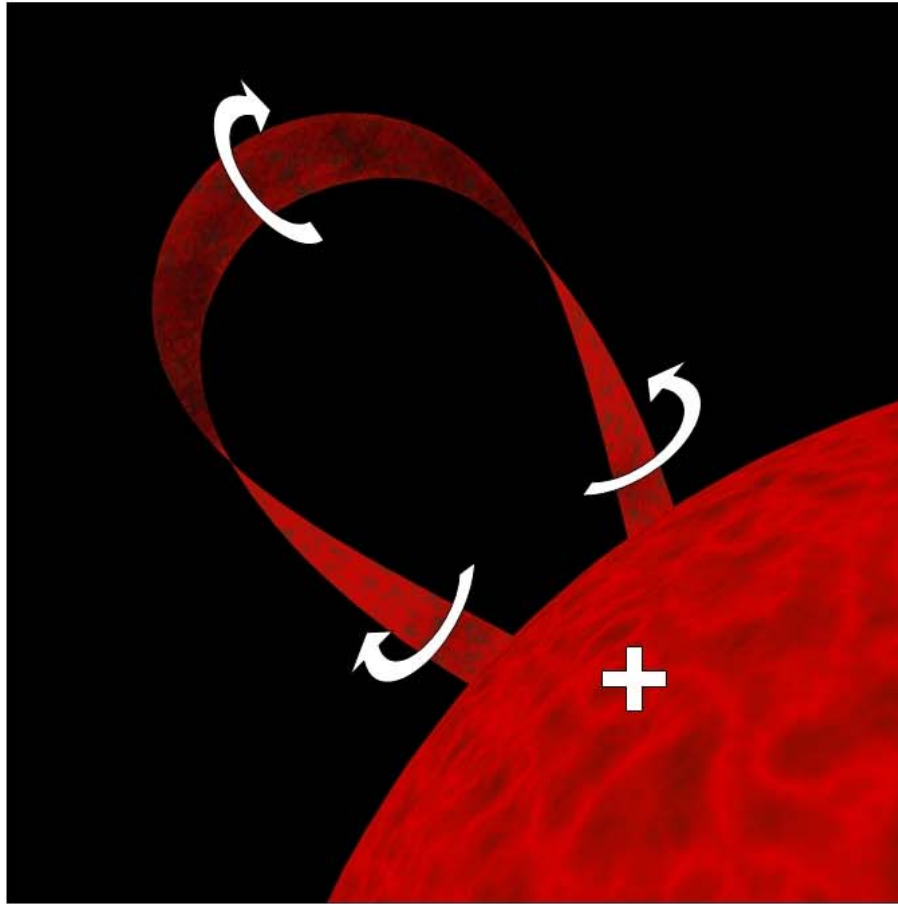
Co-Investigator: Sara F. Martin (Helio Research)

Collaborator: Paulett Liewer (JPL)

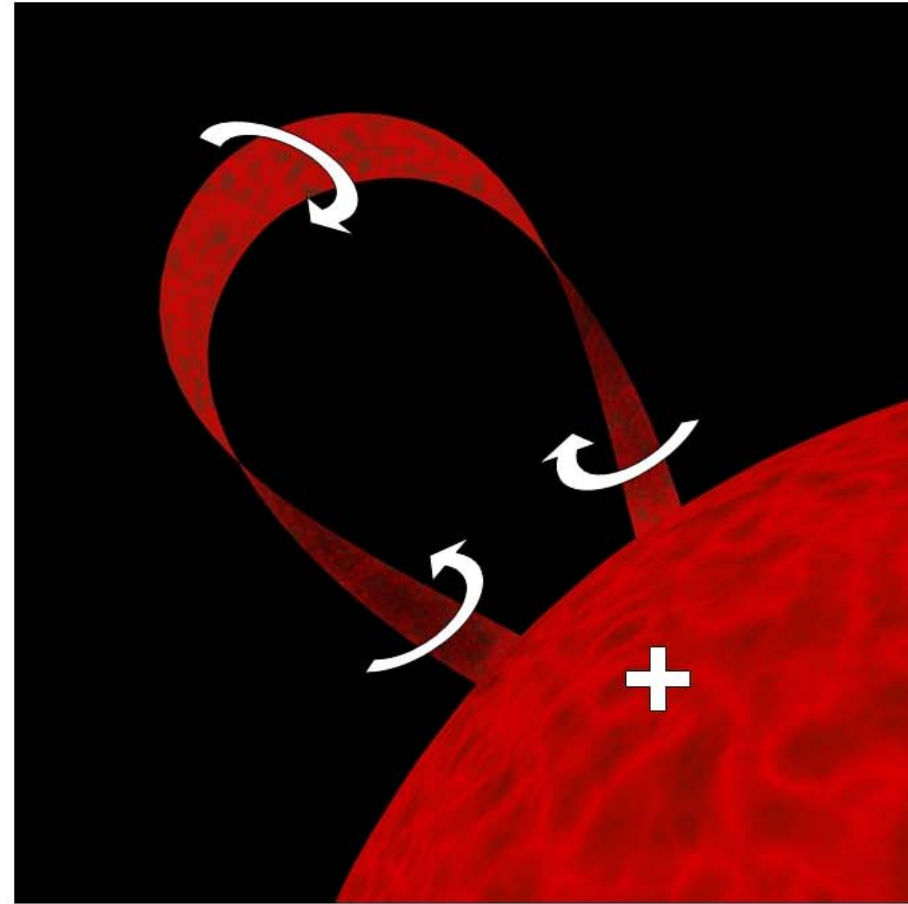
Collaborator: Mitchell Berger (Exeter, England)

Project summary: We are proposing to analyze large-scale dynamical forms of erupting filaments and prominences observed from Earth, L1 and STEREO. Our focus for this study will be the many filaments that acquire helical structure in varying degrees during their eruption. The twisted structure may result from a bodily rotation about a horizontal axis (the "roll effect") or around a vertical axis through the apex of erupting prominences. High quality H-alpha images provide the essential evidence that these two observed forms of large scale twist do not exist prior to eruption. Our goals are to: (1) expand on our new knowledge about the nature of these forms of helicity through analyses of existing and new data, (2) investigate the possible interrelationship of the two forms, (3) seek relationships between these helical motions and other large-scale patterns of motion in erupting filaments seen in SOHO and TRACE, and ground-based data (4) test a published hypothesis for the cause of the roll effect, and (5) search for possible causes of the occasional existence of the second dynamical form: rotation about a vertical axis passing through the apex of the erupting filament. To accomplish these goals, we propose the use of a broad range of available data sources on erupting prominences but will put strong focus on two primary sets which most strongly confirm the existence of the roll effect as a newly recognized dynamic form of chirality in erupting filaments. These are: (1) 304Å images recorded by the STEREO/SECCHI Extreme Ultraviolet Imager (EUVI) and (2) H-alpha Doppler movie sequences of images from Helio Research. The two simultaneous views of a prominence provided by the two STEREO spacecraft are unique in providing information on the 3-D structure of erupting prominences. The ground-based observations from Helio Research's telescope provide information on the velocity of material in the prominences. The two complementary data sets from space and from the ground will yield the most significant information on the 3-D dynamics of filaments. Our analysis include empirical modeling and theoretical investigations to decipher the topology and physics of erupting filaments as completely as possible from observed parameters. Our proposed research follows up on the new breakthrough that the roll effect affords us in understanding the previously puzzling and complex appearance of erupting prominences and this is likely to have a broad impact on related research. Our untangling of the seemingly tangled complex motions in erupting prominences will greatly aid in identifying the forces that create these helical motions and this will carry over into possibilities for forecasting properties of erupting prominences. Because of the close relationship between prominences eruptions and CMEs, the anticipated results will also affect related research on coronal mass ejections (CMEs), and the forecasting of CME helicity that is related to the unique forms of helicity in erupting prominence.

Roll effect schematic



sinistral



dextral

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about a horizontal axis (the "roll effect") or around a vertical axis through the apex of erupting prominences. High quality H-alpha images provide the essential evidence that these two observed forms of large scale twist do not exist prior to eruption.

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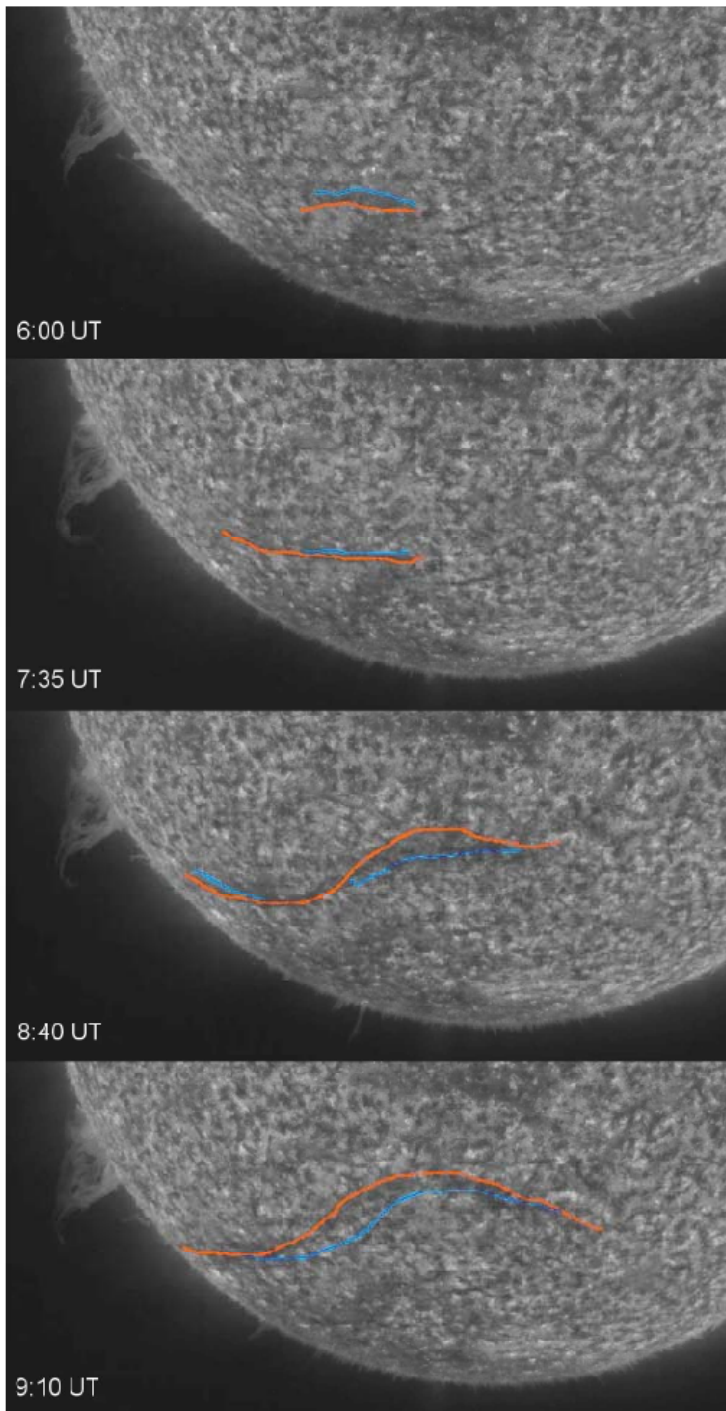
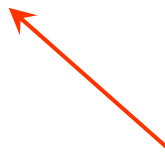
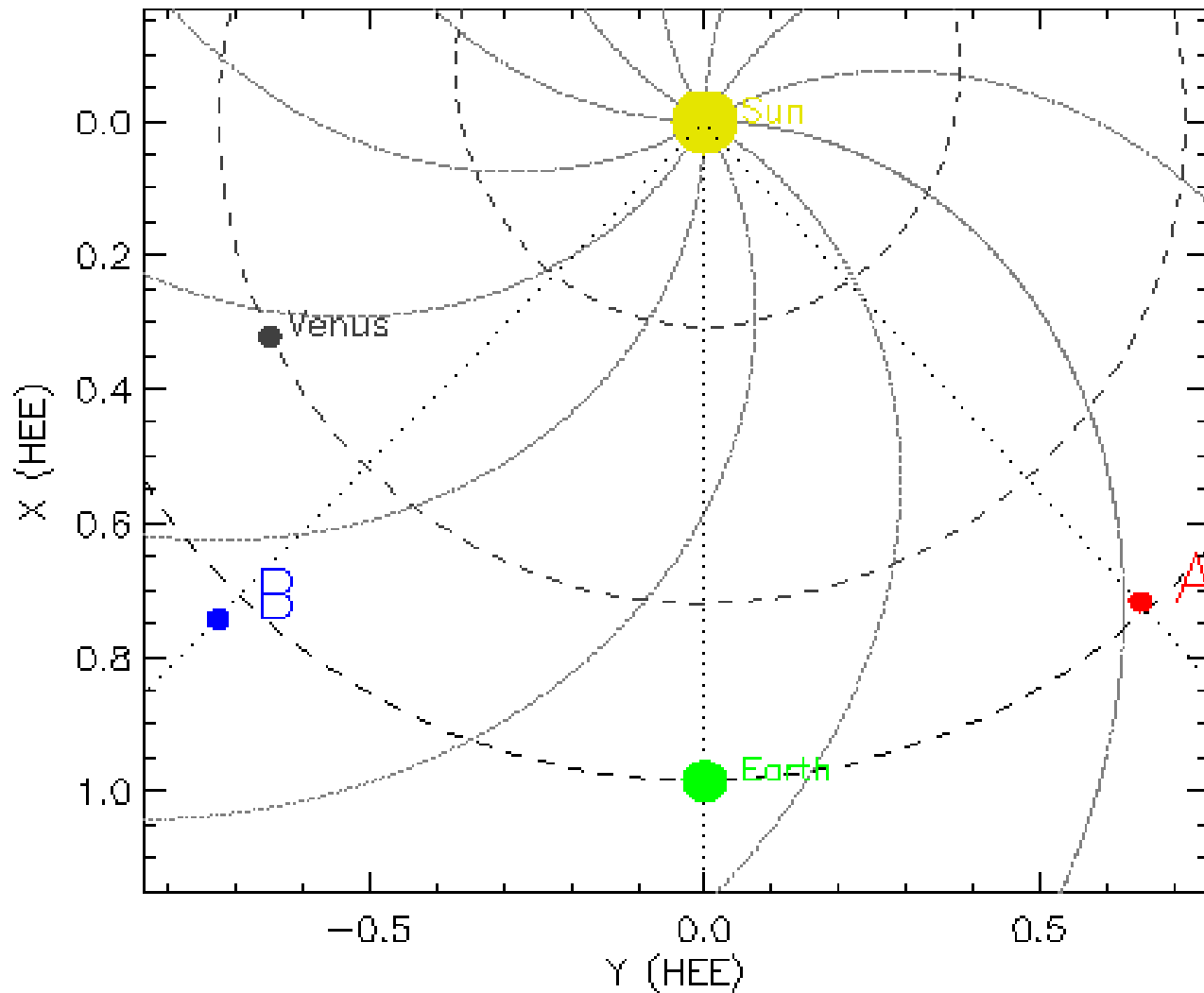


Table 1. Examples of the roll effect in erupting prominences.

	Date	Type of Data	Source of Data	Evidence of the Roll
1	1946 June 4	H α movie and images	Mt. Wilson Solar Observatory; HAO	Opposite sense of twist in legs
2	1947	H α Spectra M.A. Ellison	Mt. Wilson Solar Observatory	Velocity pattern with opposite directions of rotation in legs
3	1959 Feb 5	H α images	NSO/Sacramento Peak	Opposite sense of twist in legs
4	1997 Aug 26	304Å images	SOHO/EIT	Opposite sense of twist in legs; rolling form
5	1998 April 7	Vortical motion at the photosphere	NSO/Sacramento Peak Balasubramaniam et al. 1999	Vortical motions of opposite sense at feet of an erupting prominence
6	1999 March 6	304Å images	SOHO/EIT	Opposite sense of twist legs; form consistent with rolling
7	2001 Feb 12	304Å images	SOHO/EIT	Opposite sense of twist in legs; rolling form
8	2002 July 29	Movies in range: H α +/- 1.0Å	Helio Research La Crescenta, CA	Doppler maximum shifts on outer edges; smooth velocity gradient between
9	2003 Apr 11	304Å images	SOHO/EIT	Opposite sense of twist in legs; rolling form
10	2004 Apr 30	195Å images	TRACE	Opposite sense of twist in legs; rolling form
11	2007 May 12	304Å images and 3D movie	STEREO/ SECCHI/EUVI	Rolling form during strongly non-radial eruption
12	2007 May 16	304Å images and 3D movie	STEREO SECCHI/EUVI	Rolling form during strongly non-radial eruption





Position of STEREO A and B for December 12, 2008 05:00 UT

Separation angle 86.7 degree

STEREO

12 December, 2008

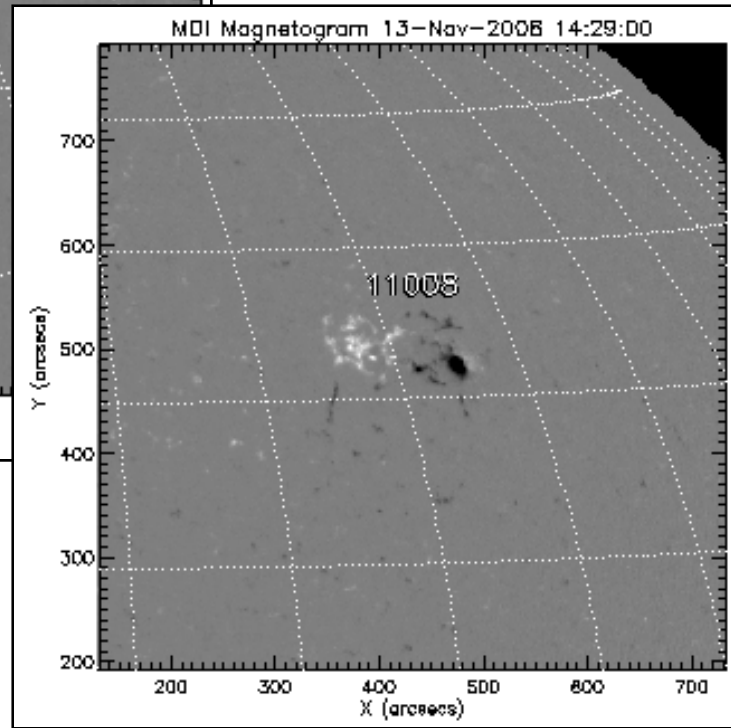
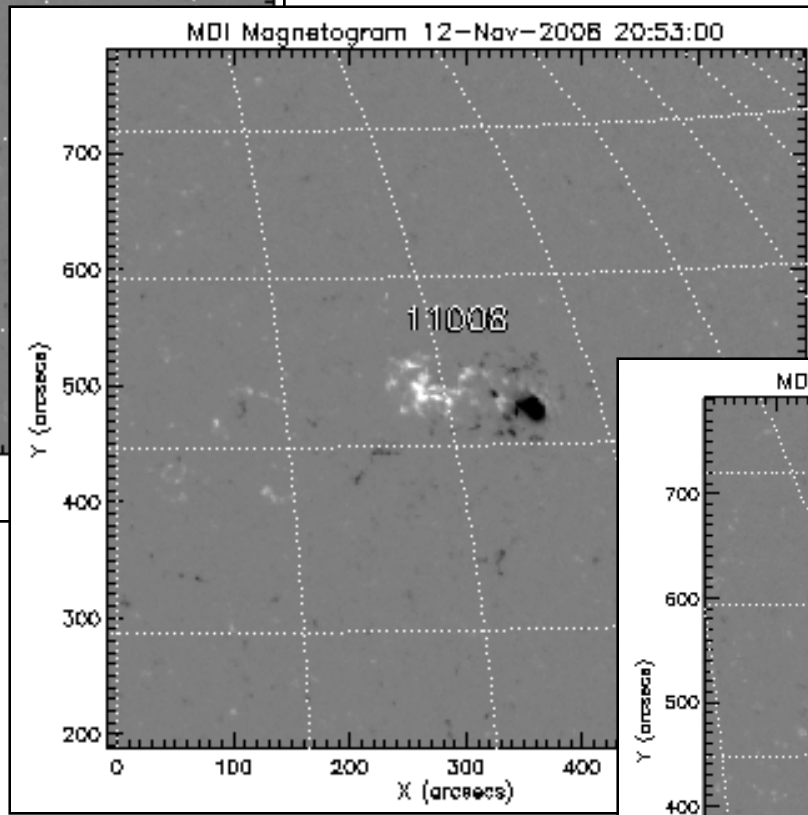
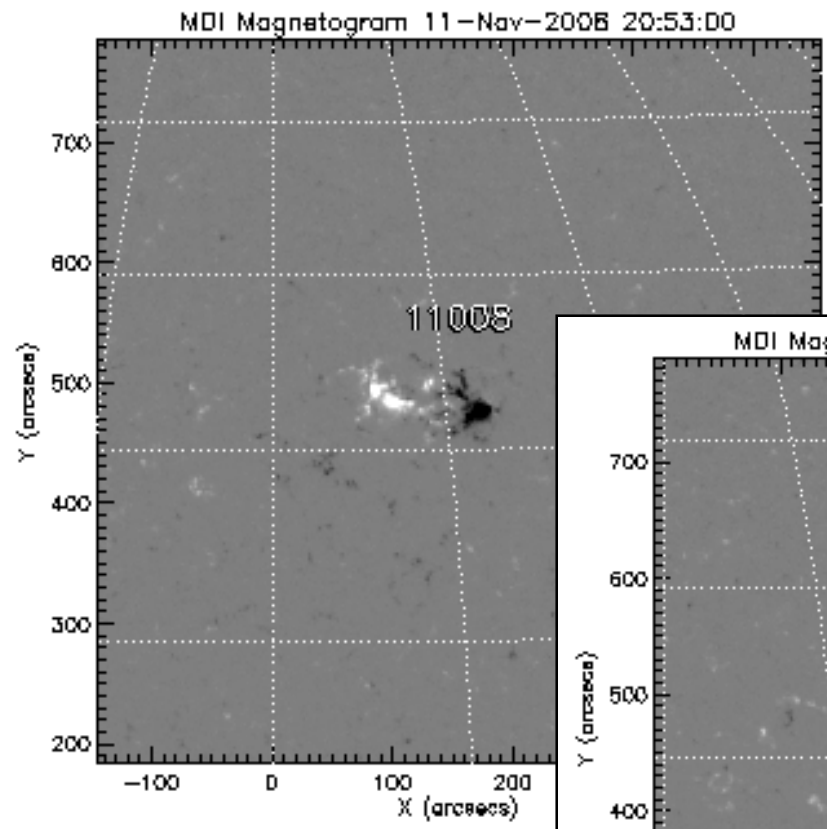
QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.

B

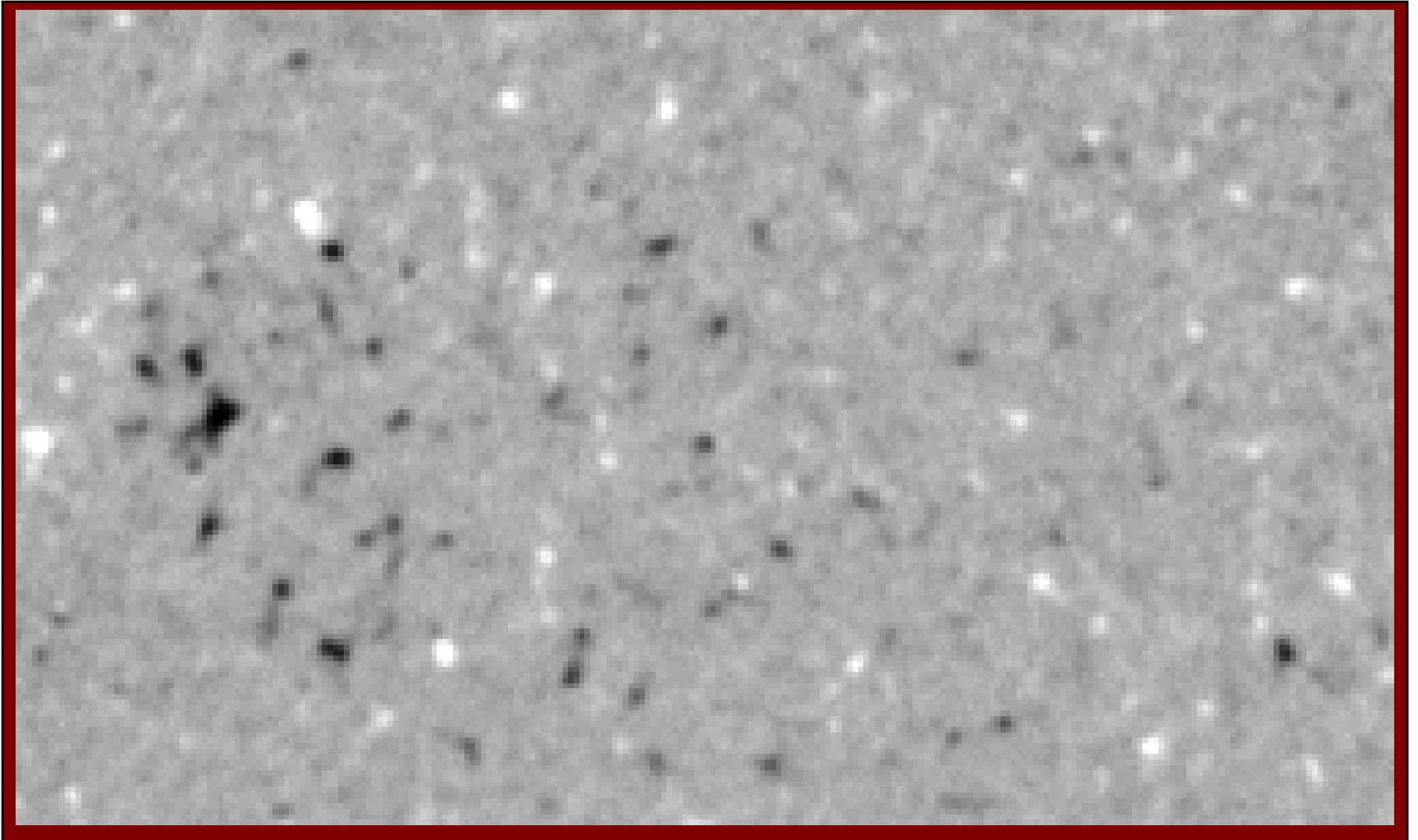
are needed to see this picture.

A

November 11-13,
2008
MDI



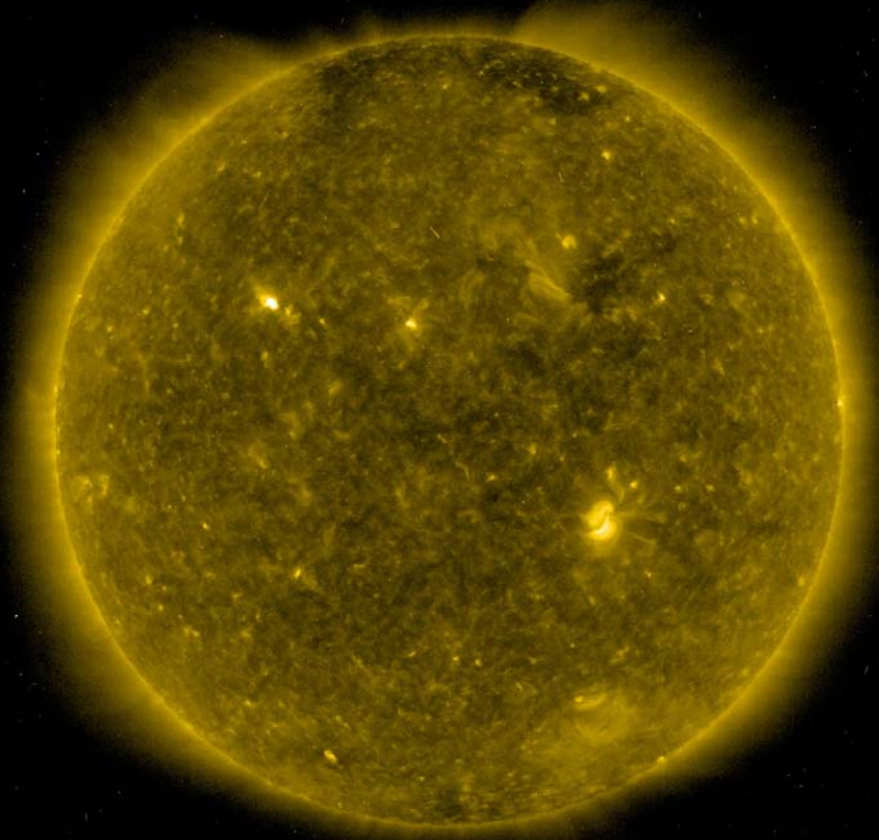
10 - 11 Nov 2008 GONG magnetograms



STEREO Behind EUVI 284

November 10,
2008

00:07:17 UT

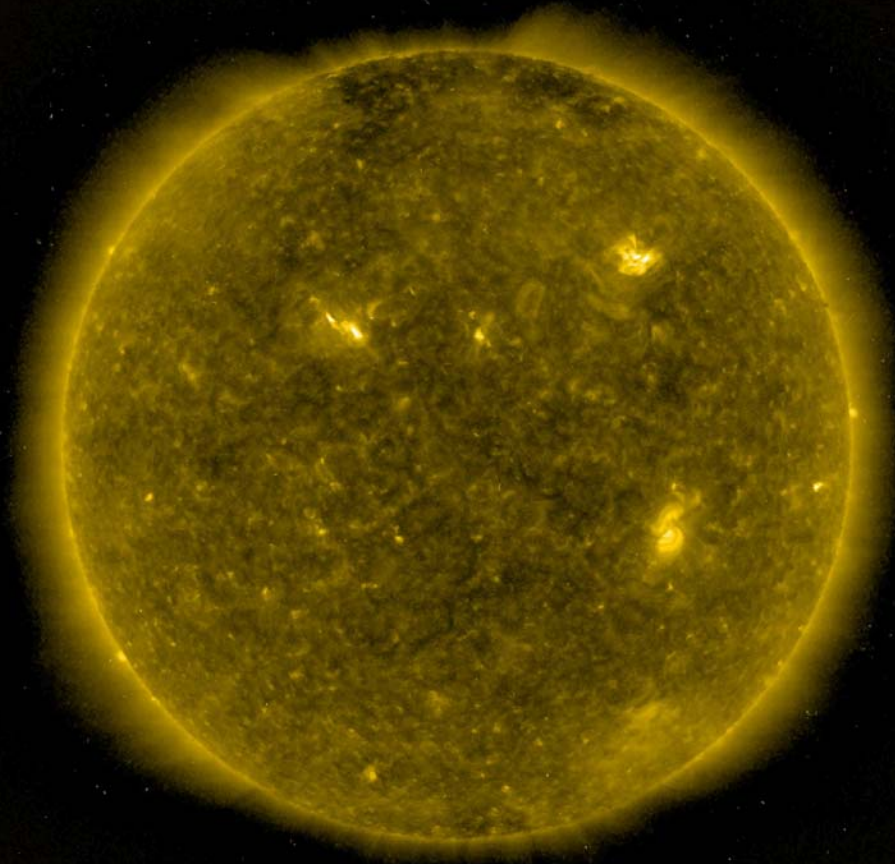


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STEREO Behind EUVI 284

November 10,
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16:27:17 UT

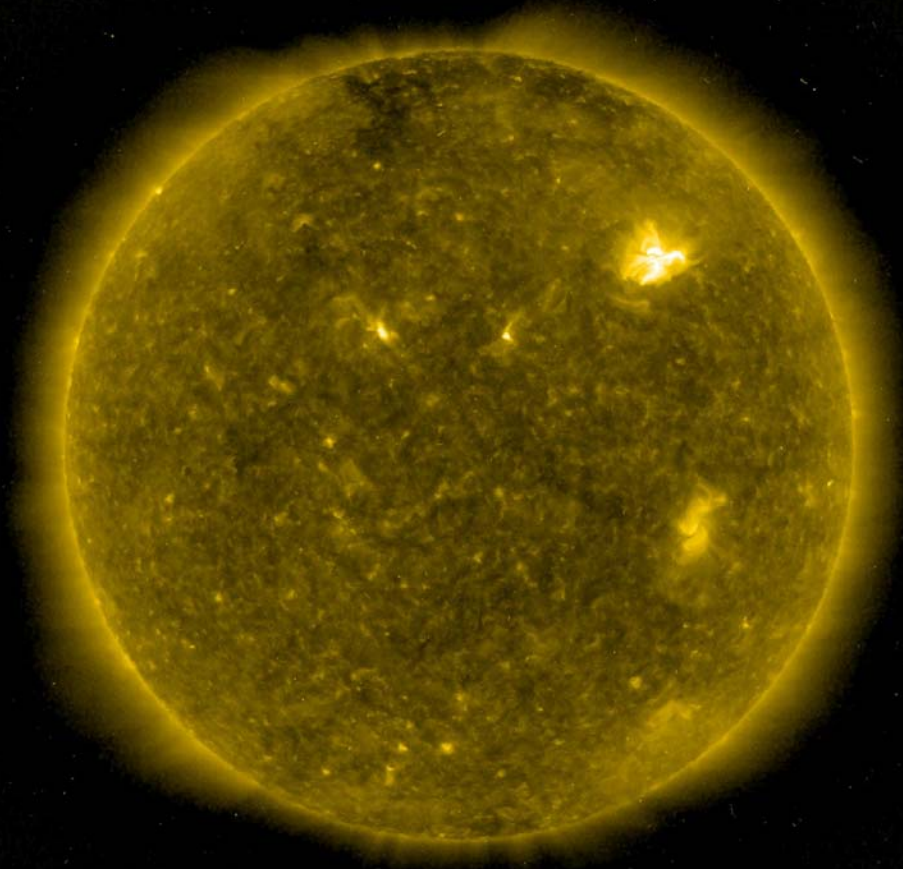


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November 10,
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23:47:16 UT

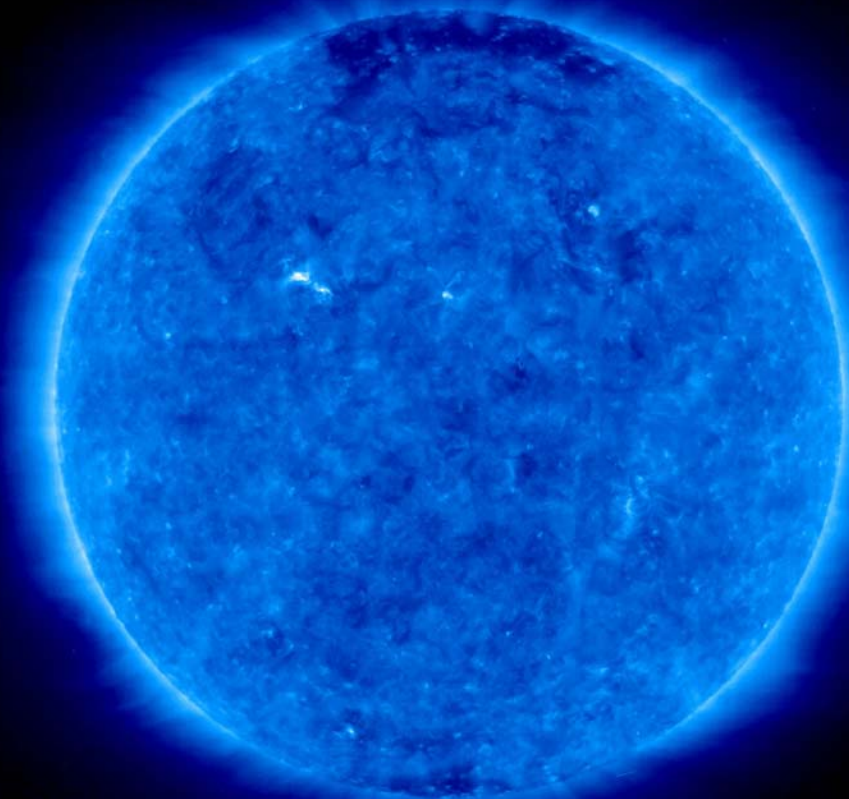


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STEREO Behind EUVI 171

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09:49:17 UT

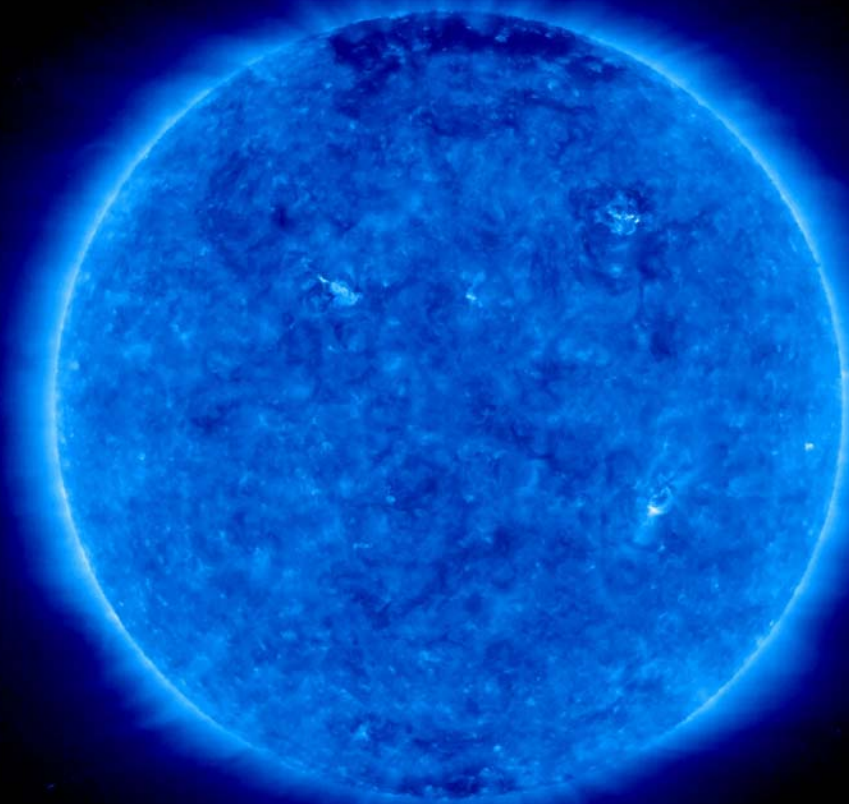


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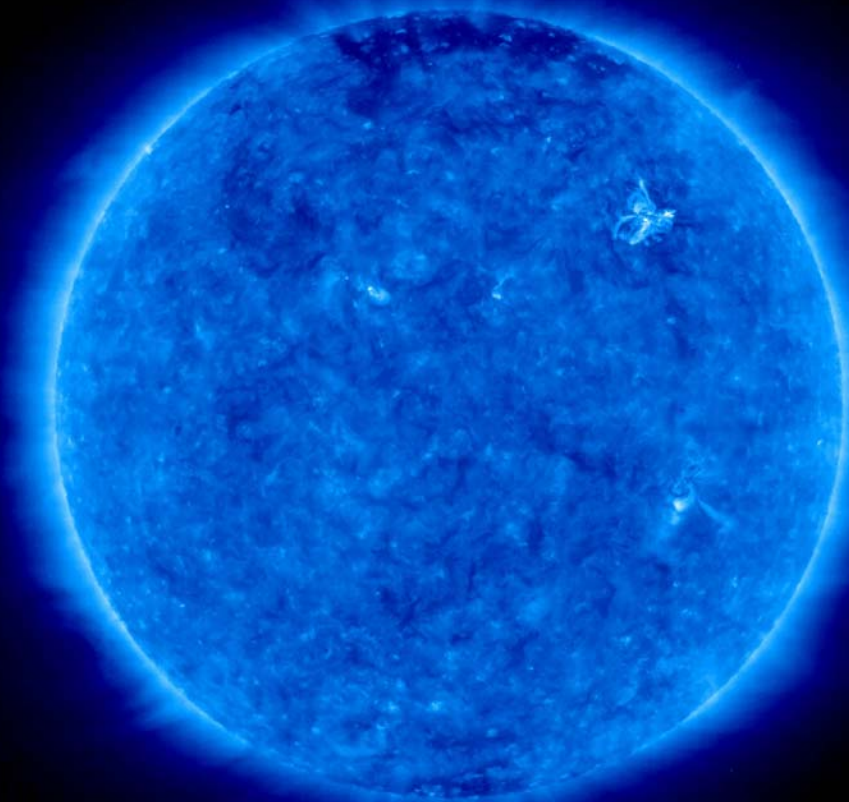


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STEREO Behind EUVI 171

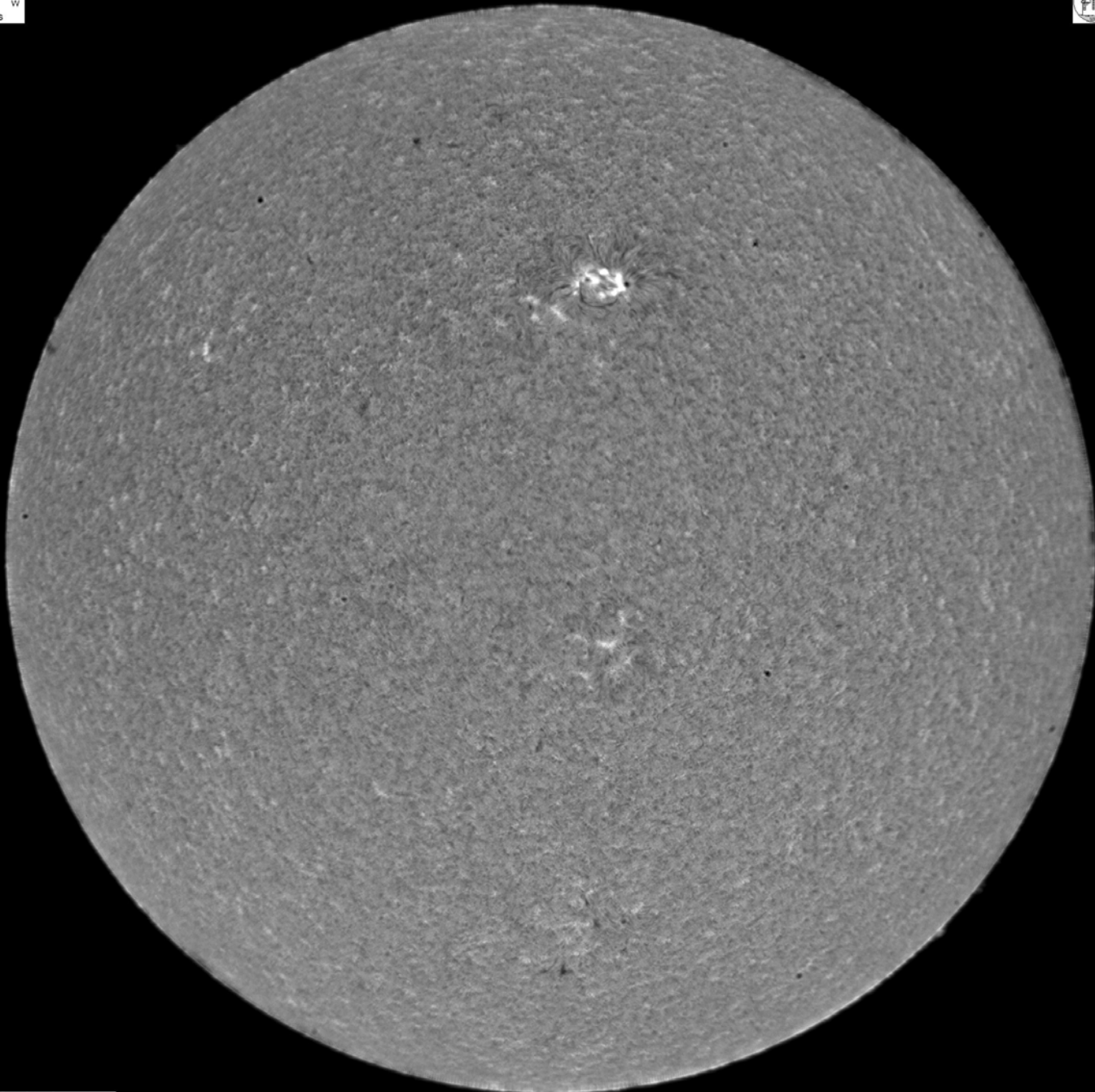
November 10,
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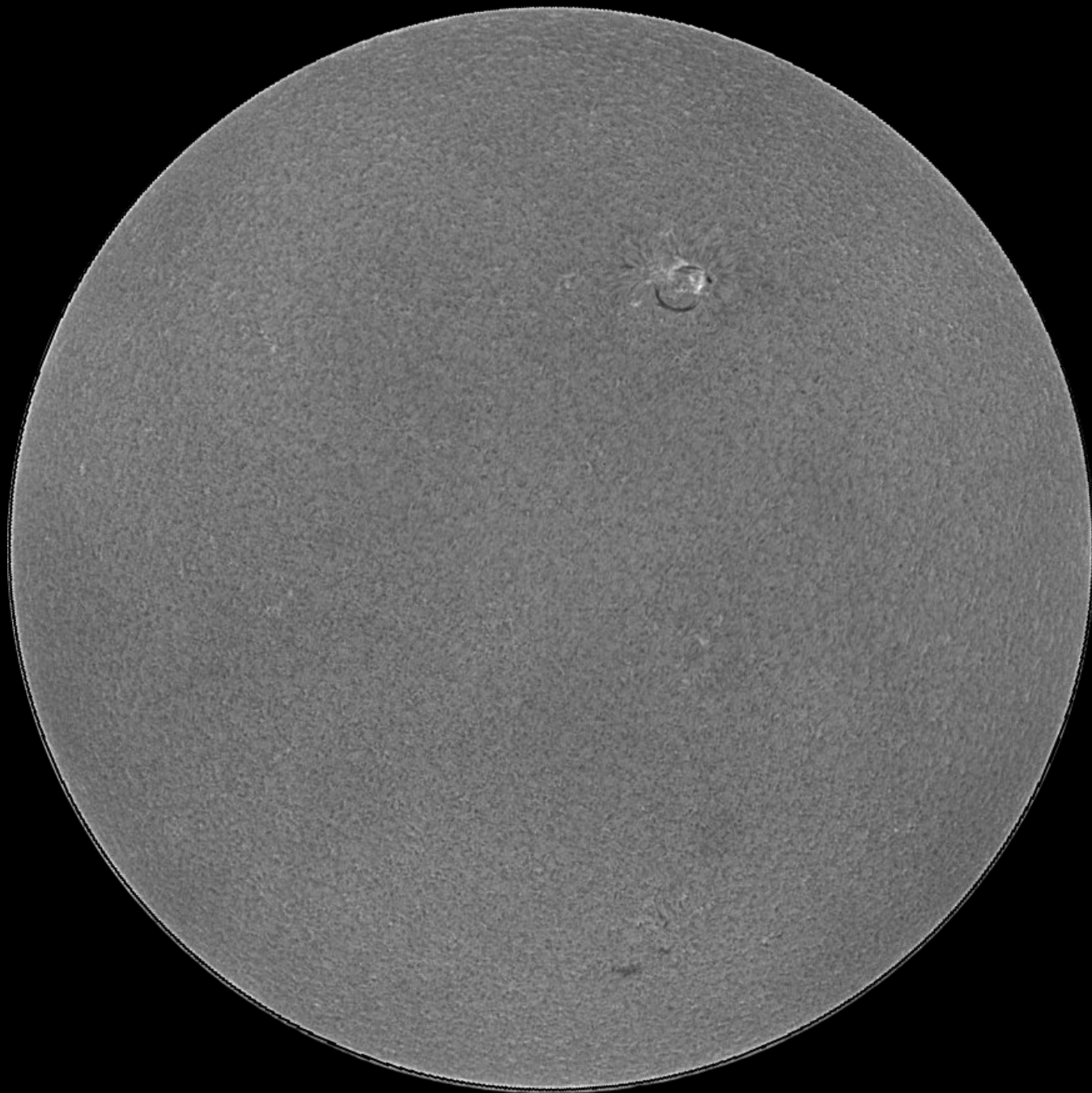
N
E W
S



BBSO

2008-11-11

17:13 UT



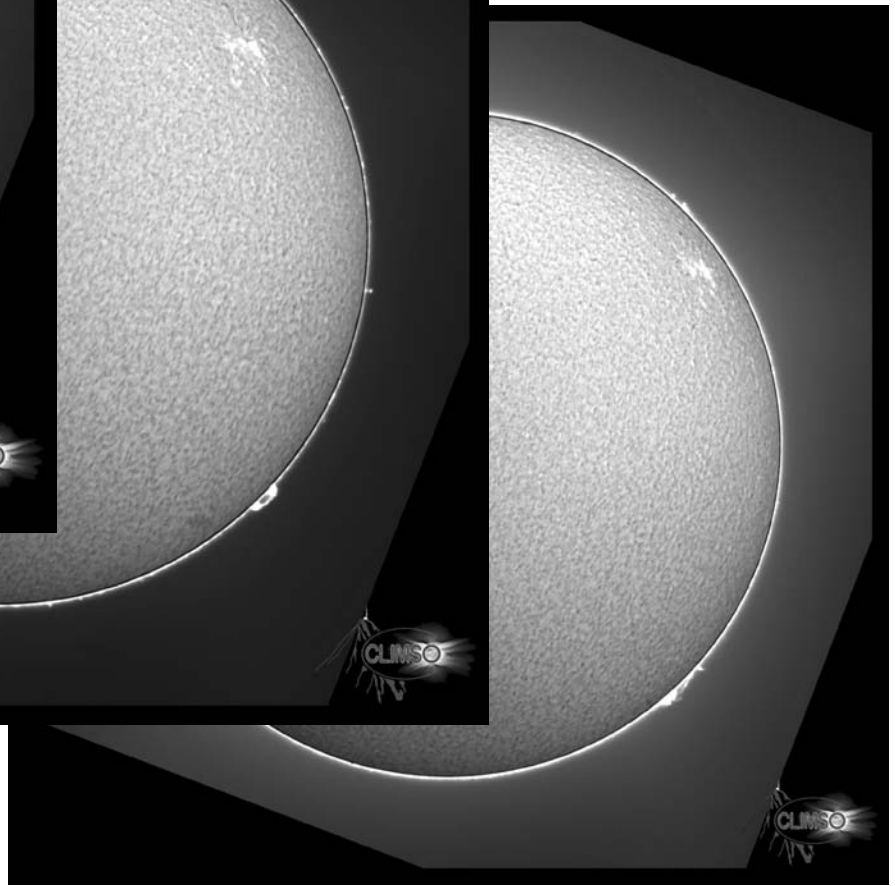
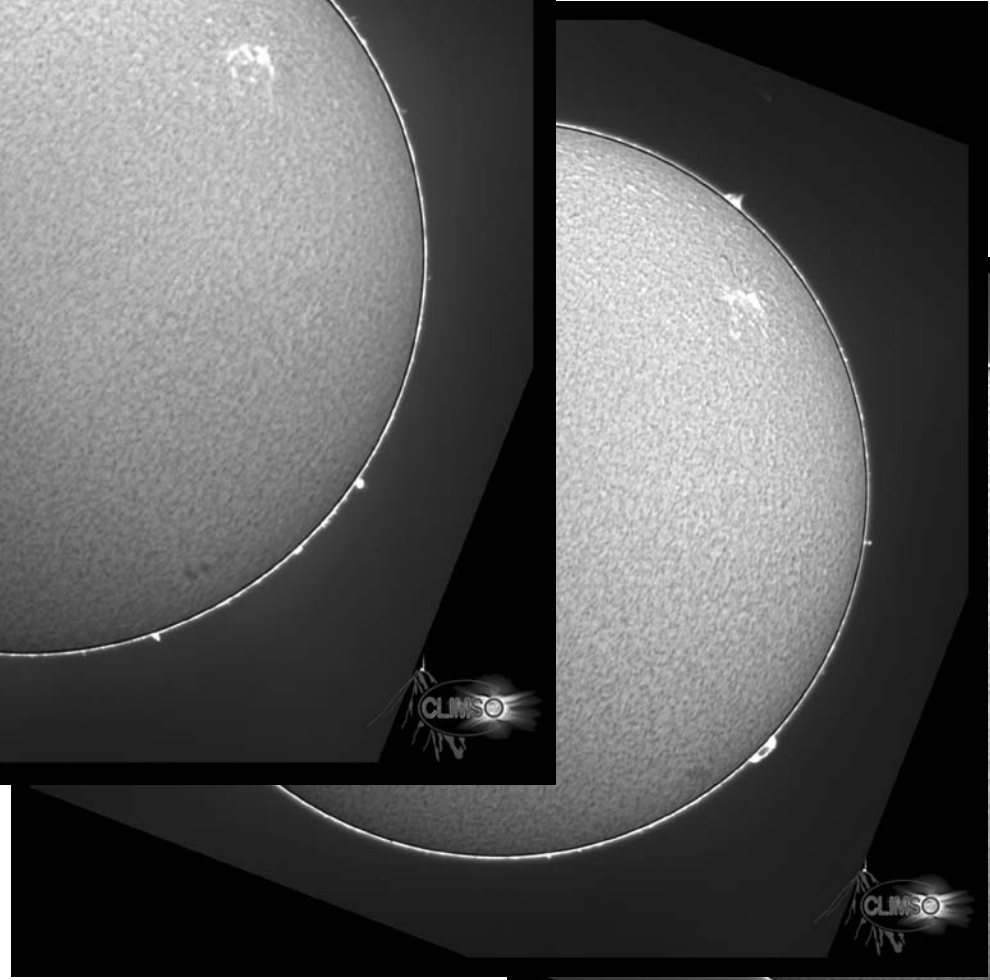
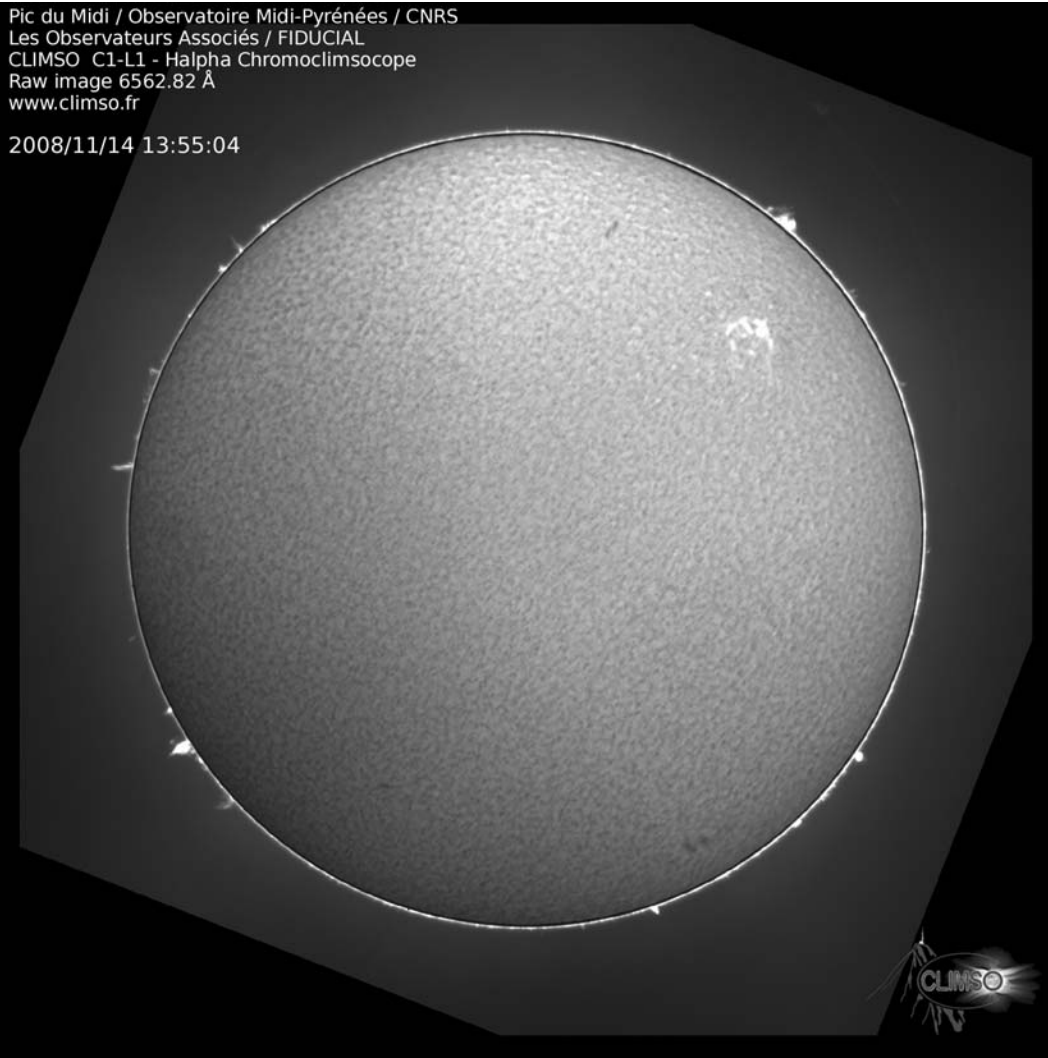
**Kanzelhoehe
Solar
Observatory**

2008-11-12

11:09 UT

Pic du Midi / Observatoire Midi-Pyrénées / CNRS
Les Observateurs Associés / FIDUCIAL
CLIMSO C1-L1 - Halpha Chromoclimscope
Raw image 6562.82 Å
www.climso.fr

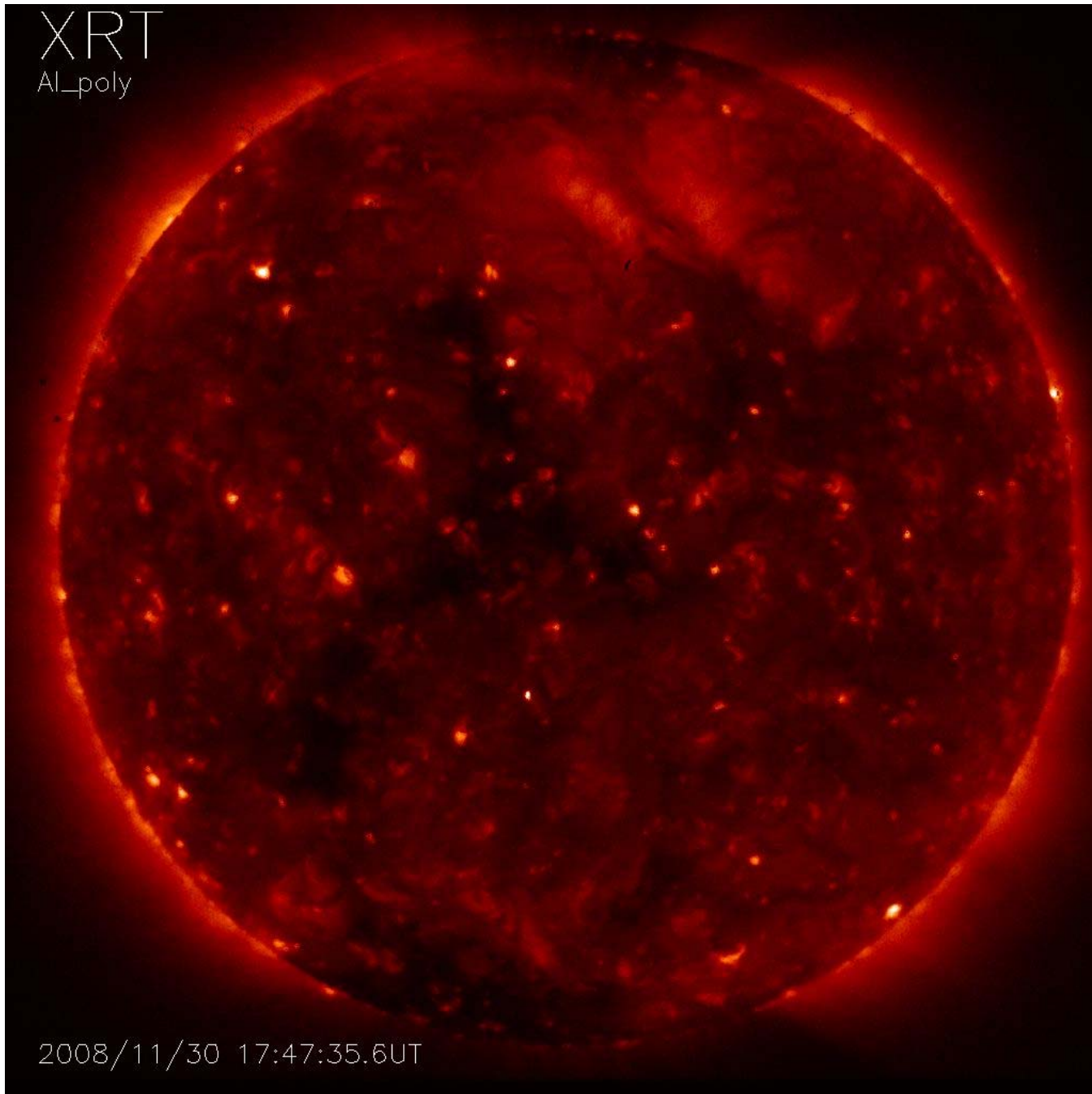
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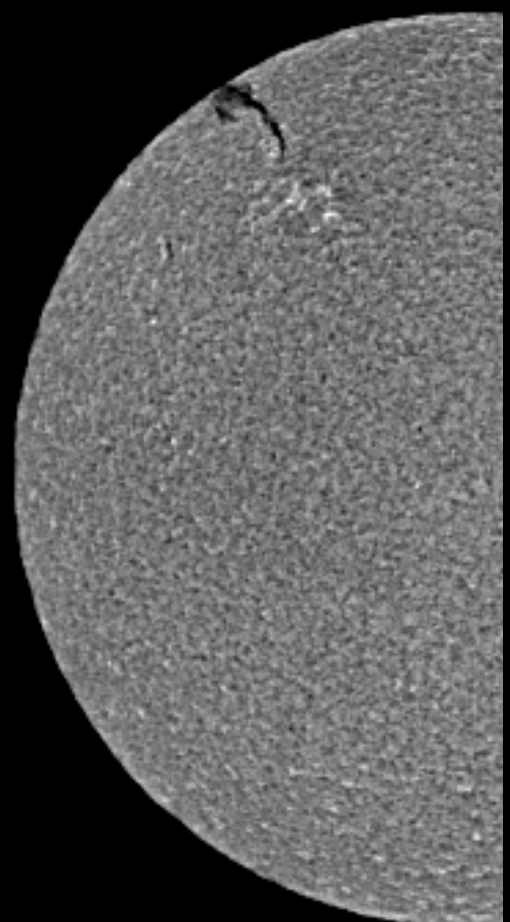
XRT
Al_poly

Hinode XRT

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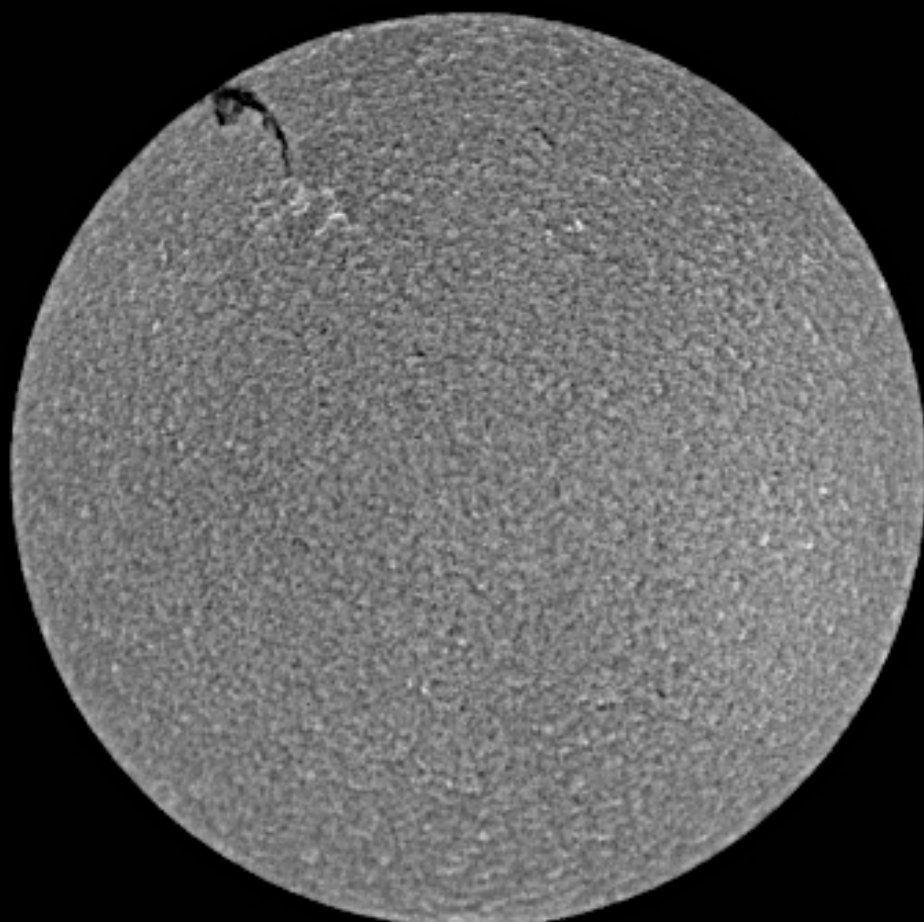
MLSOPICS
HALPHA
2008-12-07
18:11:33 UT
DOY: 342



E

Scaling: 800 to 1200

N
MLSOPICS
HALPHA
2008-12-07
20:50:31 UT
DOY: 342



E

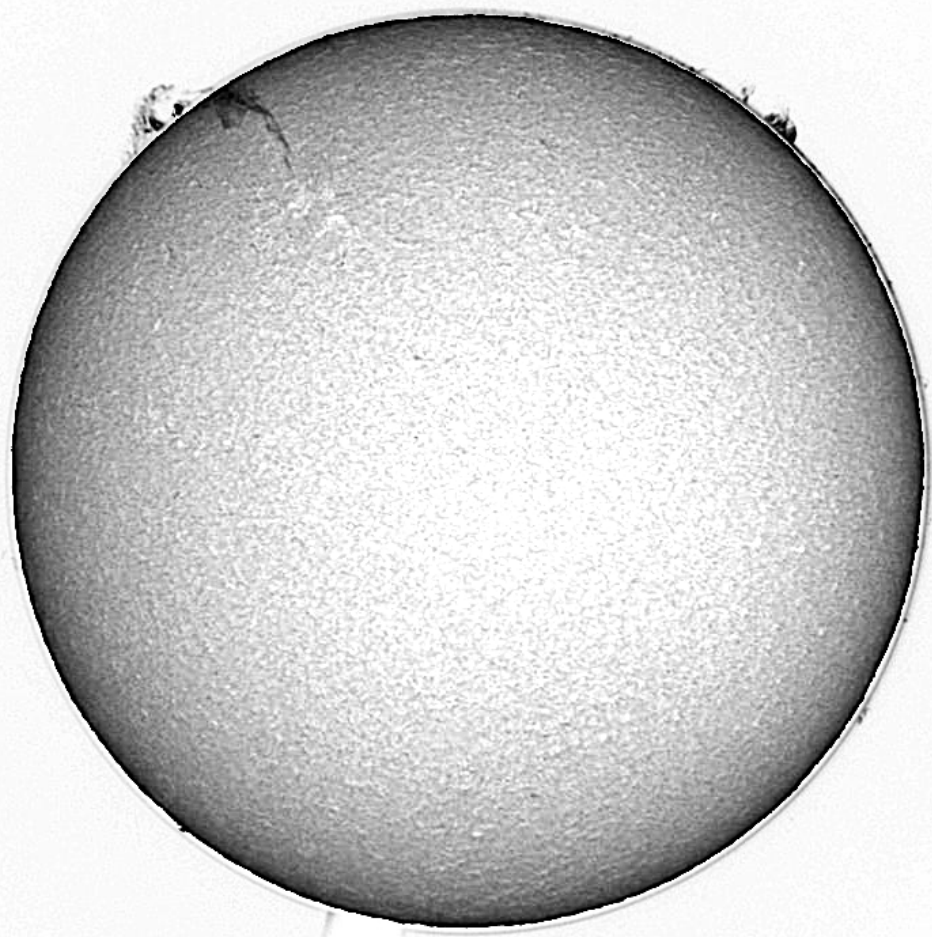
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S

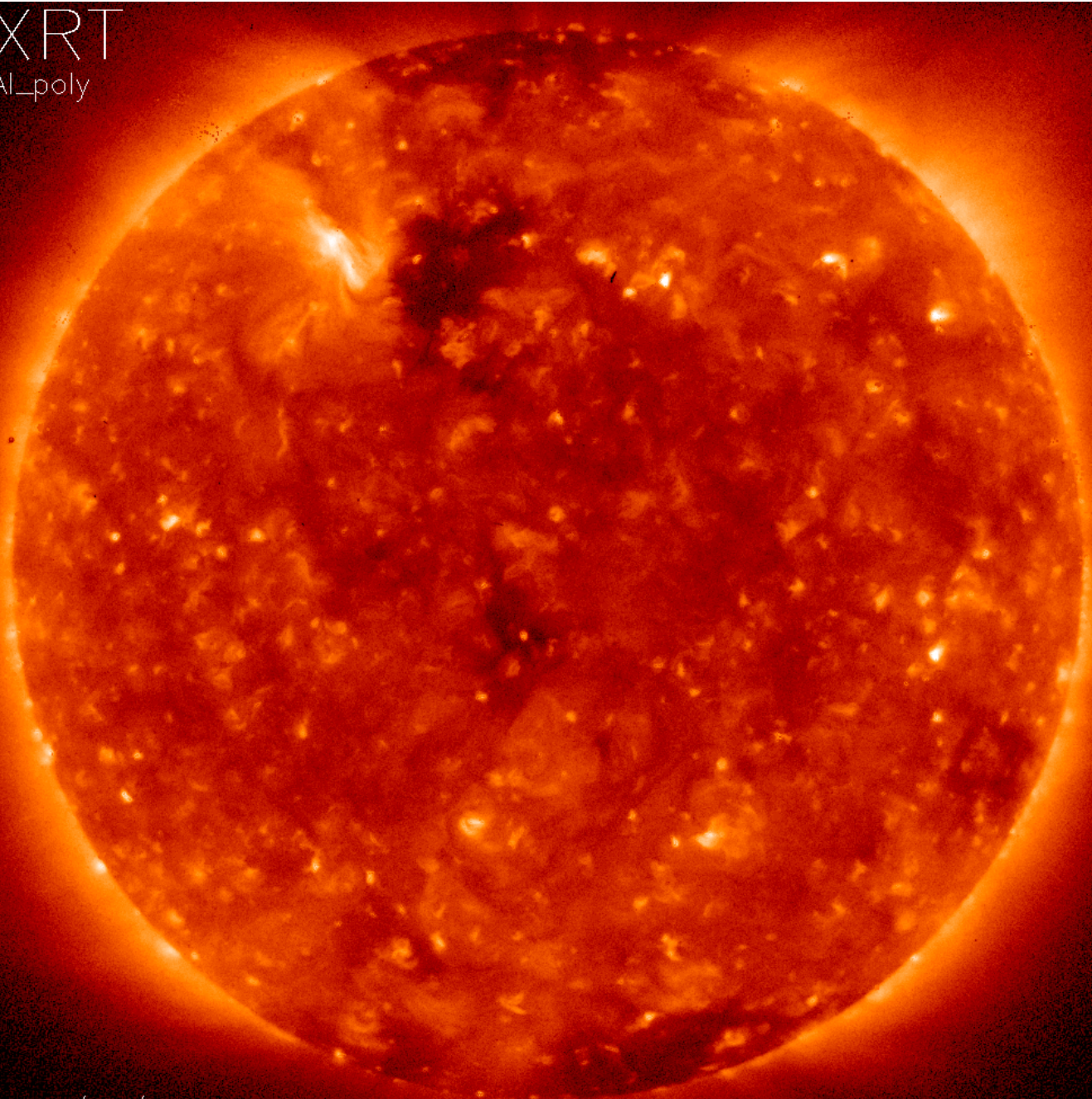
East

West

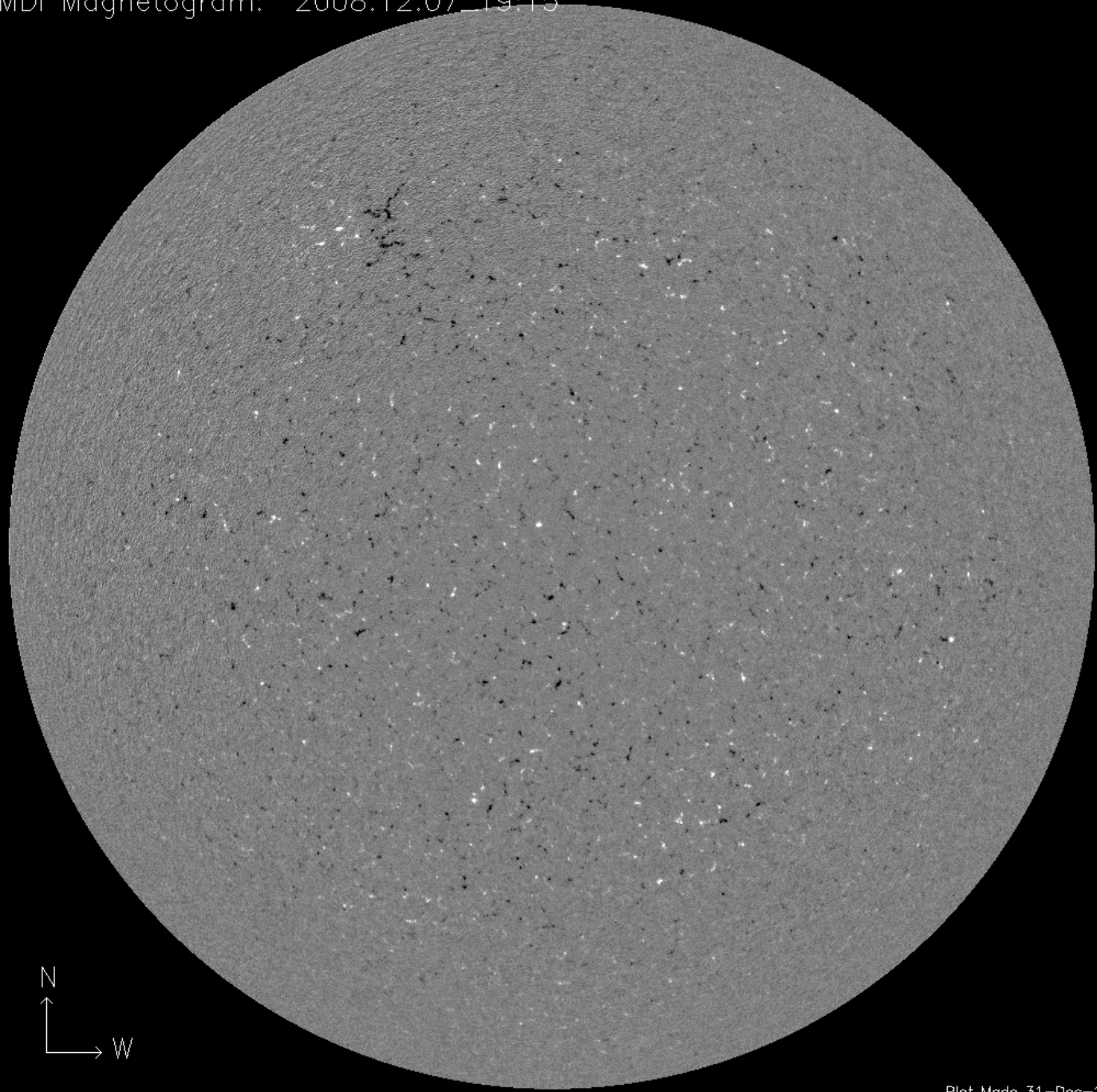


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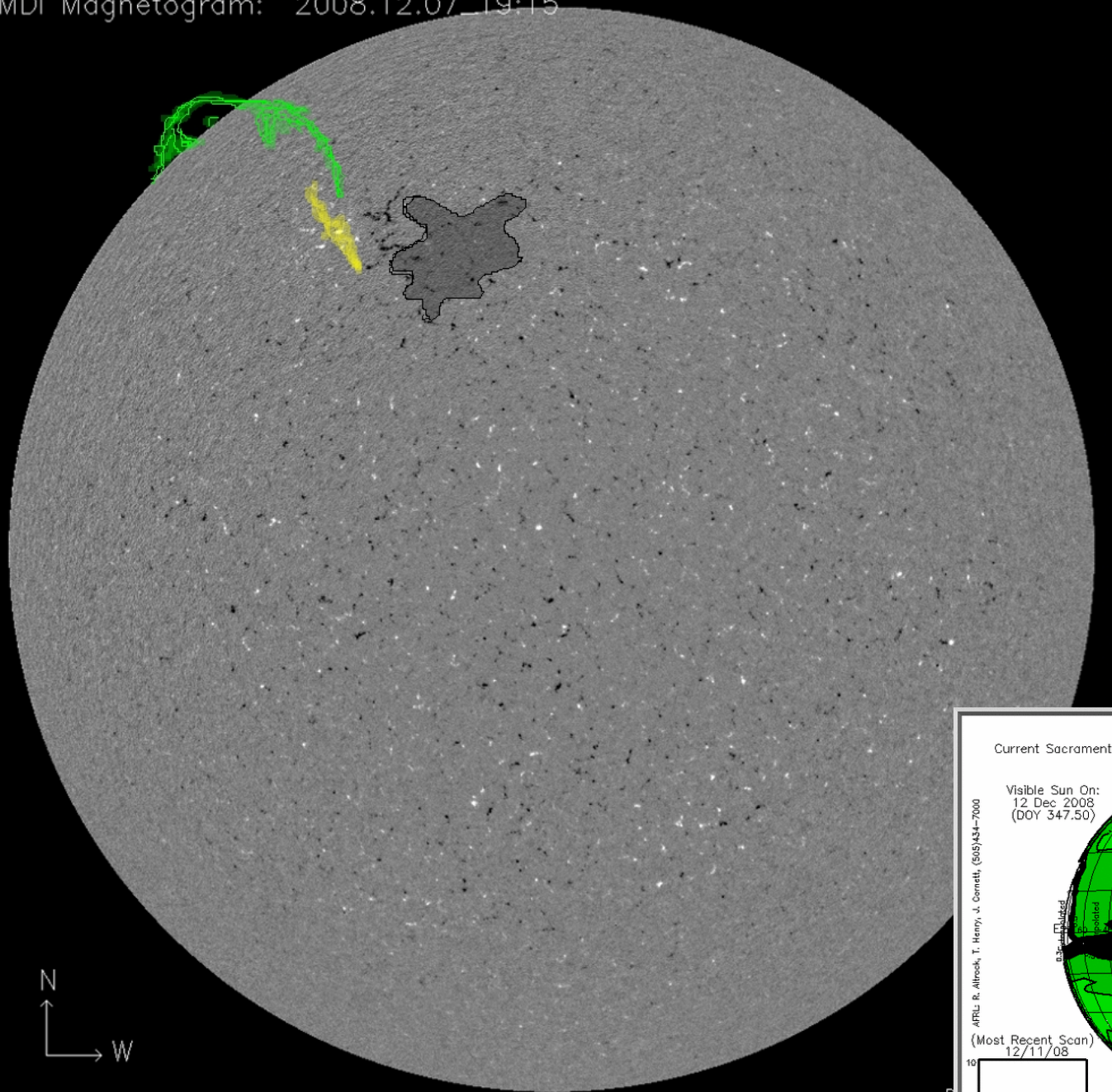
MDI Magnetogram: 2008.12.07_19:15



N
↑
W
→

Plot Made 31-Dec-20

MDI Magnetogram: 2008.12.07_19:15



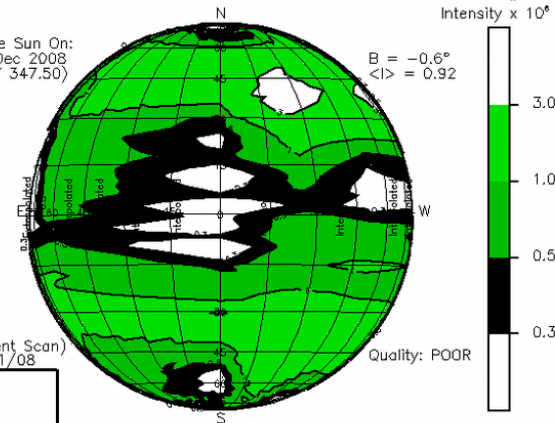
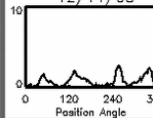
Current Sacramento Peak Fe XIV 5303Å Green-Line Corona at $R = 1.15R_{\odot}$, Intensity $\times 10^6$

Visible Sun On:
12 Dec 2008
(DOY 347.50)

$B = -0.6^{\circ}$
 $\langle I \rangle = 0.92$

APL: R. Allrook, T. Henry, J. Cometti, (SOS)434-7004

(Most Recent Scan)
12/11/08



2008 East-Limb Data

Coronal Holes are Shown as White Bordered by Black

efz20081206_011936.fits_0

Solar



800

600

400

-900

-800

-700

-600

-500

-400

Solar



efz20081206_071937.fits_0

solar



solar

400

600

800

-900

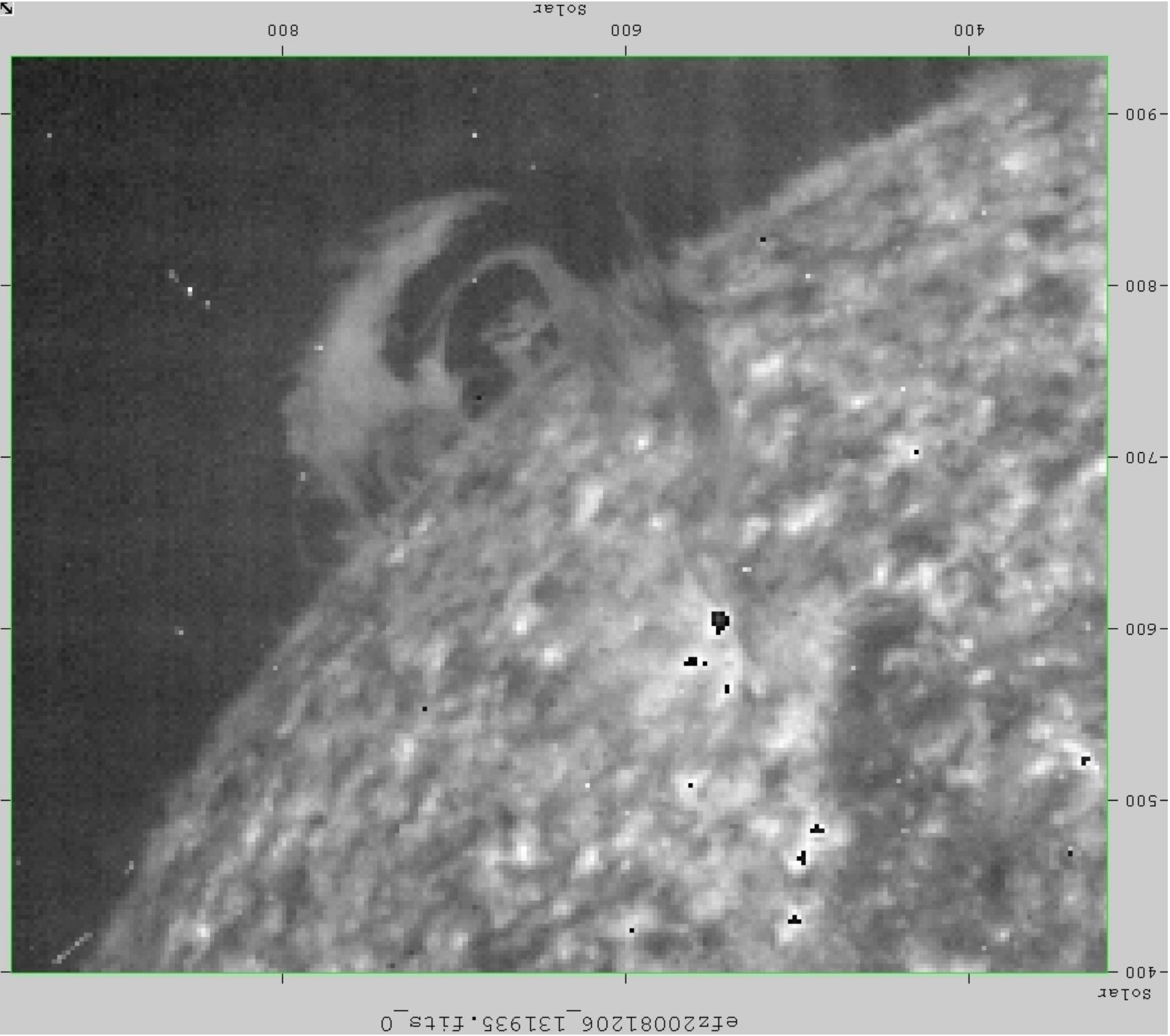
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-700

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-500

-400





ftz20081206_191936.fits_0

Solar

800

600

400

Solar

900

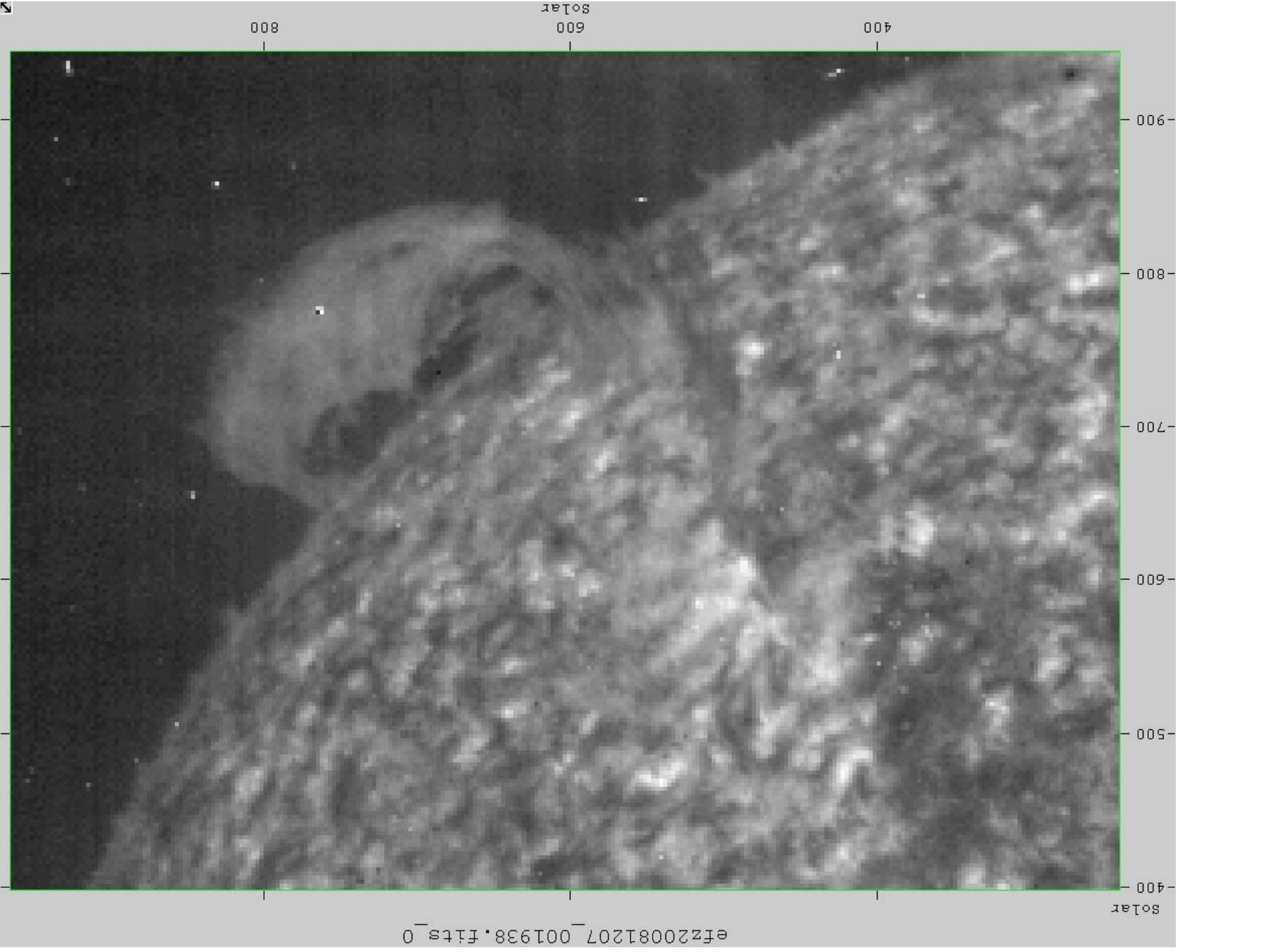
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700

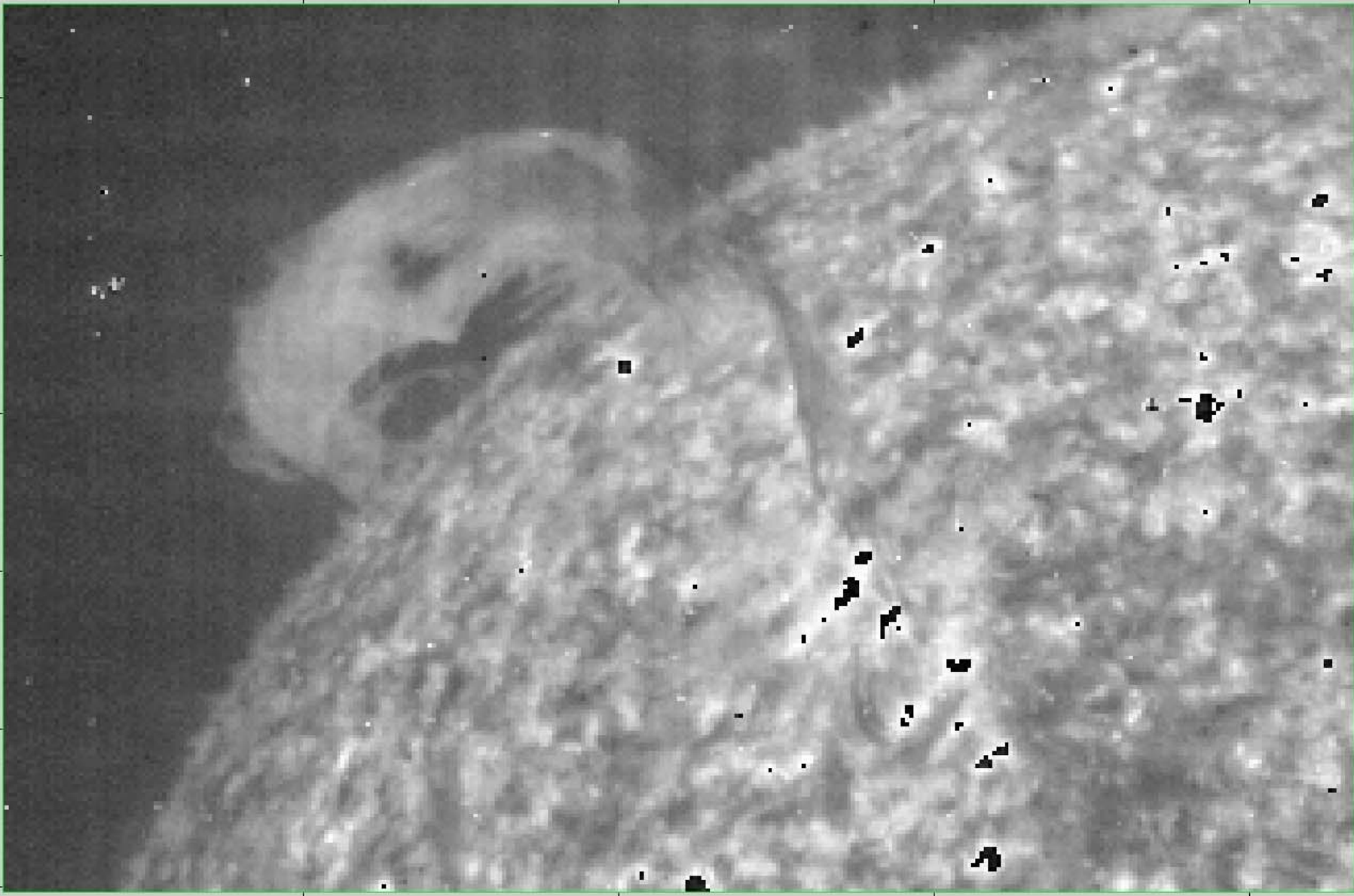
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500

400



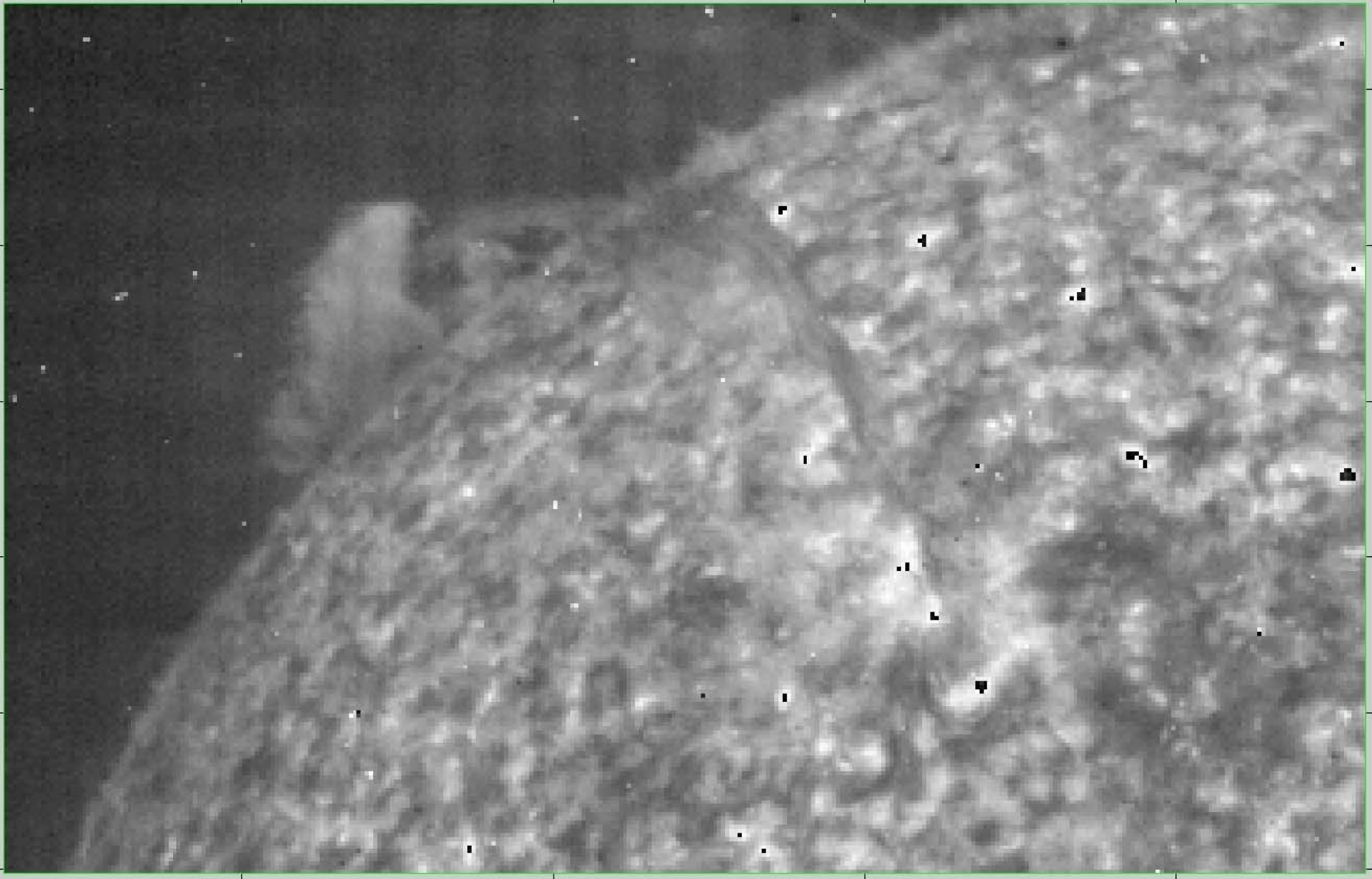
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Solar

800

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-900

-800

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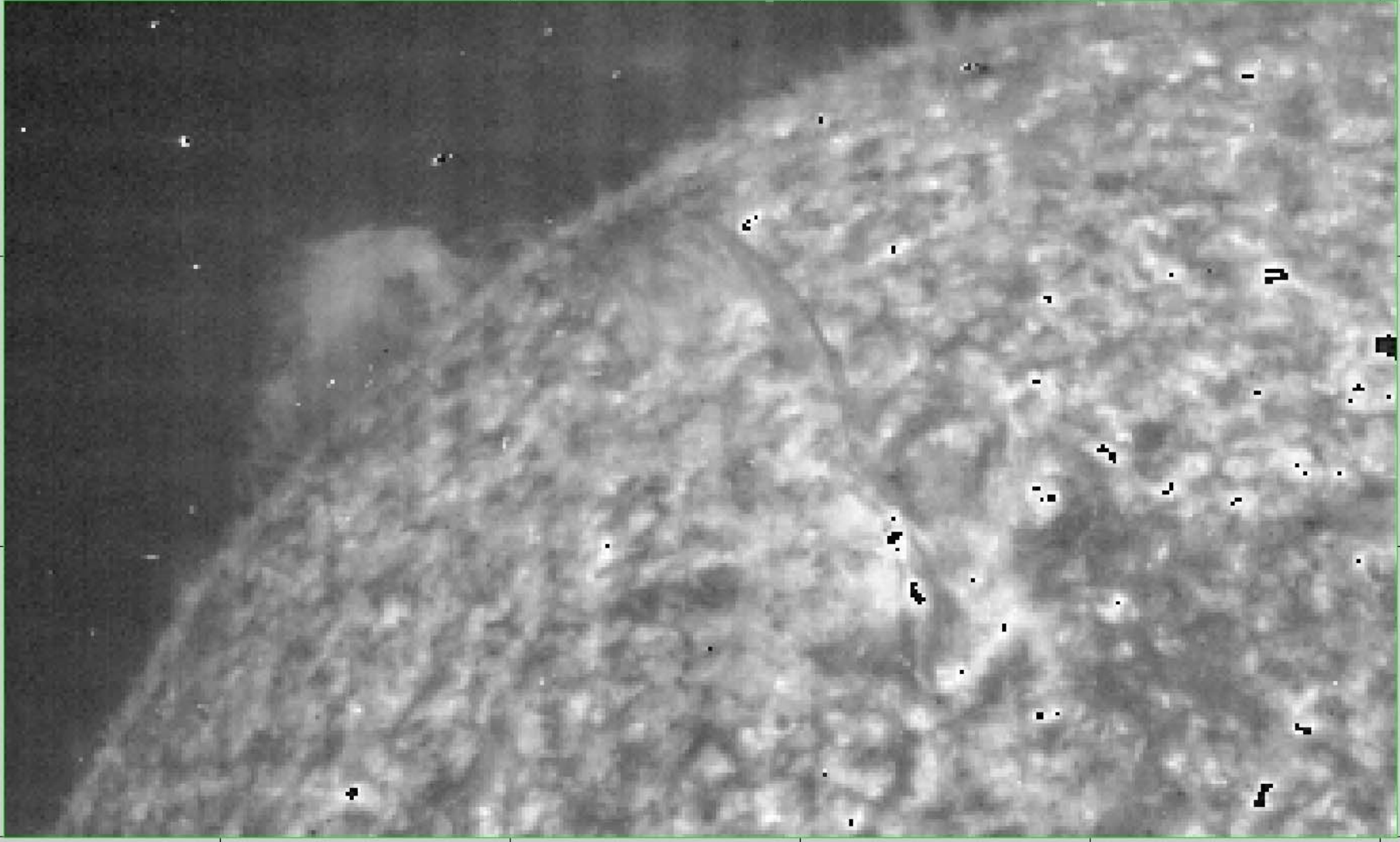
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Solar

efz20081208_011936.fits_0



Solar

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solar

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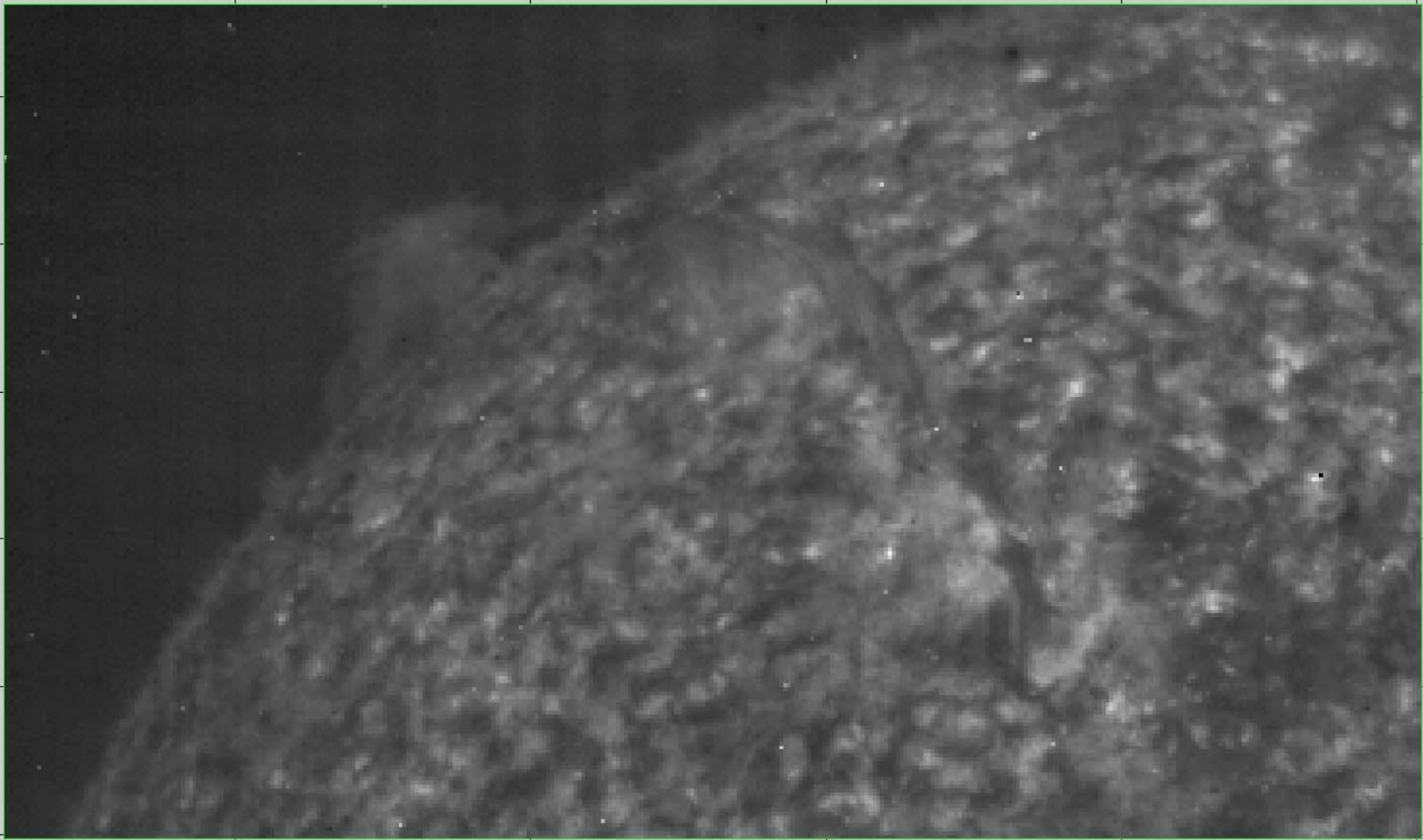
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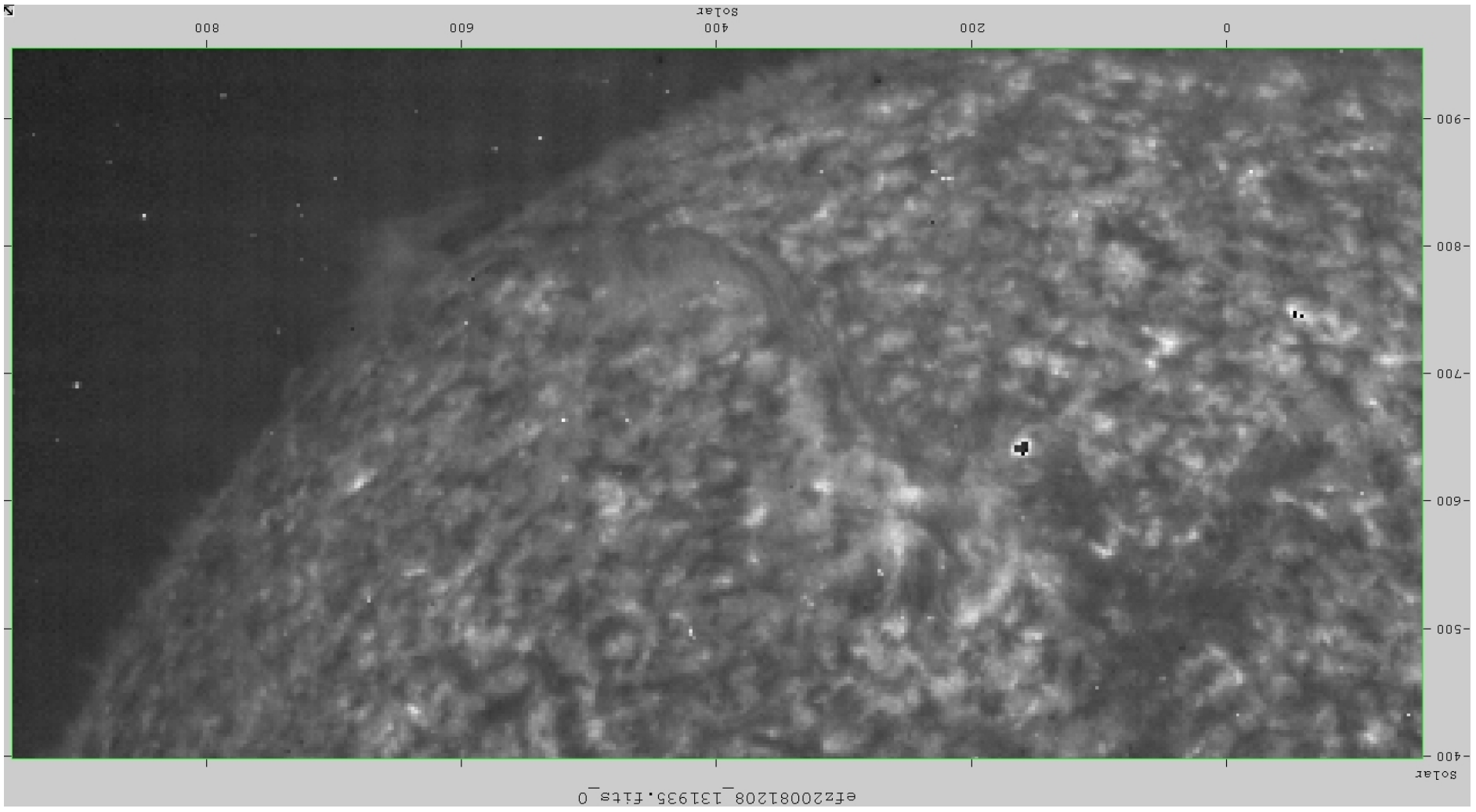
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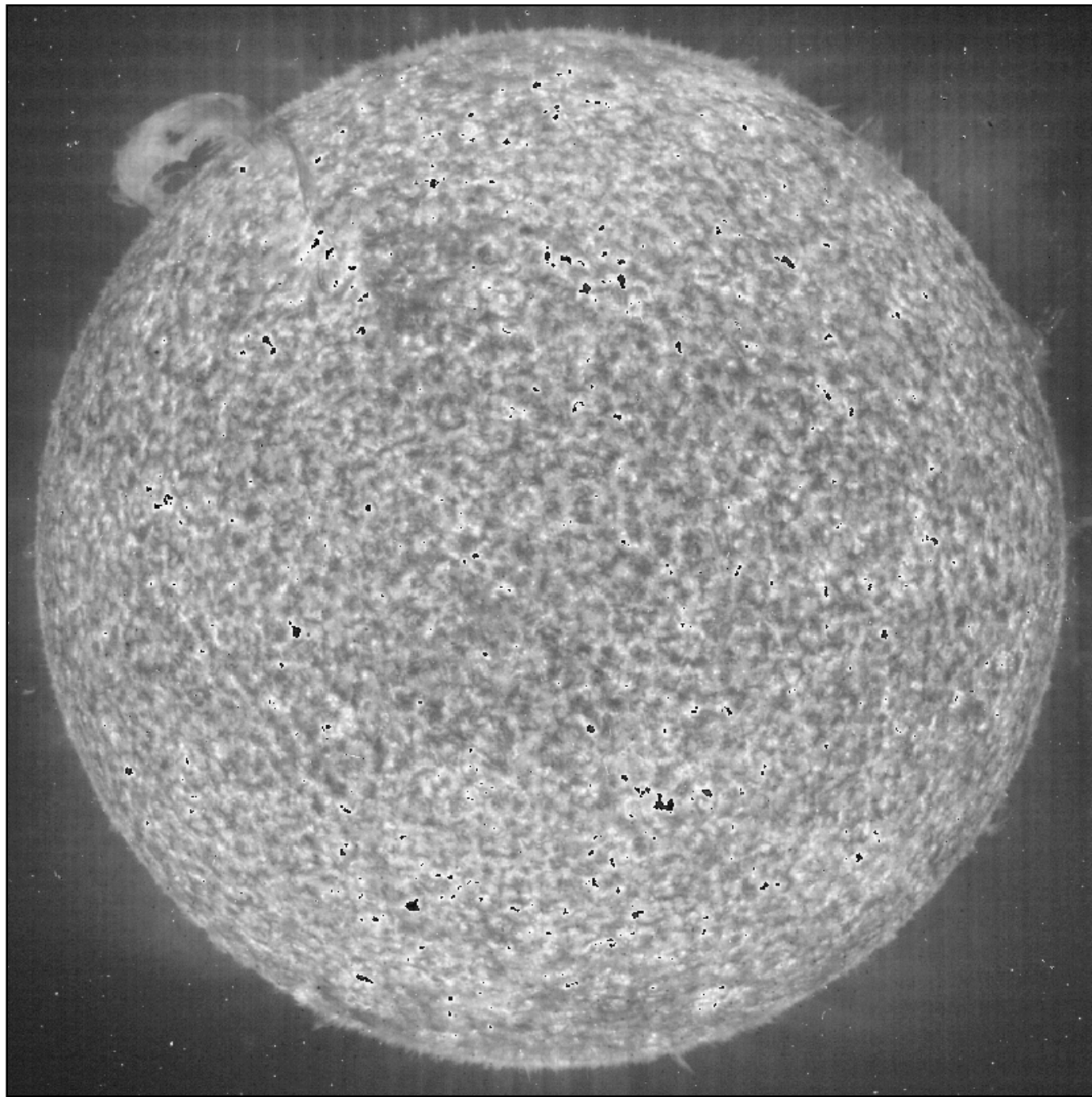
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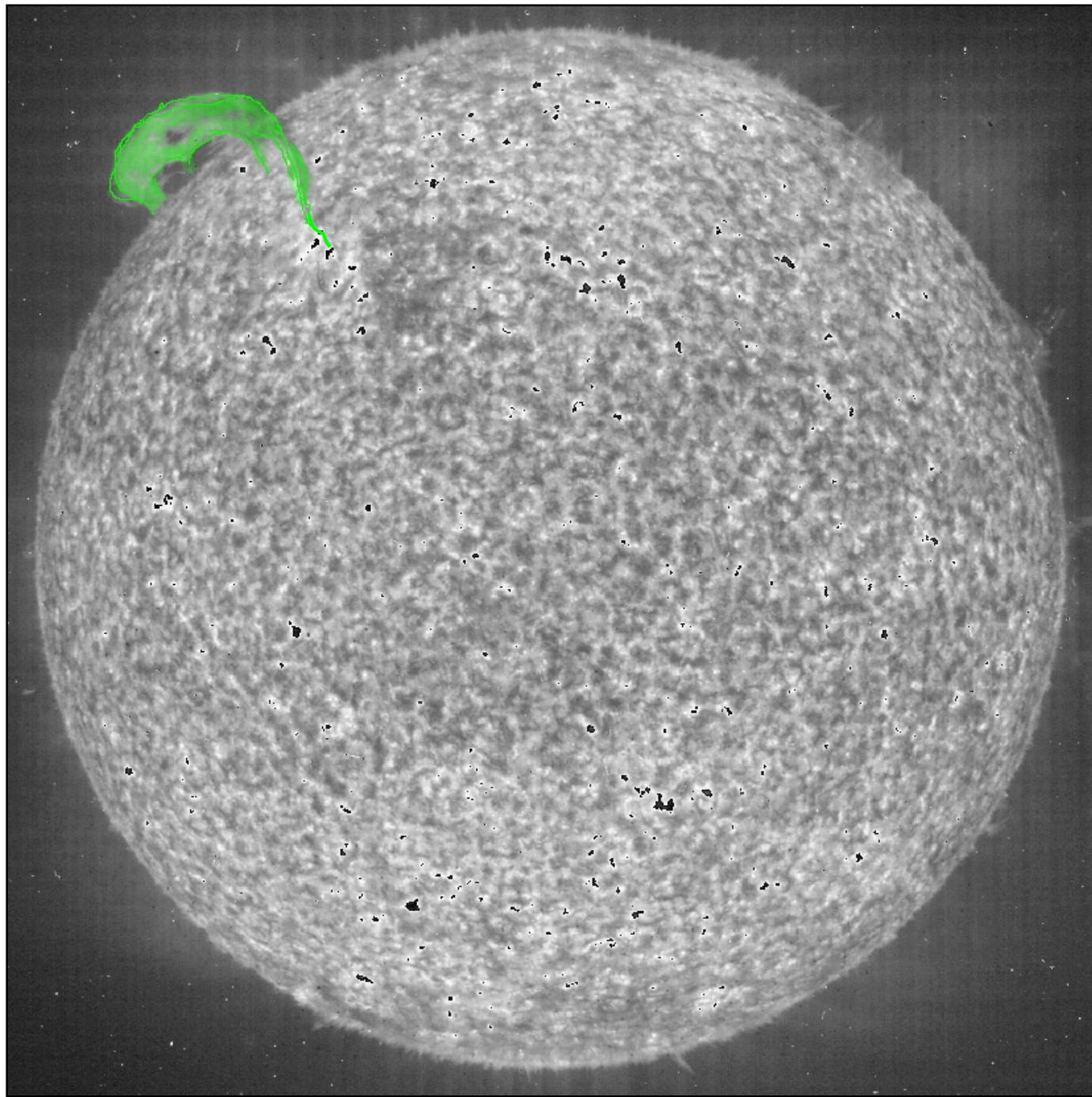
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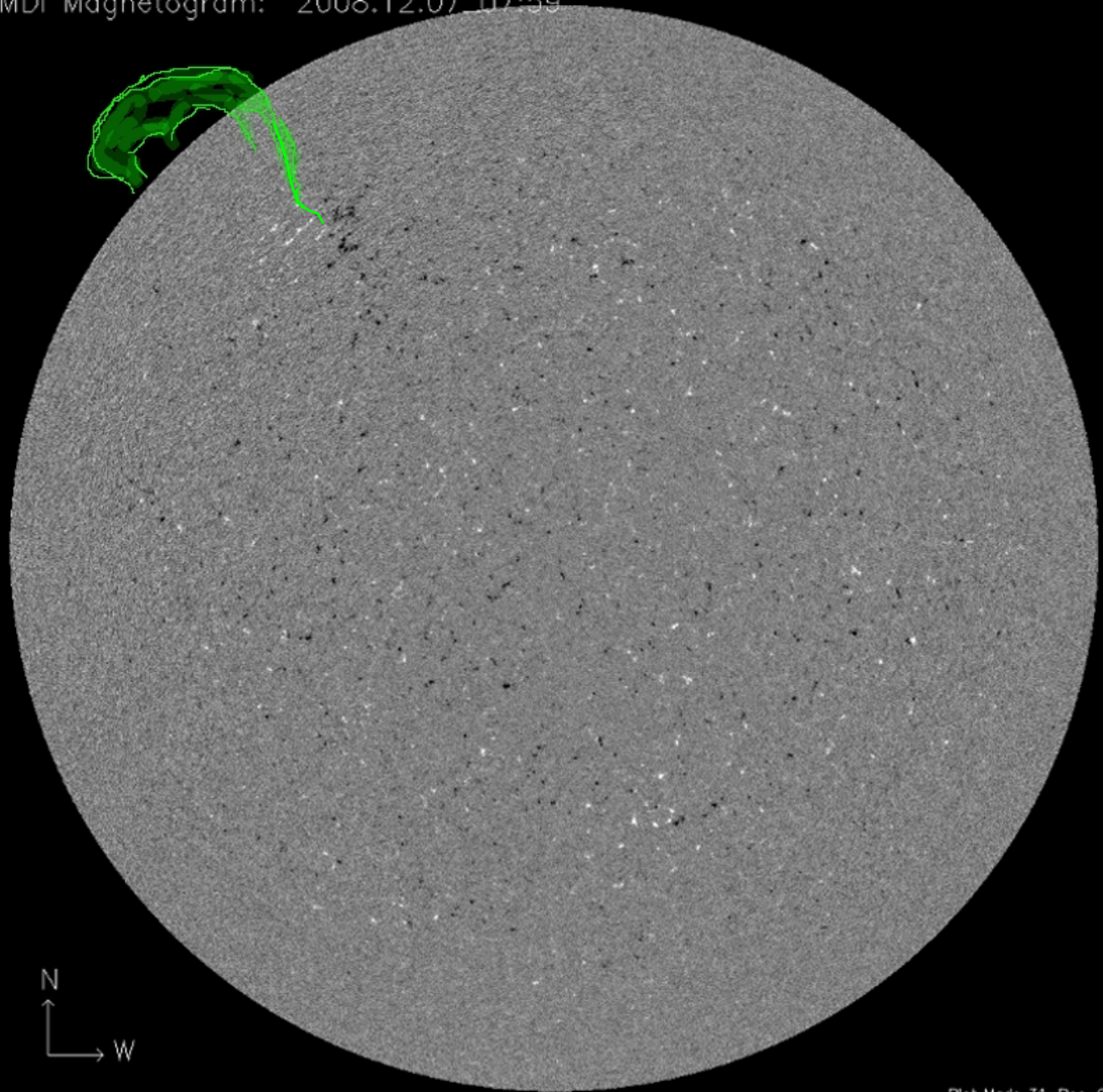






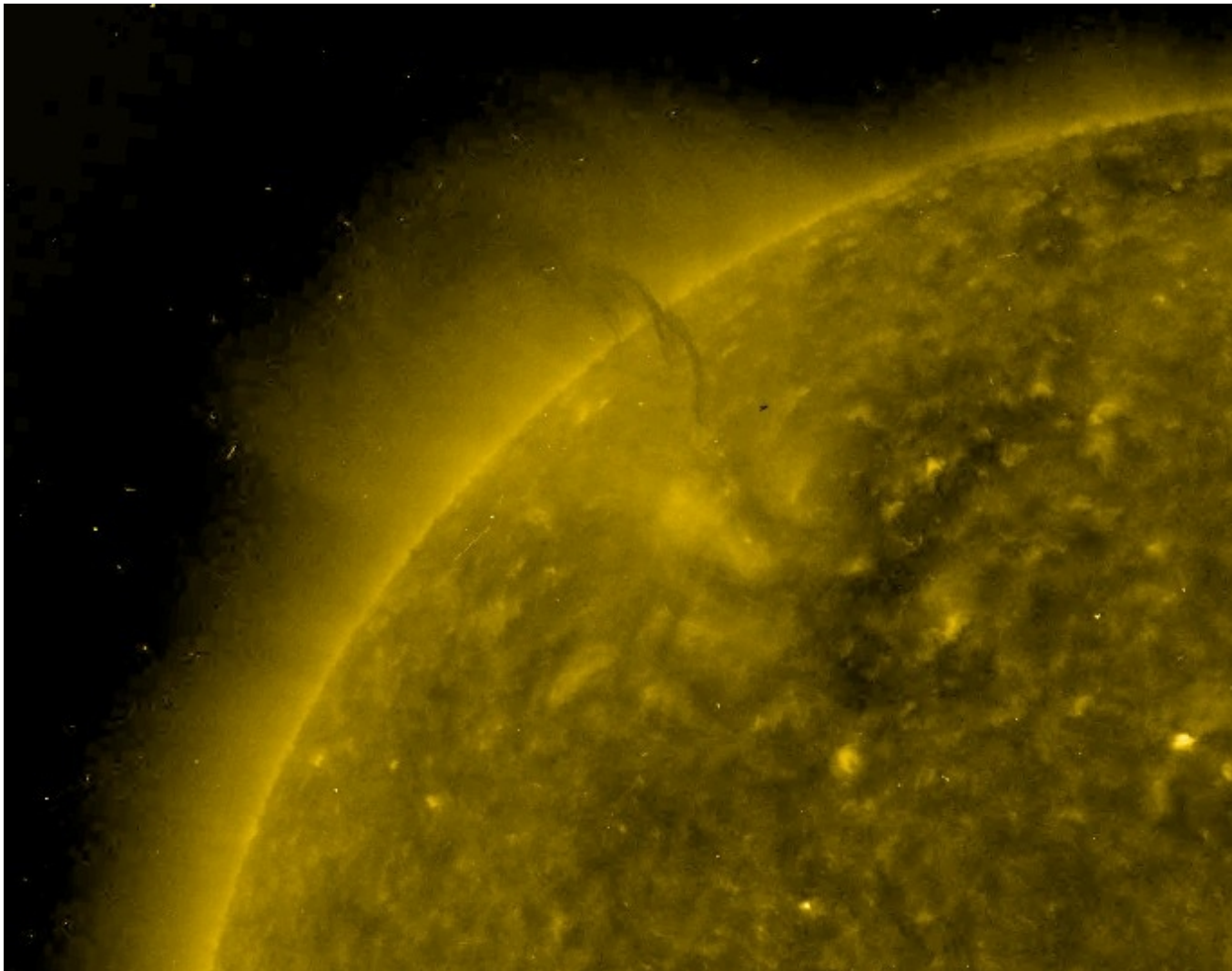


MDI Magnetogram: 2008.12.07 07:59



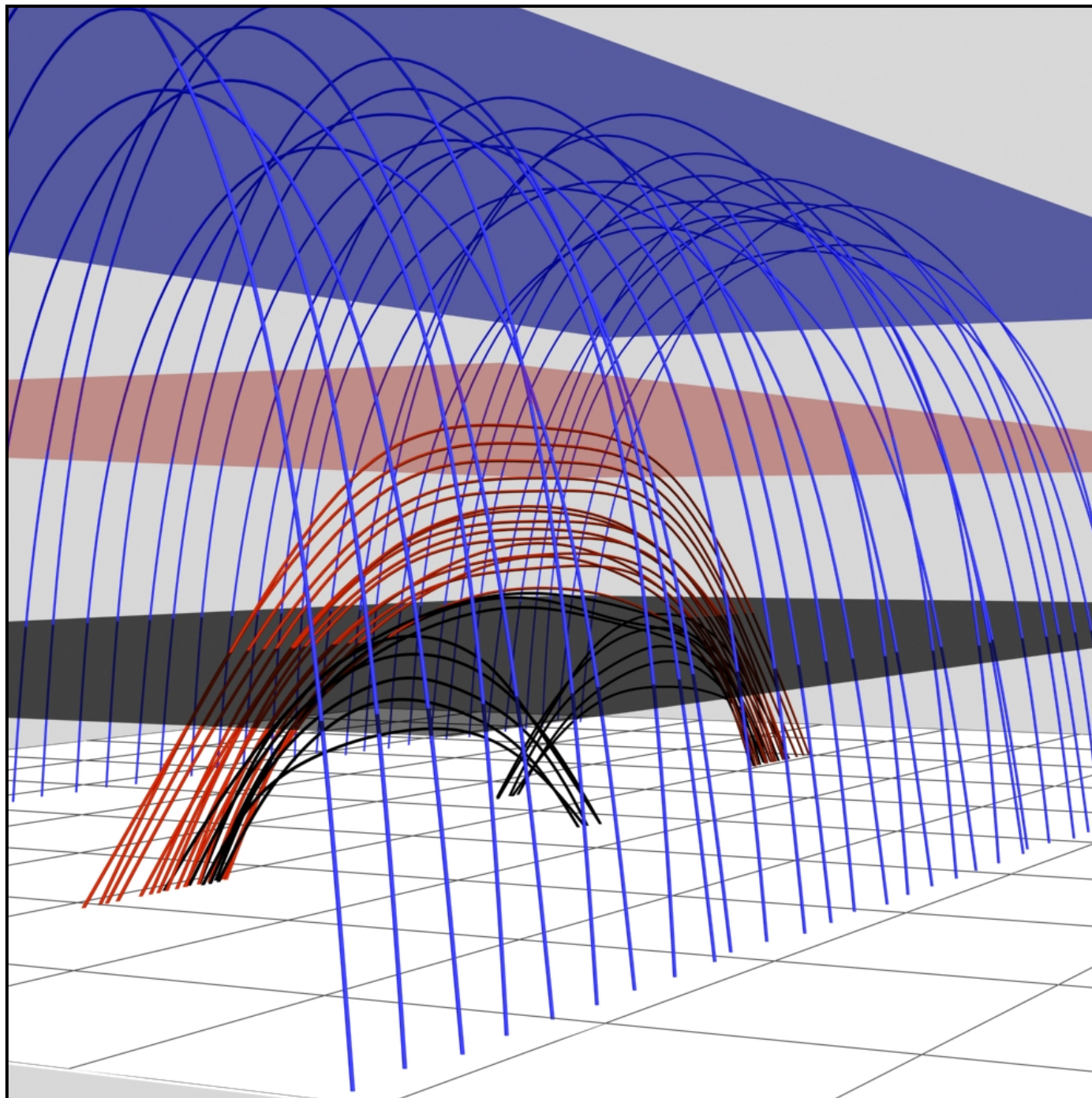
N
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Plot Made 31-Dec-2008

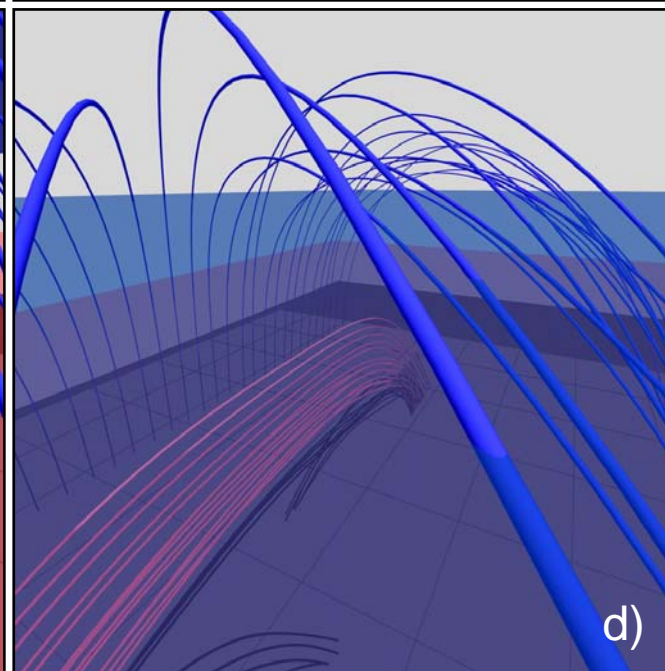
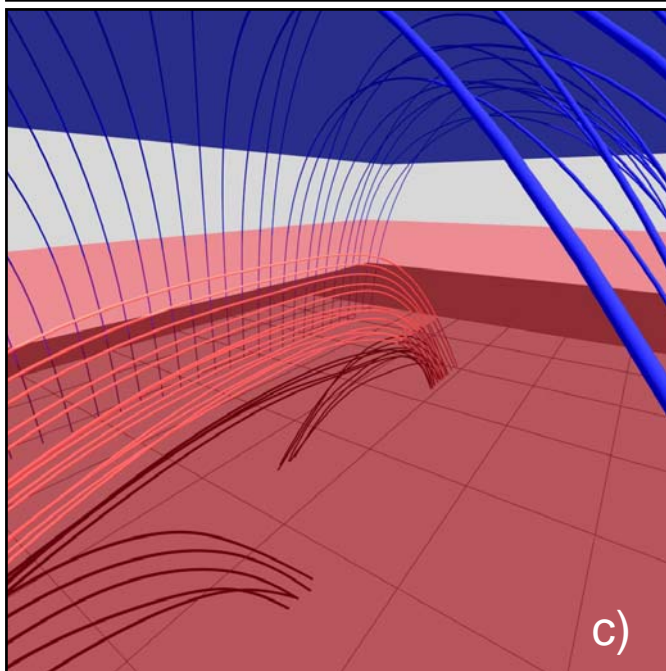
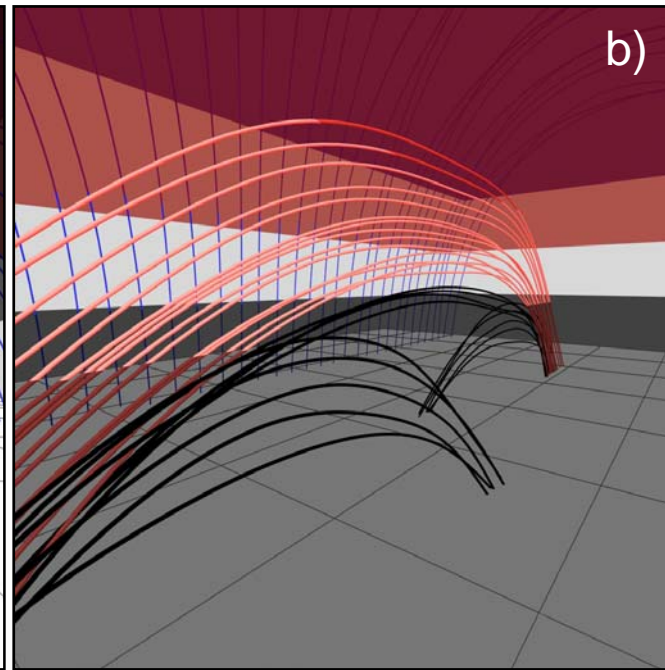
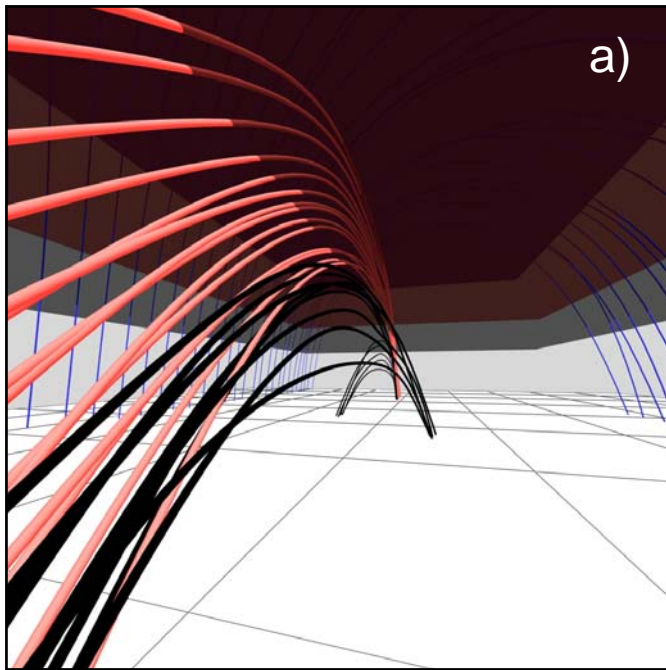


10 December 2008 03:46 UT

STEREO Ahead EUVI 284 Å



We intersect the filament and its overlying arcade with four planes: the white plane represents the photospheric level (MDI magnetograms); black - the chromospheric level (H-alpha); red - the low corona (304 Å); blue - the upper corona (171 Å, 195 Å, 285 Å). These levels allow us to understand which part of the filament or filament system (including arcade) we observed in magnetograms and different spectral lines.

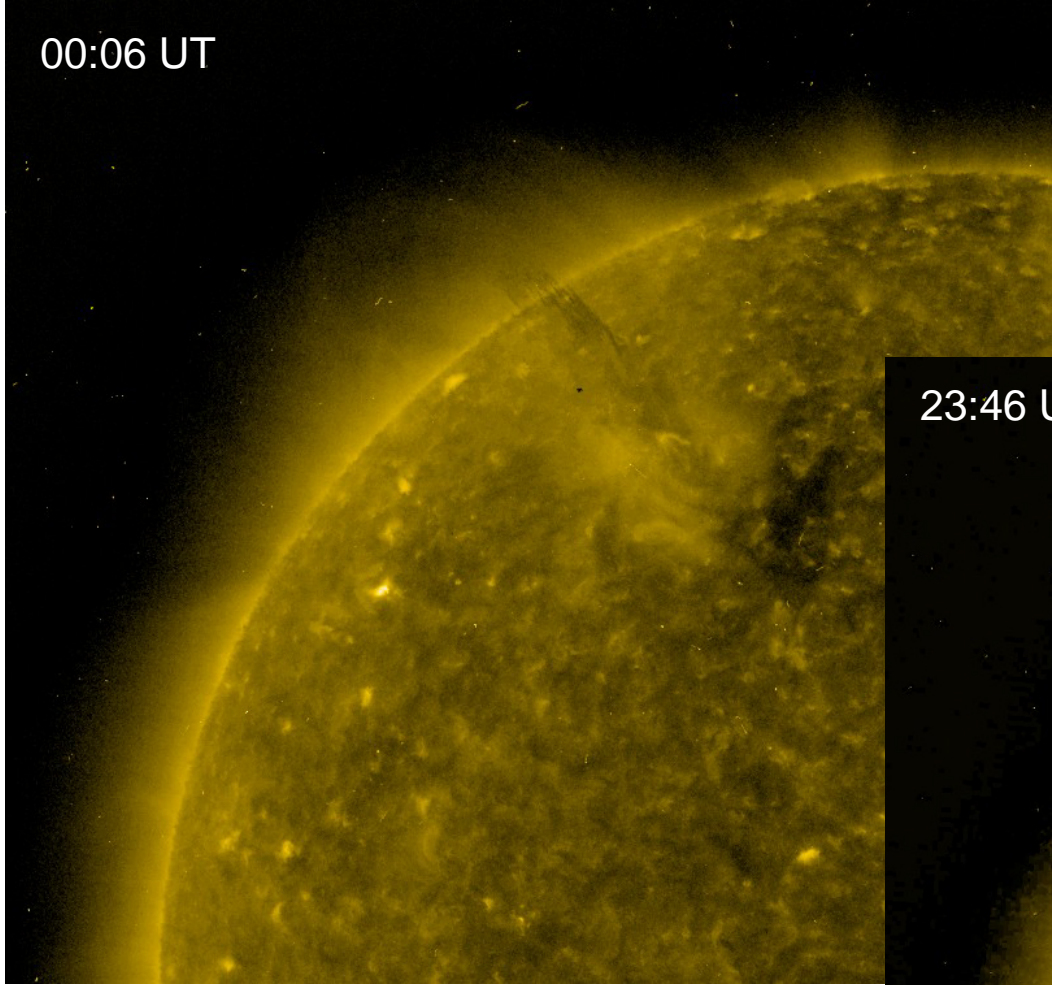


More detailed images (view from inside) of the filament system at the different levels: a) chromospheric level with barbs and low part of filament spine in H-alpha; b) low coronal level with upper part of filament spine in 304 A; c) coronal level crossing the cavity above the filament; d) upper corona level with overlying arcade visible in 171 A.

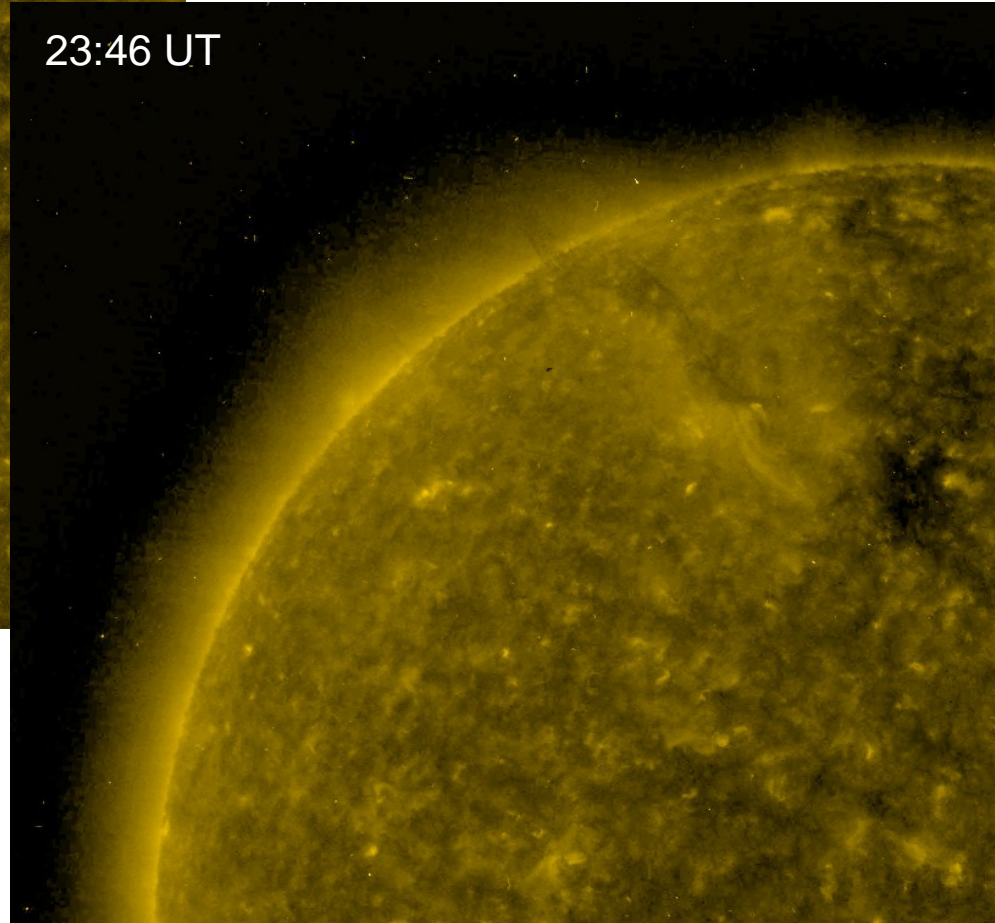
11 December 2008

STEREO Ahead EUVI 284 Å

00:06 UT



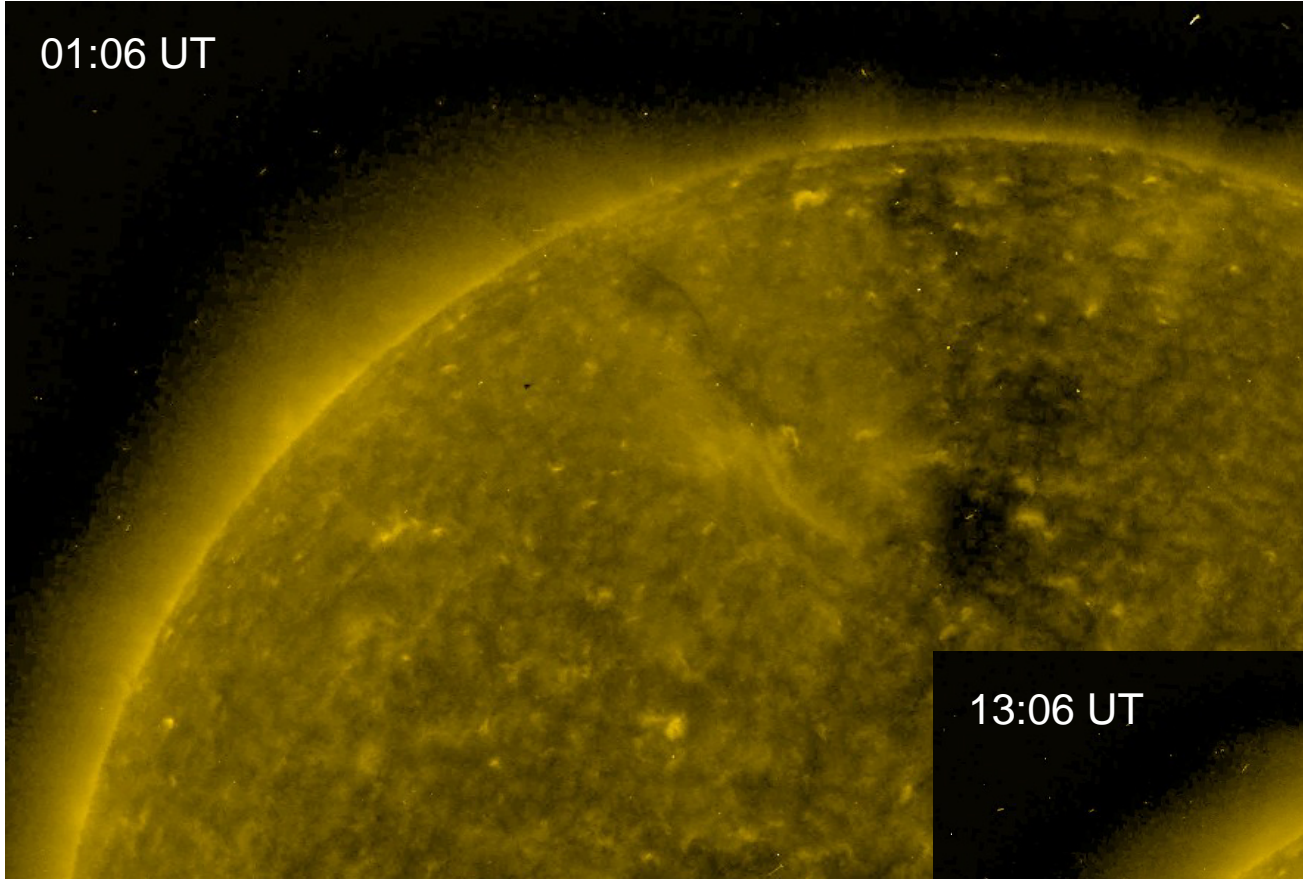
23:46 UT



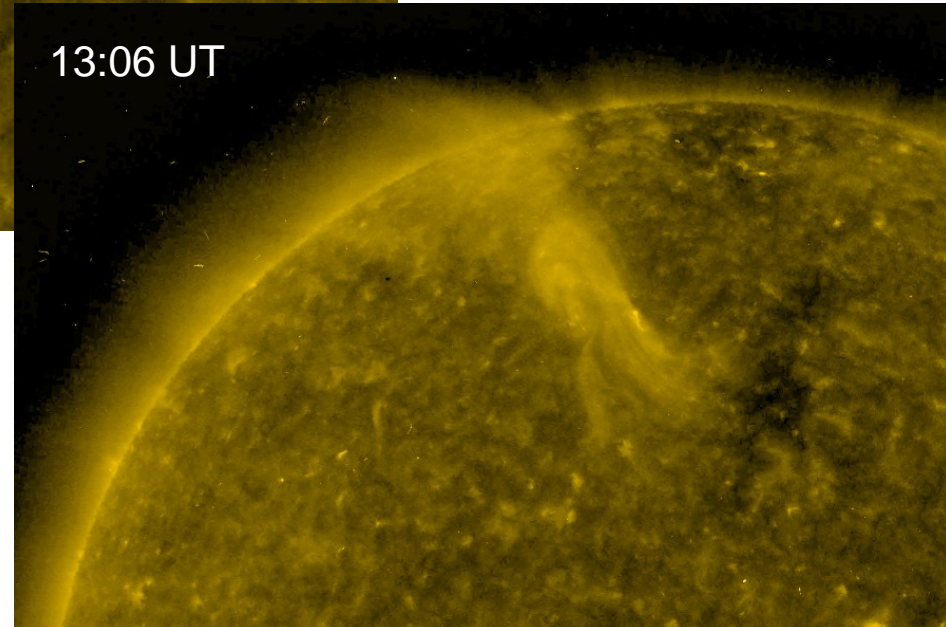
12 December 2008

STEREO Ahead EUVI 284 Å

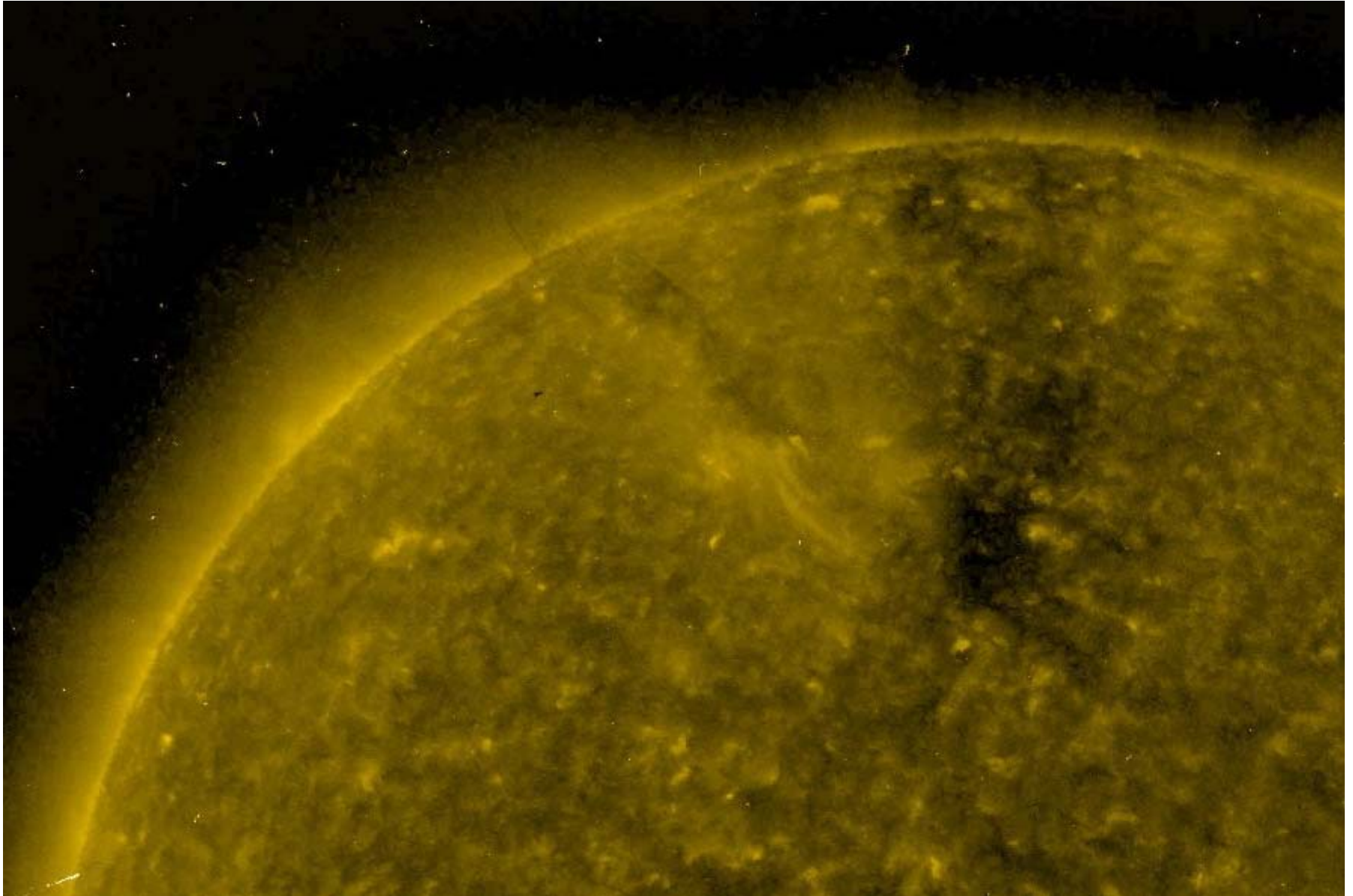
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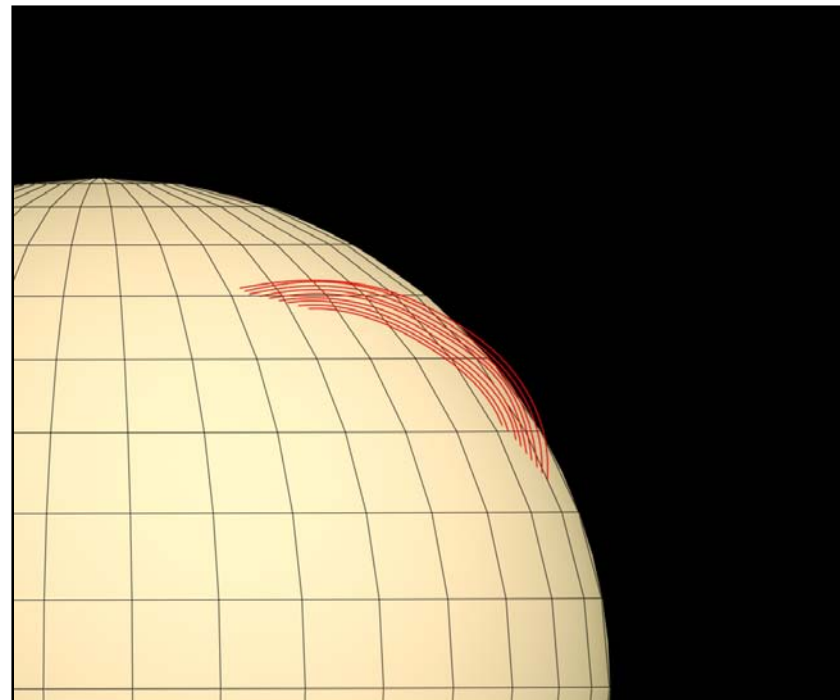
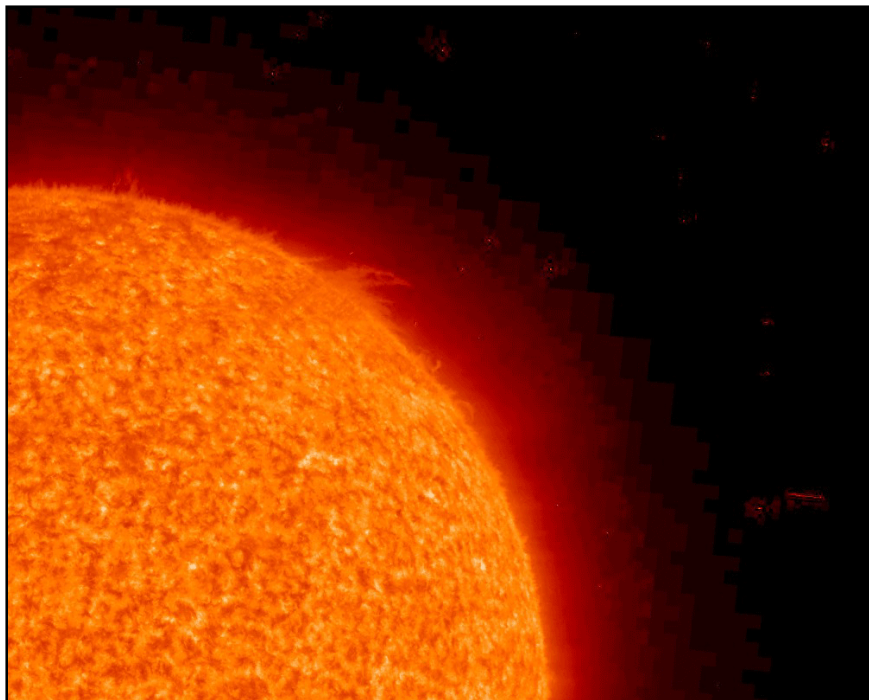
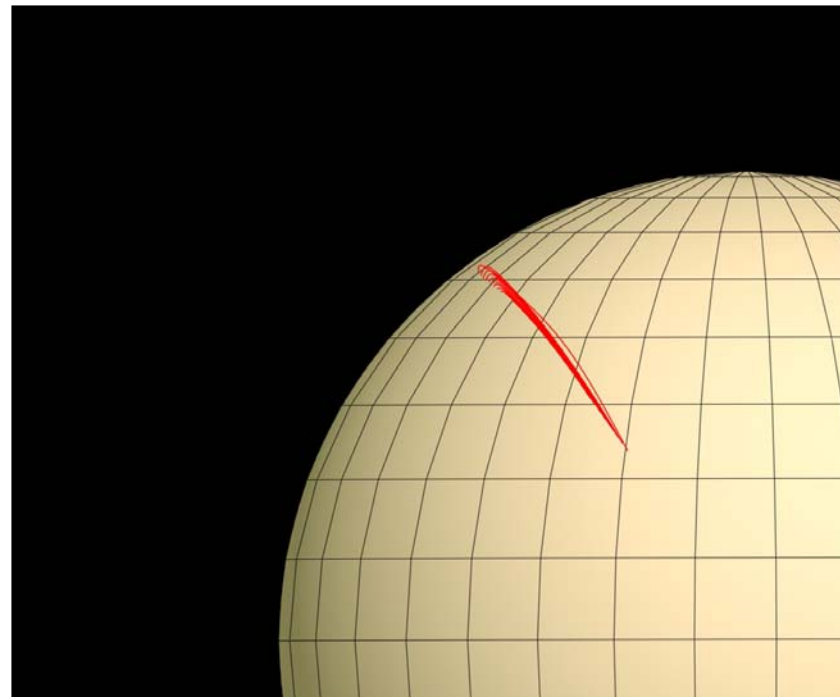
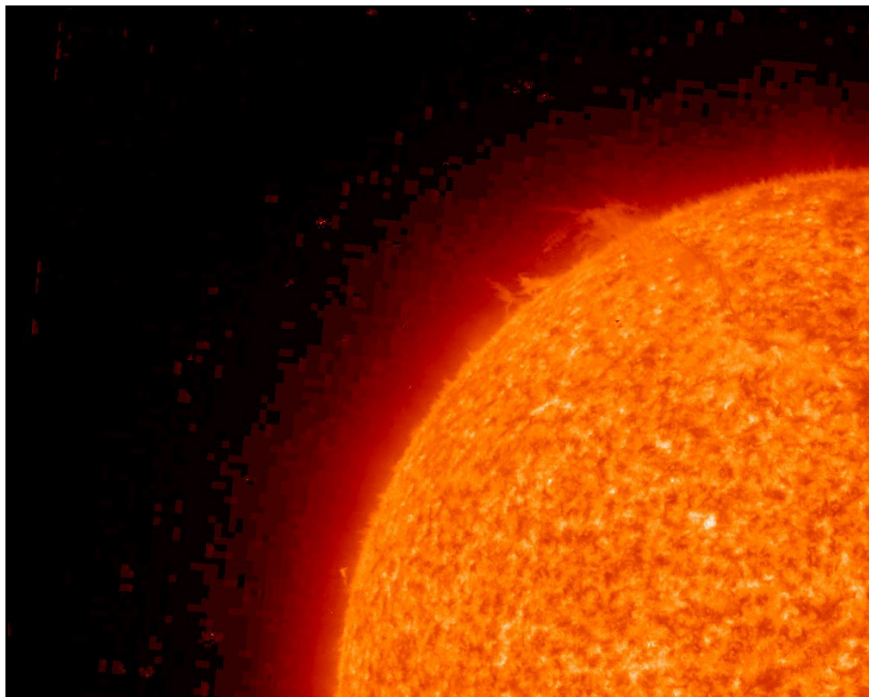


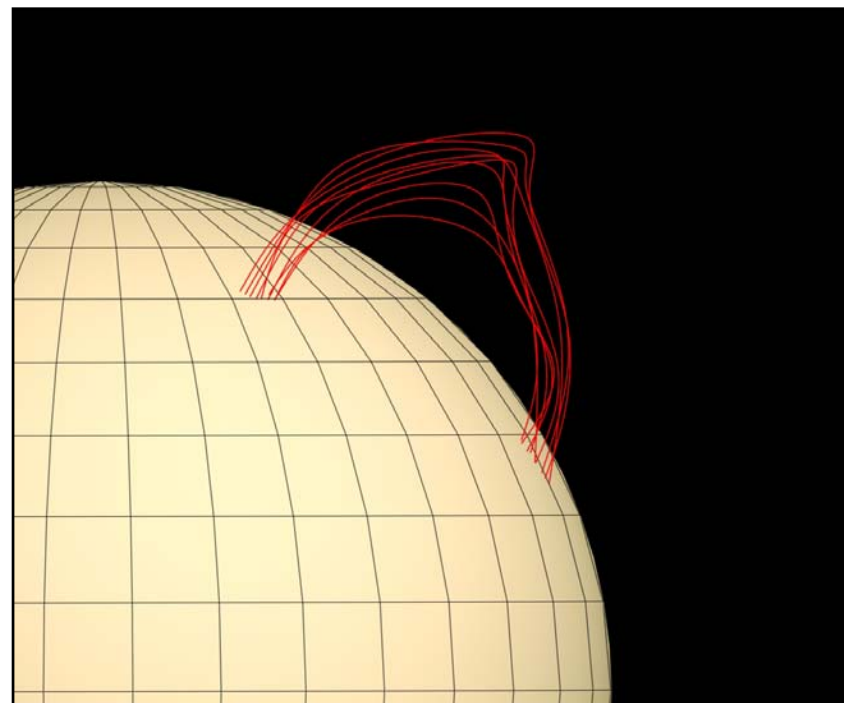
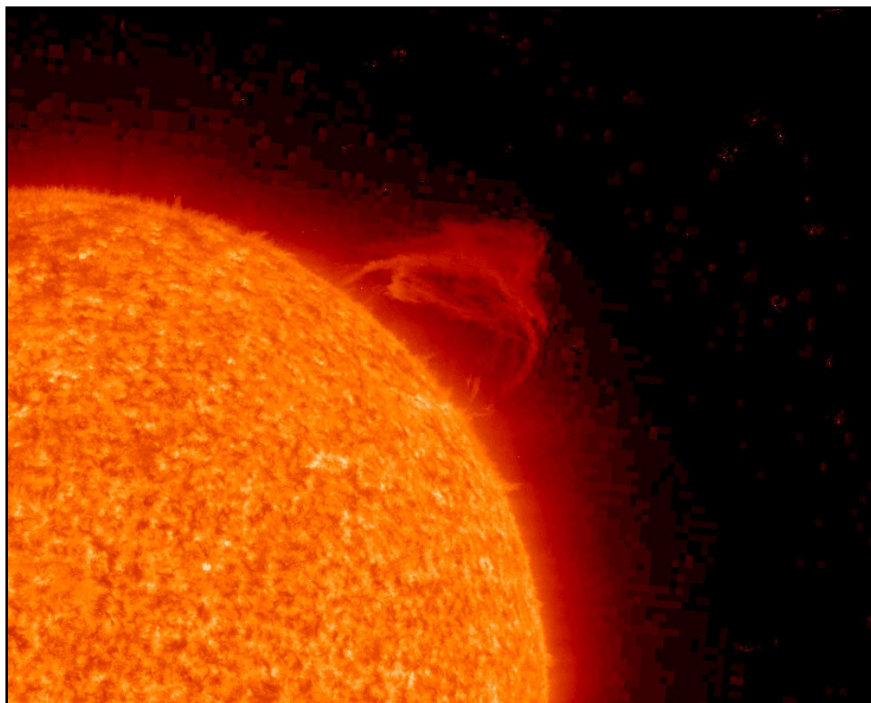
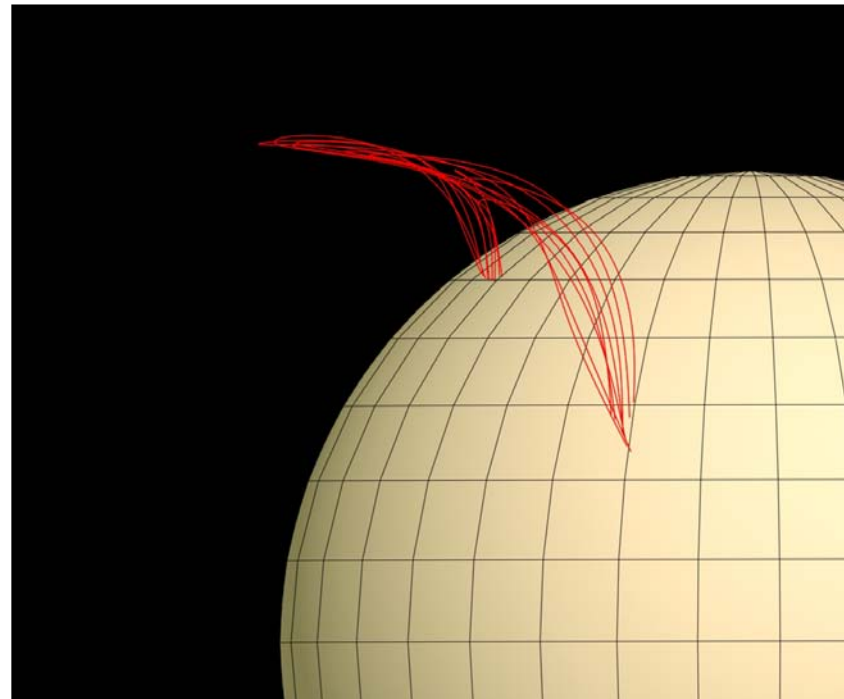
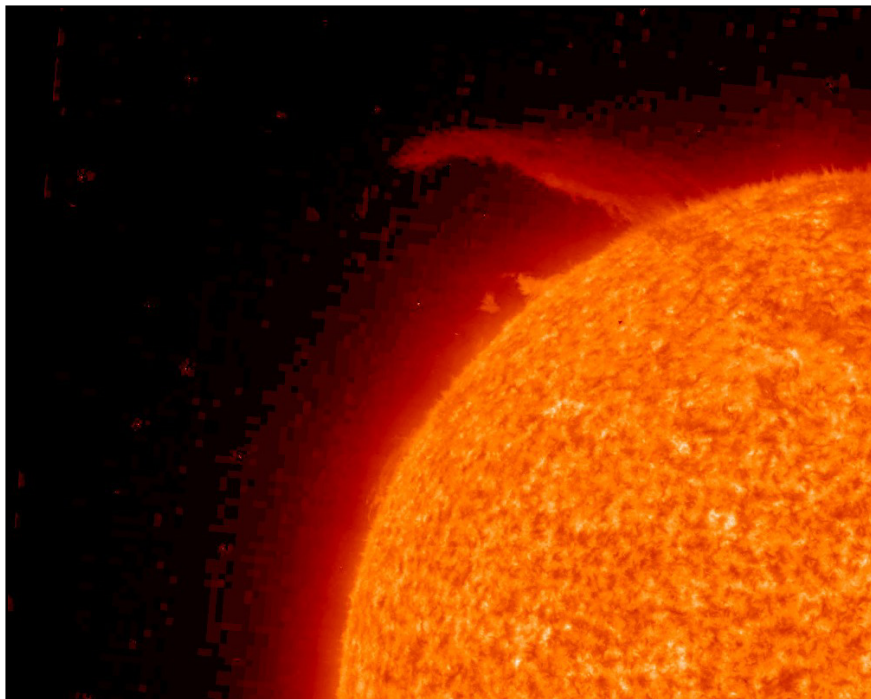
13:06 UT



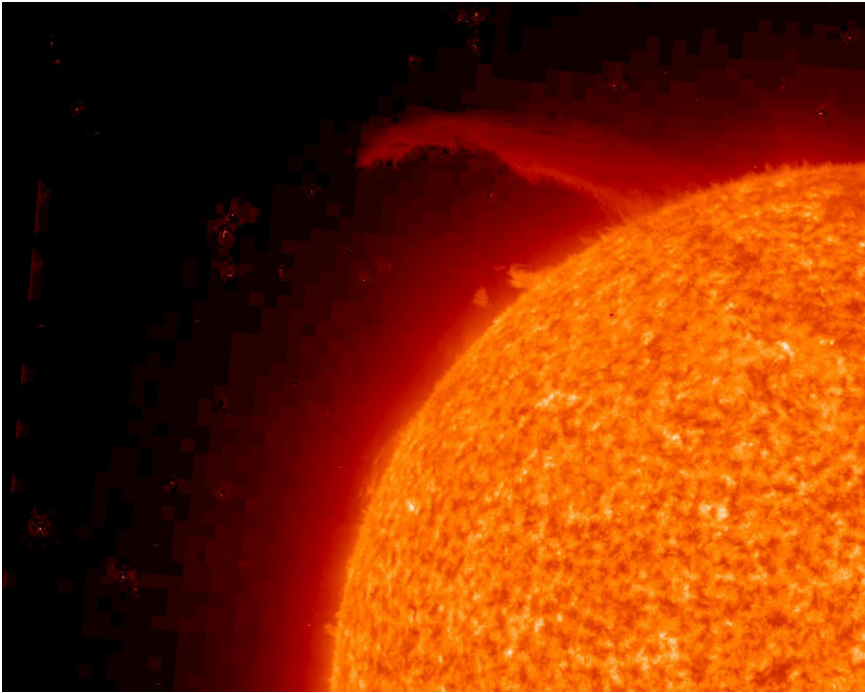
12 December 2008 STEREO Ahead EUVI 284 Å

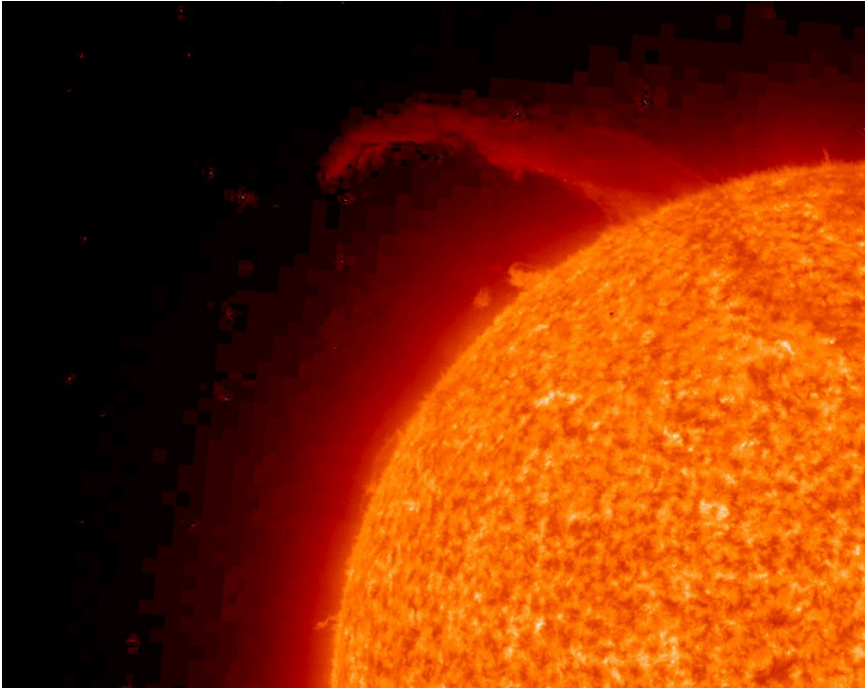


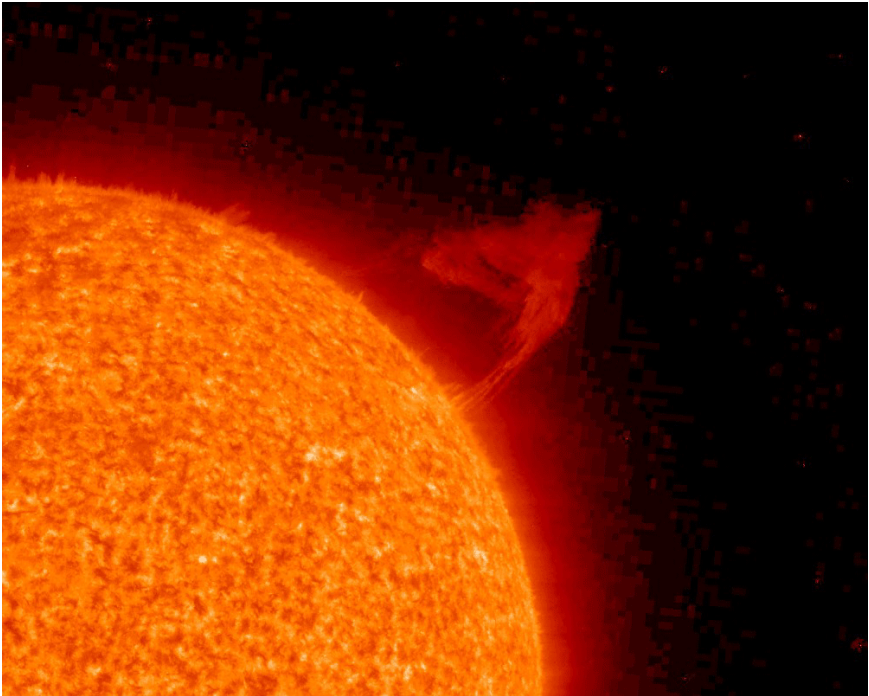
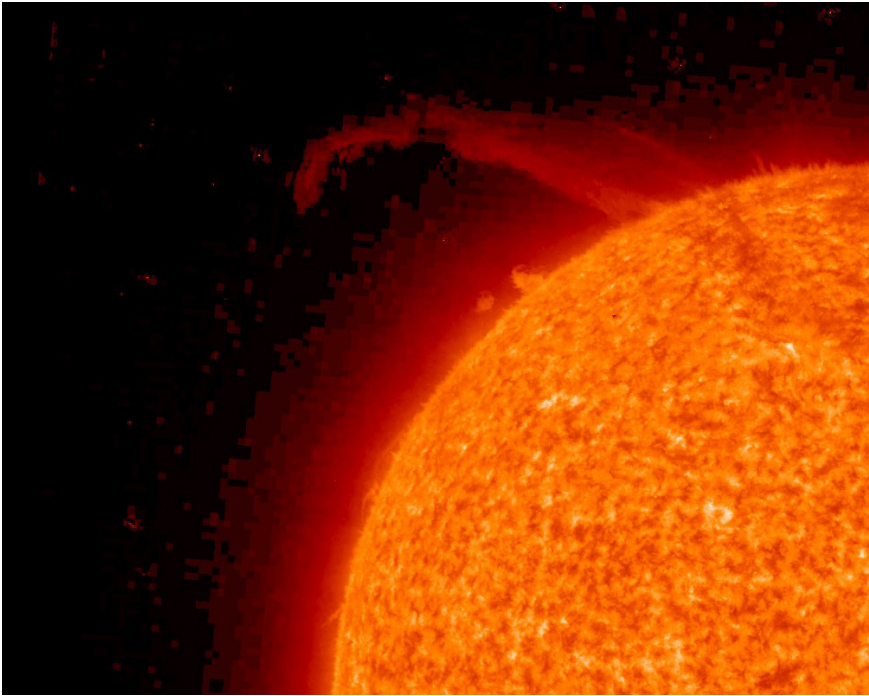


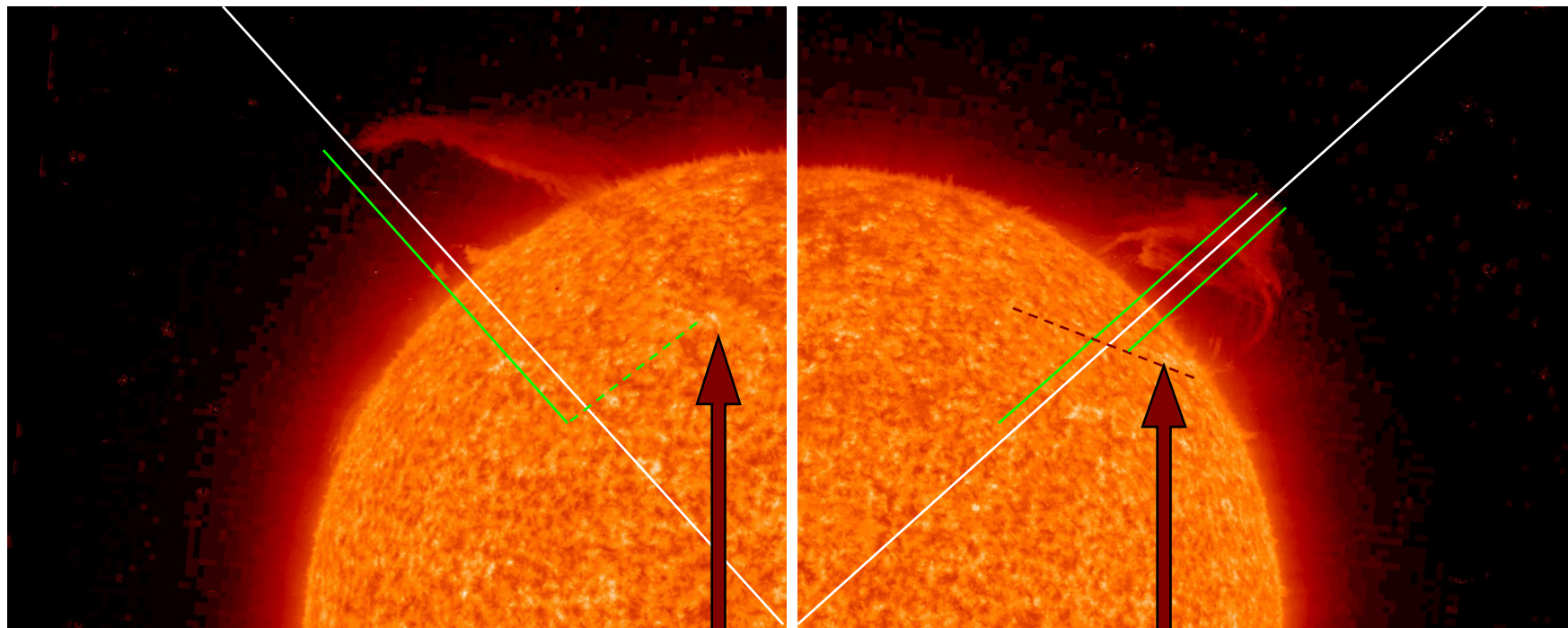


QuickTime™ and a
Animation decompressor
are needed to see this picture.





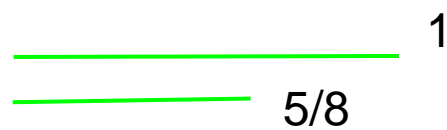




A

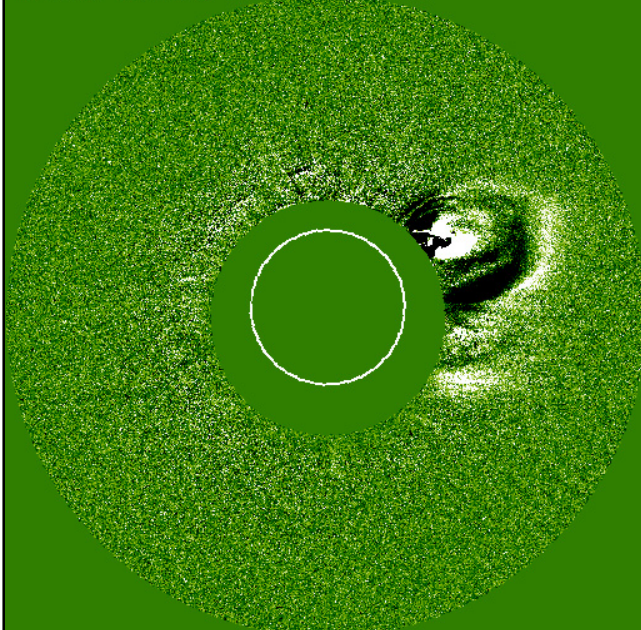
B

05:36 UT



COR1b: Running Difference Movie.

COR1a: Running Difference Movie.

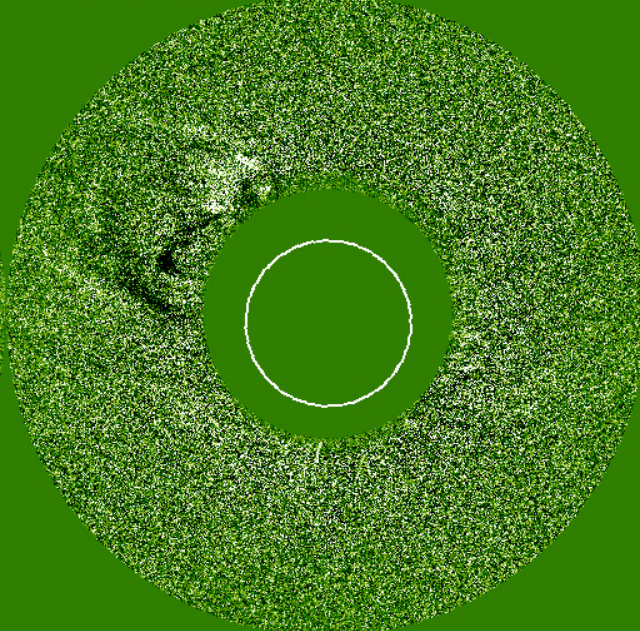
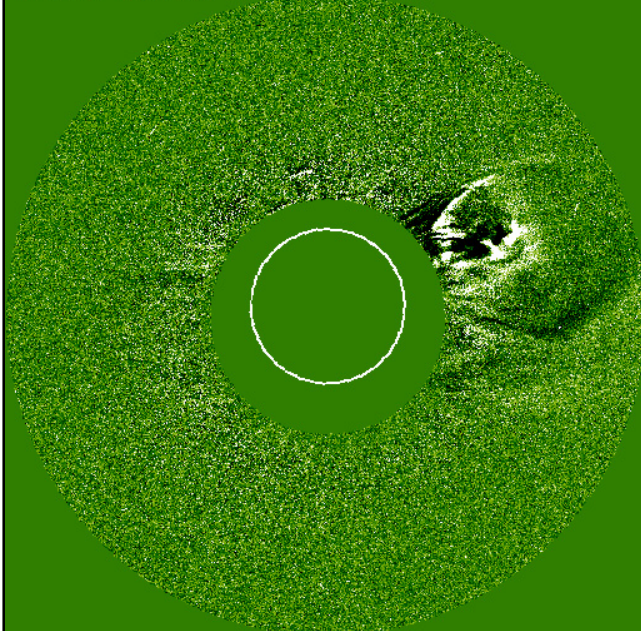


21 2008/12/12 T07:25:44.861 21

2008/12/12 T07:25:09.010

COR1b: Running Difference Movie.

COR1a: Running Difference Movie.



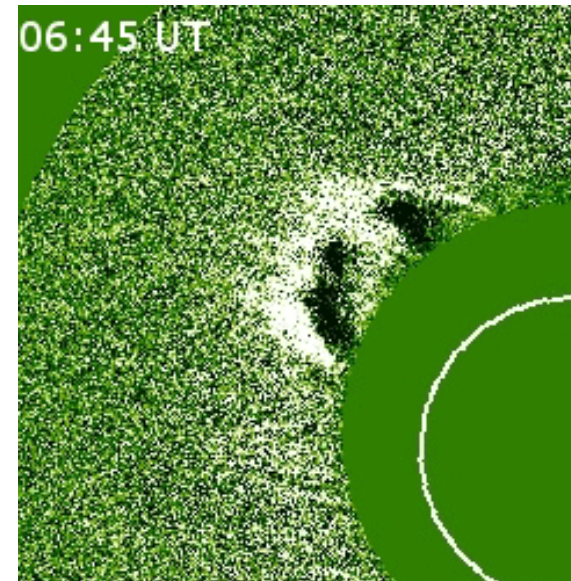
25 2008/12/12 T08:45:44.842 25

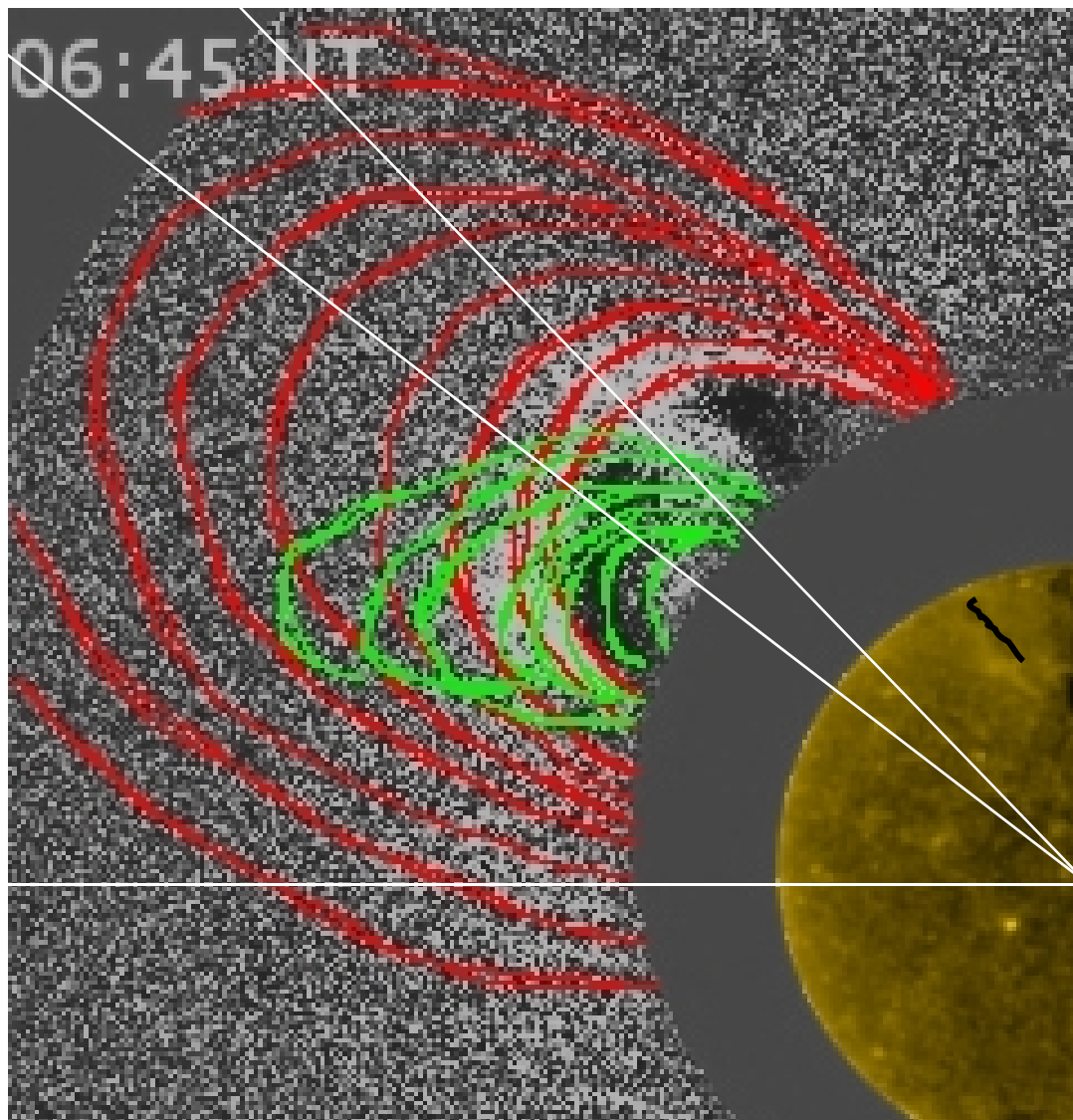
2008/12/12 T08:45:09.005

12 December
2008

STEREO COR 1

Ahead





12 December 2008

**STEREO Ahead
COR 1**

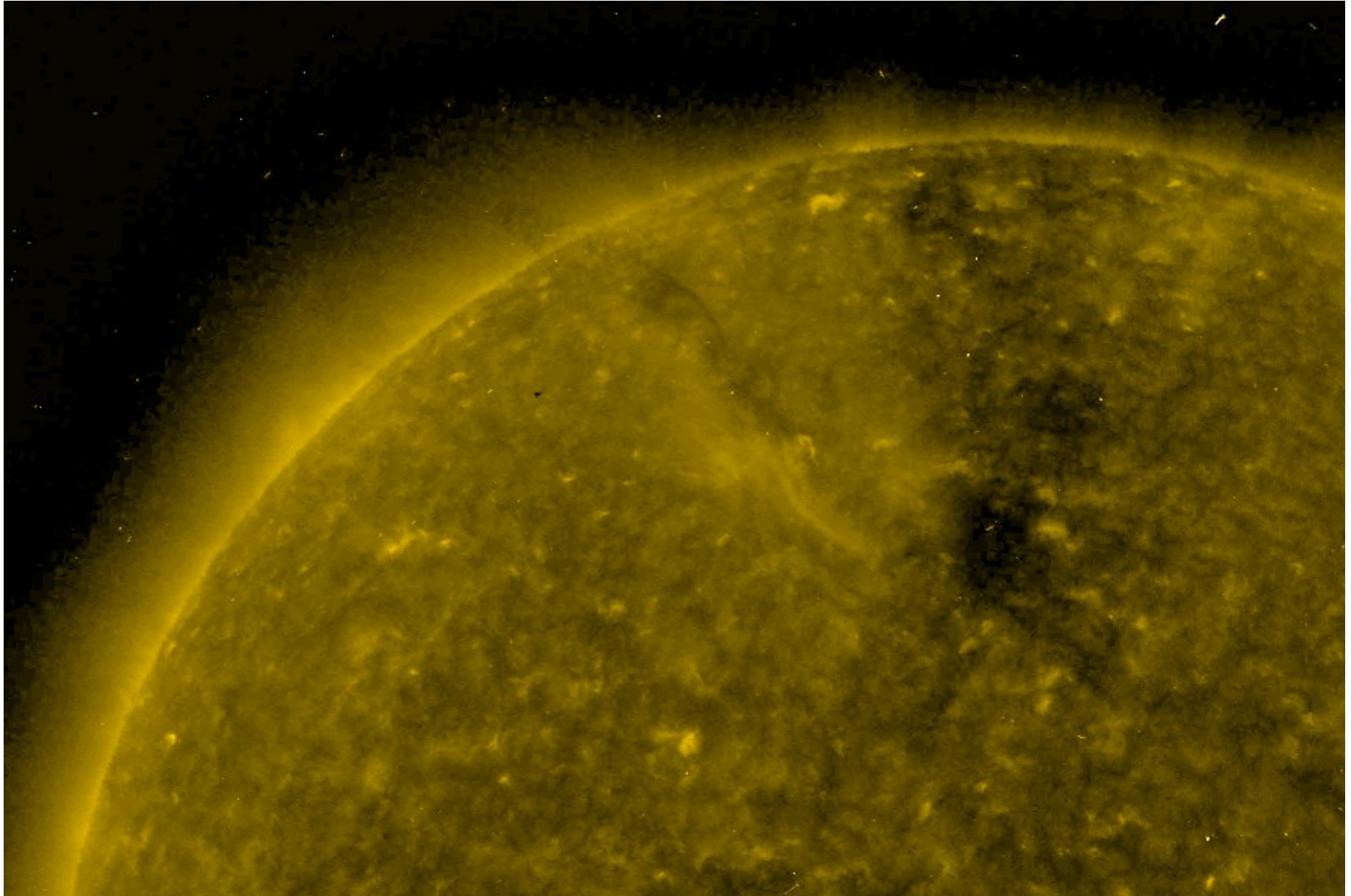
(6:45 UT - 10:05 UT)

and EUVI 284 Å

(01:06 UT)

12 Dec 2008 01:06 UT

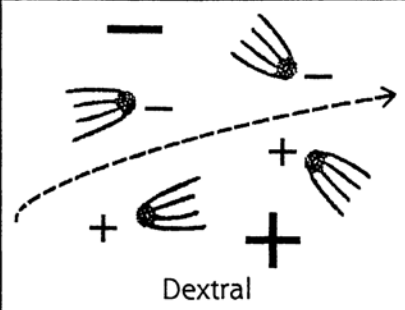
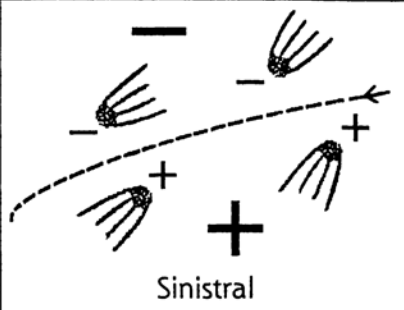
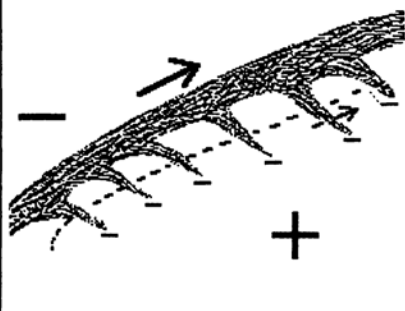
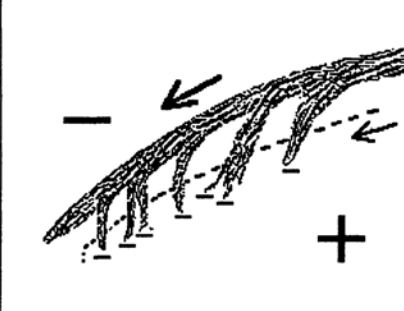
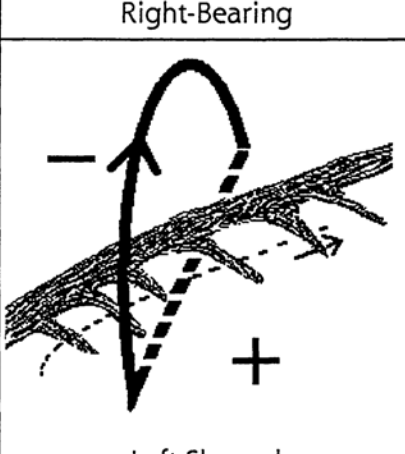
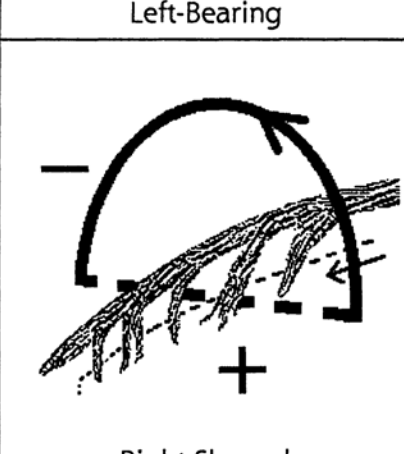
STEREO Ahead EUVI 284 Å



Zirker et al. 1997 (seven patterns of chirality)

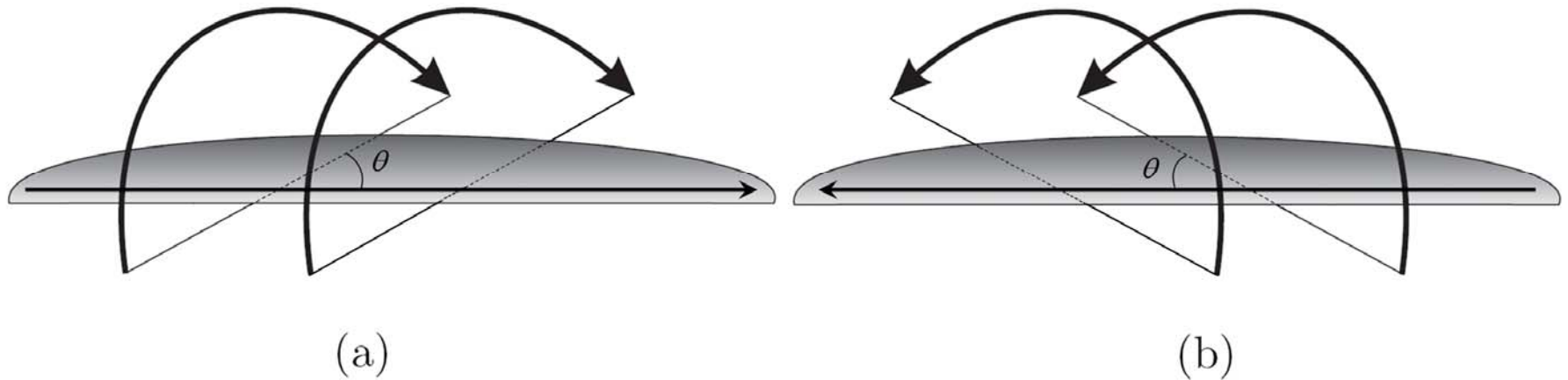
Martin 1998 (relationships between these patterns)

Chirality patterns of solar features involving filaments. Top: fibrils in filament channel; Middle: filaments; Bottom: system of coronal loops overlying filaments.

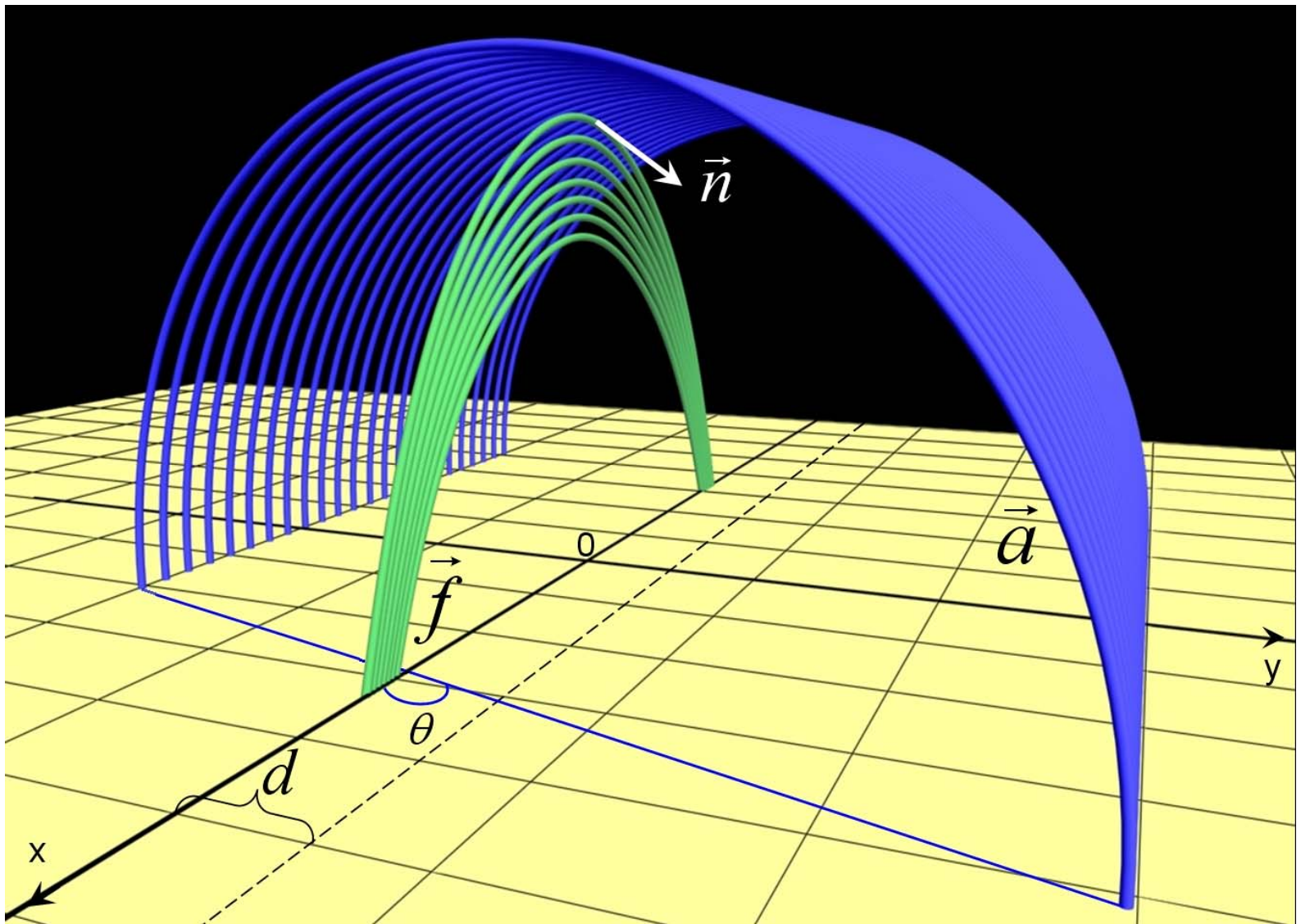
Feature	Chirality	
	N_{LW}	
1. Filament Channels Small Scale	 <p style="text-align: center;">Dextral</p>	 <p style="text-align: center;">Sinistral</p>
2. Filaments Medium Scale	 <p style="text-align: center;">Right-Bearing</p>	 <p style="text-align: center;">Left-Bearing</p>
3. Coronal X-Ray Arcades Large Scale	 <p style="text-align: center;">Left-Skewed</p>	 <p style="text-align: center;">Right-Skewed</p>
	Dominant in Northern Hemisphere	Dominant in Southern Hemisphere

**QuickTime™ and a
decompressor
are needed to see this picture.**

**QuickTime™ and a
decompressor
are needed to see this picture.**



The shaded sheet represents a filament and the arcs represent the overlying arcade field. The two different for a filament ribbon are: (a) dextral with left-skewed arcade field and (b) sinistral with right-skewed arcade field (observed from the positive polarity side of filament).



Because of the asymmetric placement of the filament with respect to the arcade, the top of the filament is pushed downwards and toward the center of the arcade.

