Namur ESWW-8 29 Nov 2011
Tuesday afternoon PROBA2 science splinter

"Deep imaging using the SWAP: coronal cavities, plasmoids, jets and rays"

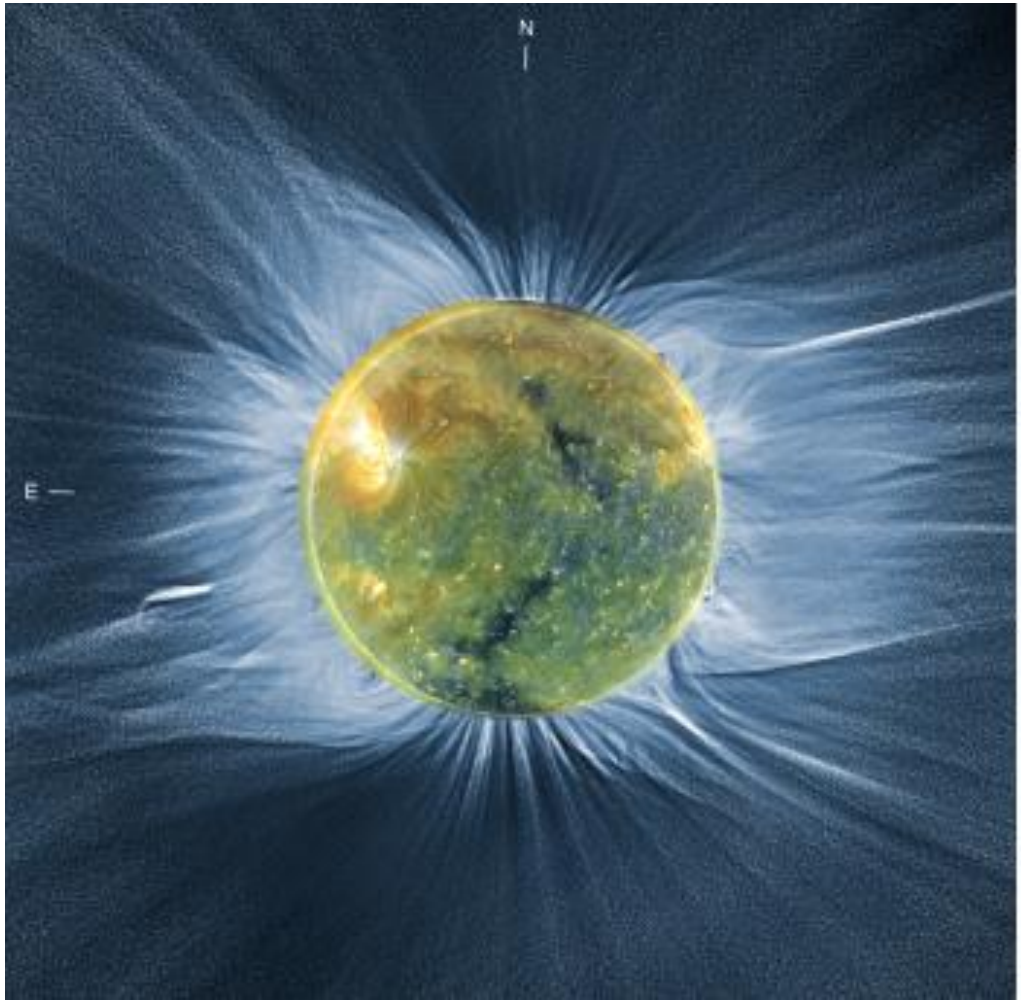
by

Serge Koutchmy, Cyril Bazin, Boris Filippov and Ehsan Tavabi

Institut d'Astrophysique de Paris- UMR 7095, CNRS & UPMC and IAS- Orsay,

Results following the GI 2011 program (ROB) of Proba-2

A- Prominence- cavity regions in Helium lines from eclipse spectra (2010) and simultaneous SWAP 174 filtergrams of FeIX (part of C.Bazin's PhD work)

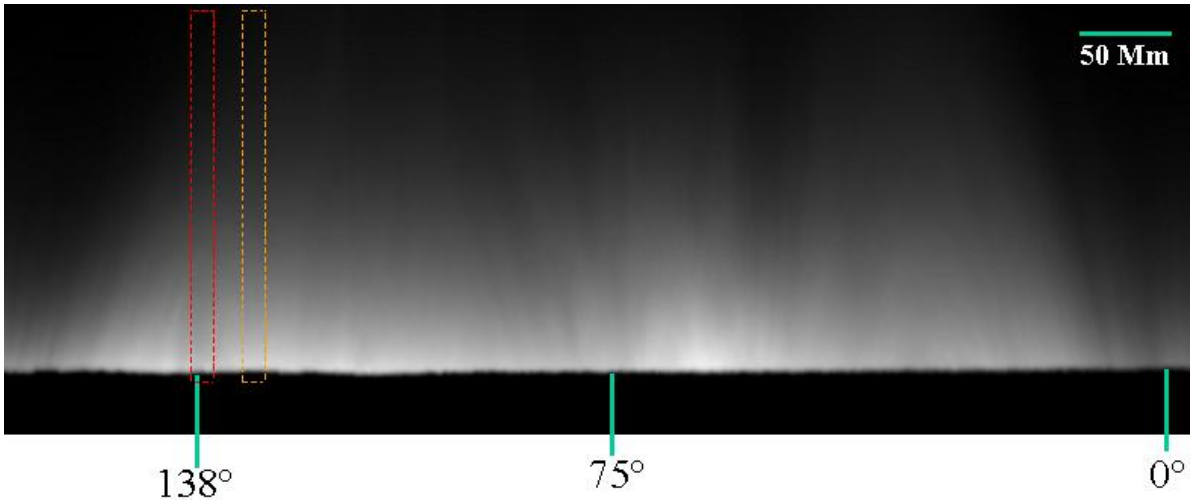


SP paper submitted nov. 2011

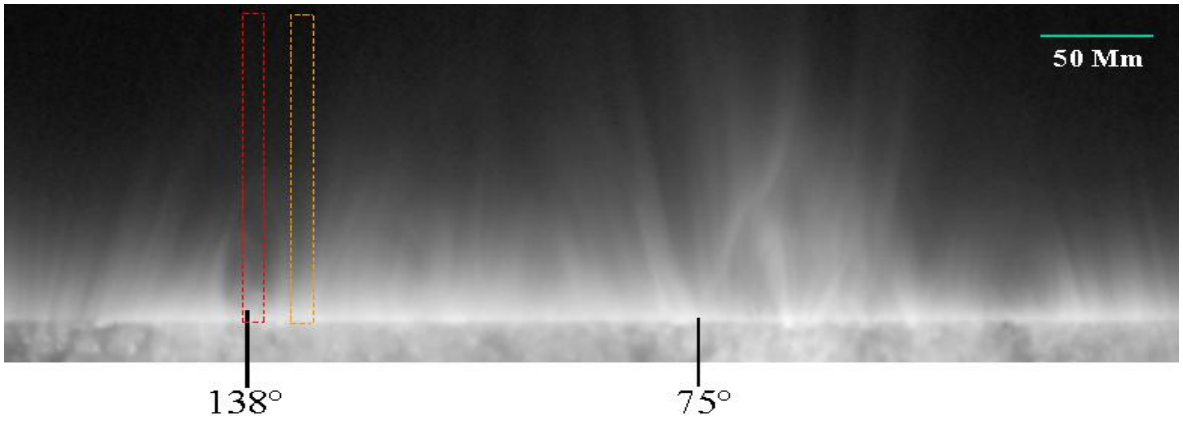
Coronal Cavities (C.C.)

- C.C. seen in W-L at eclipses: depressed densities in the inner corona where prominences are
- Related to prominences: is it the missing material filling the prominence due to the radiative instability?
- Also: a C.C. is « ejected » at time of a 3-part CME

- Nature of the cavity: temporal variation? Origin?
- Temperature? Magnetic field (polarity inversion line)?

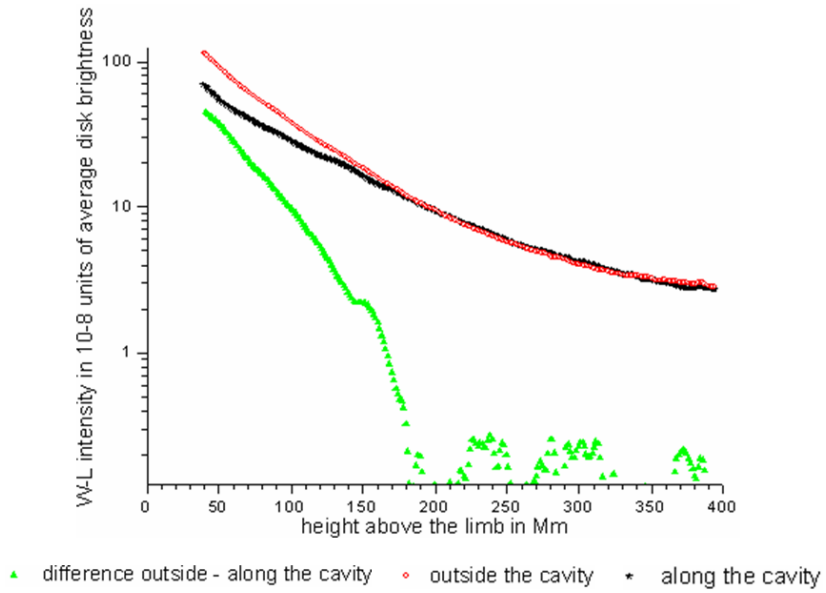


A W-L original image converted in polar coordinates, to deduce the radial cuts and show the radial gradients. The red and orange dotted lines indicate where the radial cuts are taken, along and outside the cavity



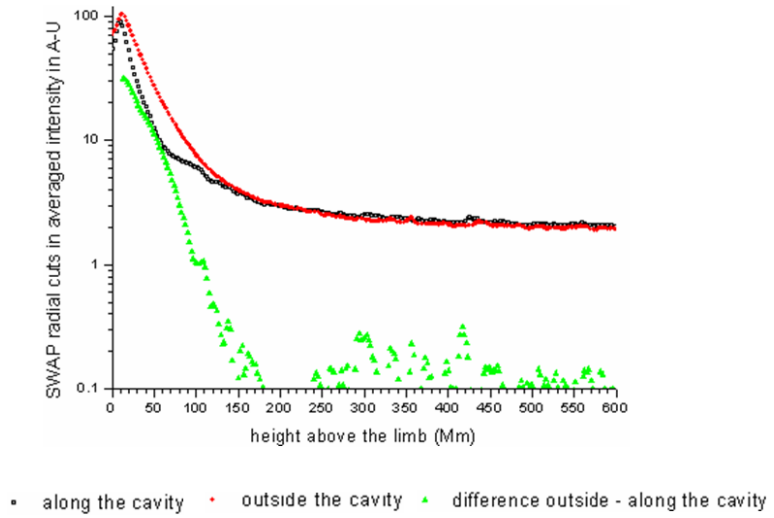
SWAP image converted in polar coordinates. The studied cavity is situated at 138° heliocentric coordinates. The red and orange dotted lines indicate were the radial cuts are taken along and outside the cavity

The missing emission

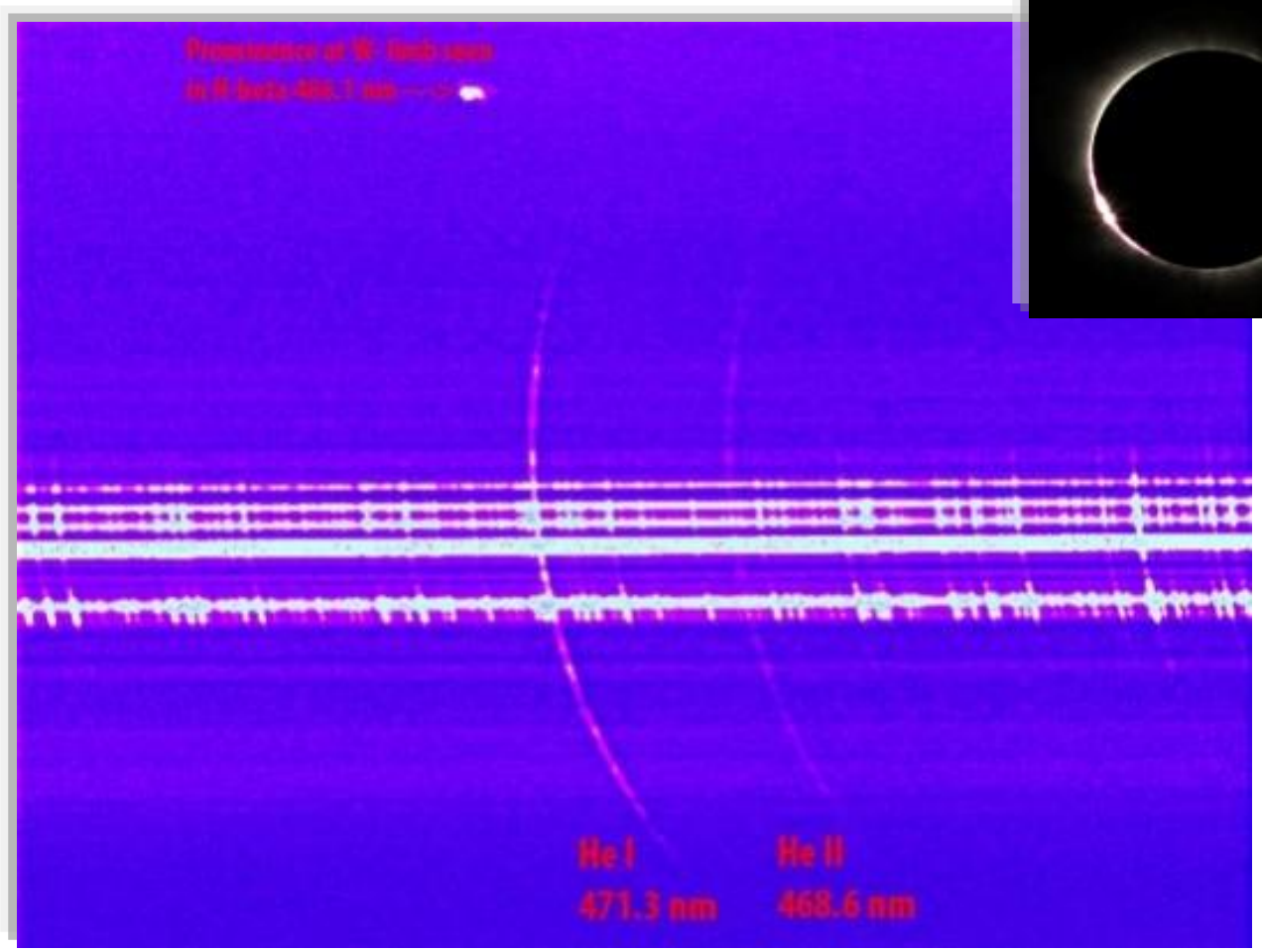


White Light radial cut along the cavity in red and outside in dark. The F-corona has been subtracted

Radial intensity profiles from SWAP taken in the region of the South East cavity at 138° and in green, the difference between the radial cut along and outside the cavity in Log scale.



Extract of the spectral sequence obtained in the vicinity of the 2nd contact, to show reversed lines seen in ***emission*** *(immediately above the white band corresponding to an over-exposed part of the high photosphere where the lines are still measured in absorption), and, simultaneously, on a greater extent, the chromospheric envelopes which surround entirely the Sun in the line of neutral helium (HeI to 471 Nm) and also,* ***for the first time****, of ionized helium (HeII line at 468.6 Nm).*



Emission lines of prominences with continuum between seen near 2nd contact (80 stacked images)

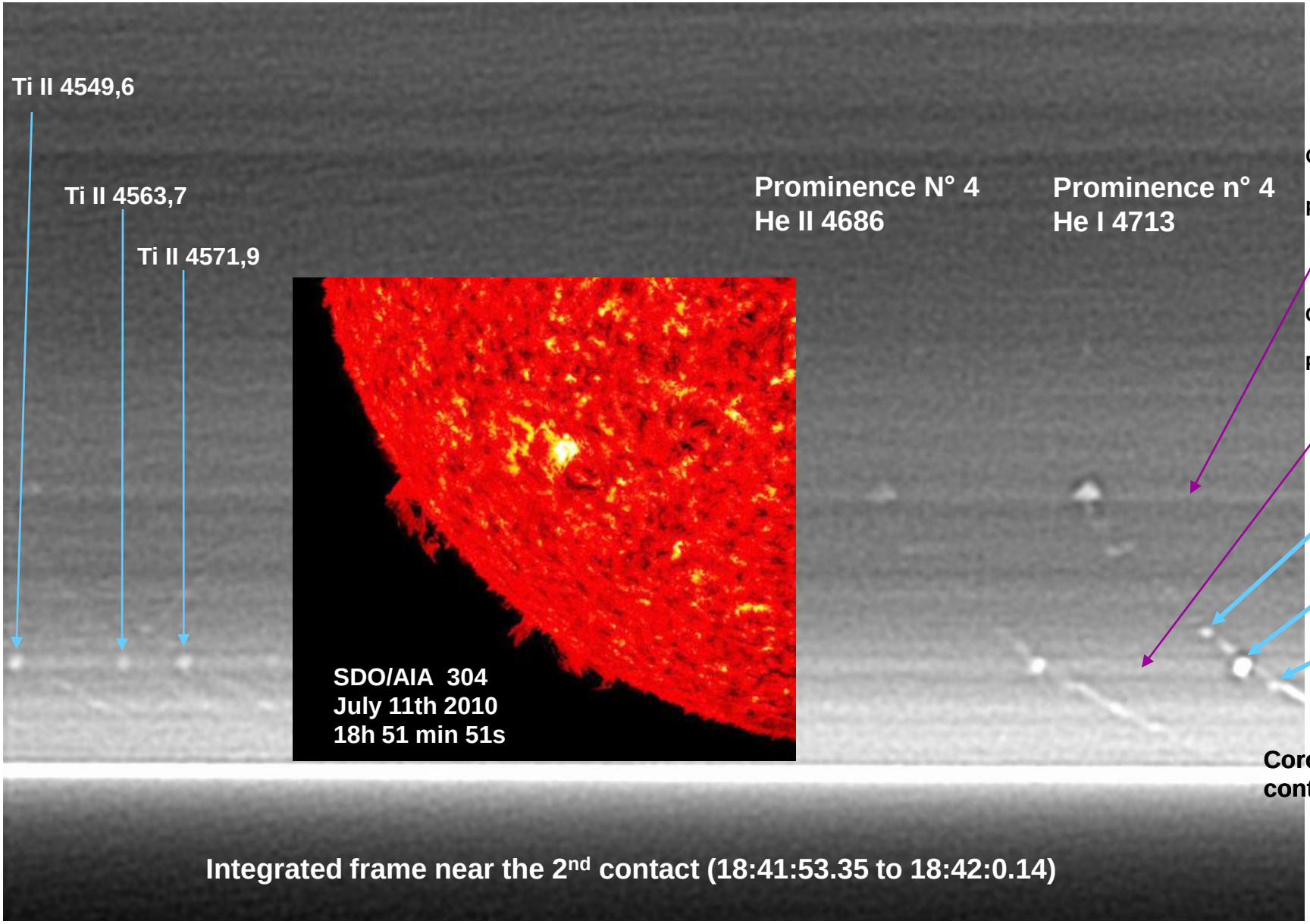
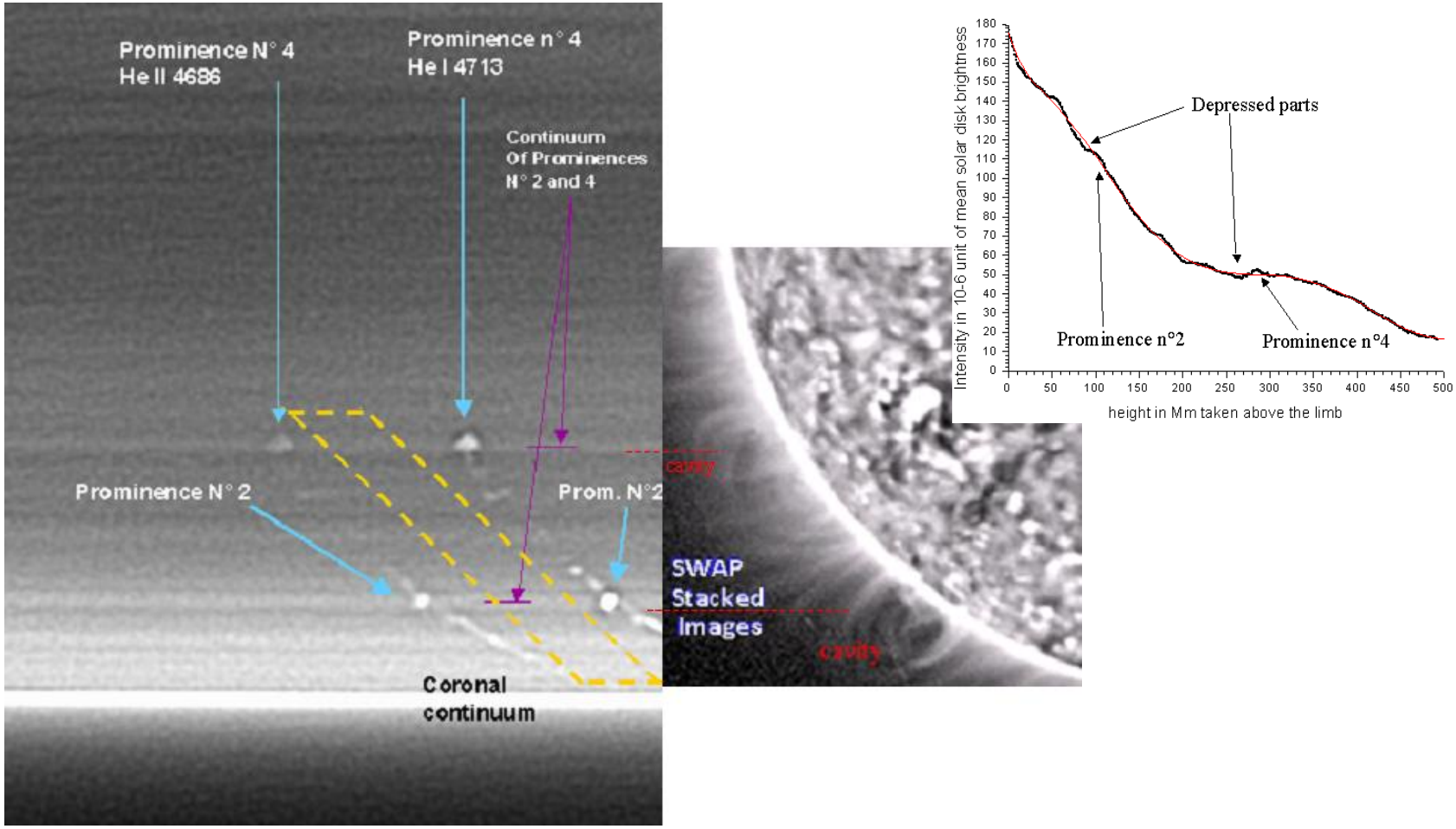
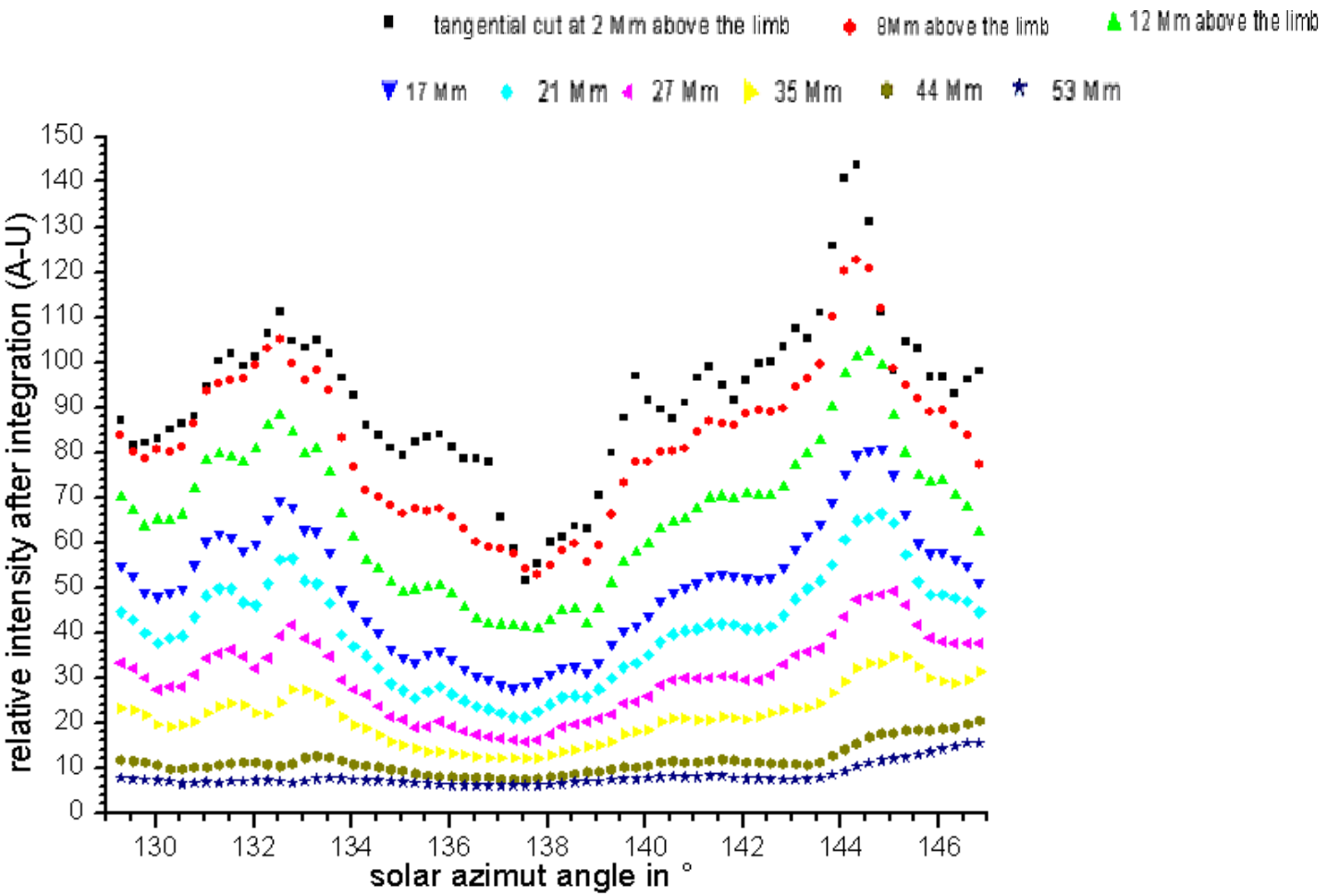
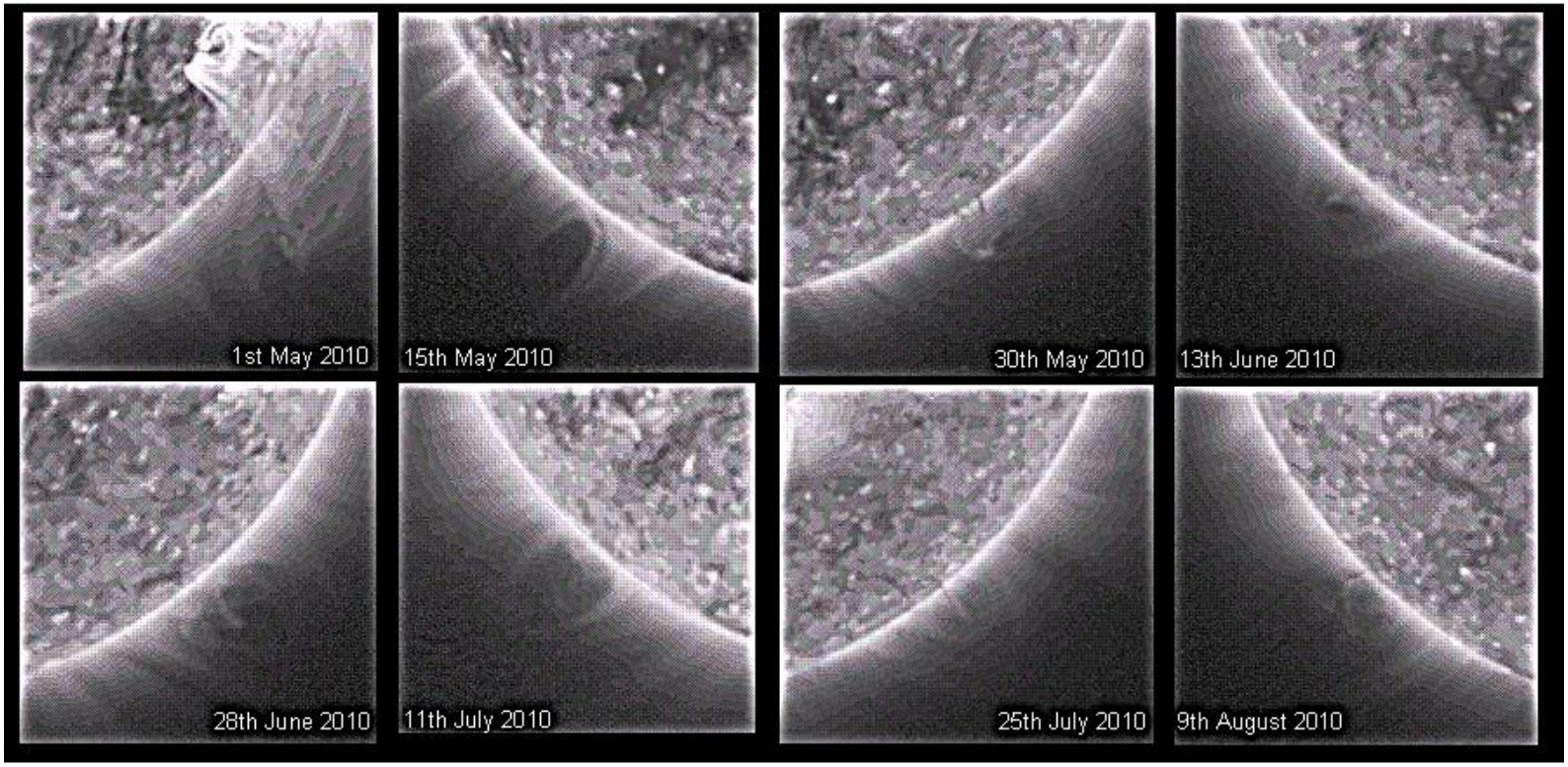


Image extracted from the eclipse spectra taken near the 2d contact shows the continuum between helium prominences. The “cavity” effect (decreased fluxes) can be compared to a partial SWAP processed image taken in the same location at the South-West limb. The dashed yellow lines show the extension used to perform the photometric analysis of the continuum shown after. It is spectrally situated between the He I and He II emission lines. Note the faint W-L emission at the exact location of the prominences and the relative depression from each side.

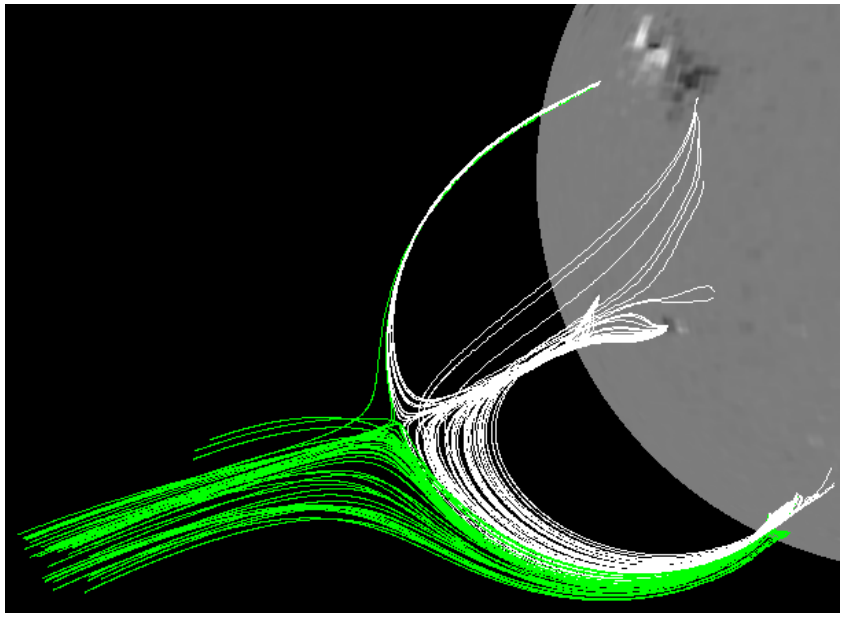




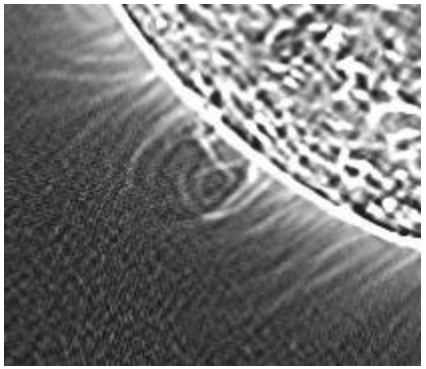
tangential cuts taken in the SWAP cavity region showing the variations with heights in the region of the depression



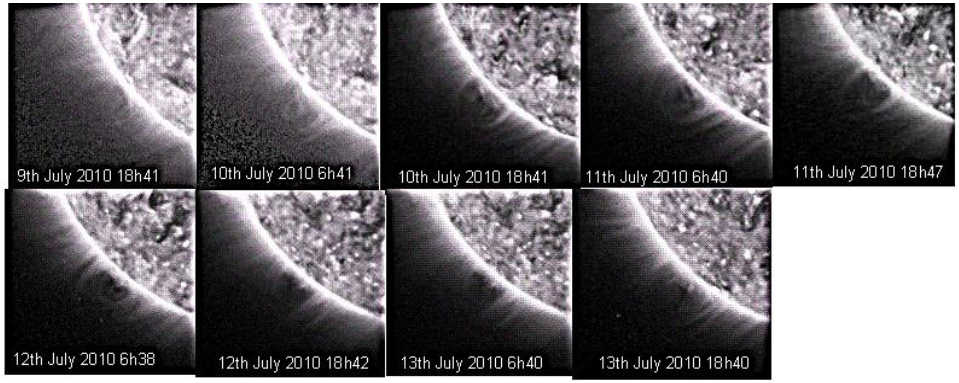
Partial images in the southern regions using 20 stacked SWAP images to show the cavity and channel flows evolving in 60° latitude Southern polar regions: 15 days of time intervals were used corresponding to the synodic period of differential rotation for a 60° latitude region.



South-East Potential Field Source Surface (PFSS) model of the SWAP cavity computed for the time of the 11th July 2010 total eclipse above the cavity (SWAP)



White light image at the time of the eclipse totality of the South-East corona after processing to show the helmet feature associated with the cavity in lower altitudes.



Fluctuations around the cavity as seen every 12 hours of time intervals. It shows possible structuration of plasma flows in the cavity core. Some twisted channels flows inside the cavity are seen the 10th and 11th July 2010.

B- Plasmoids

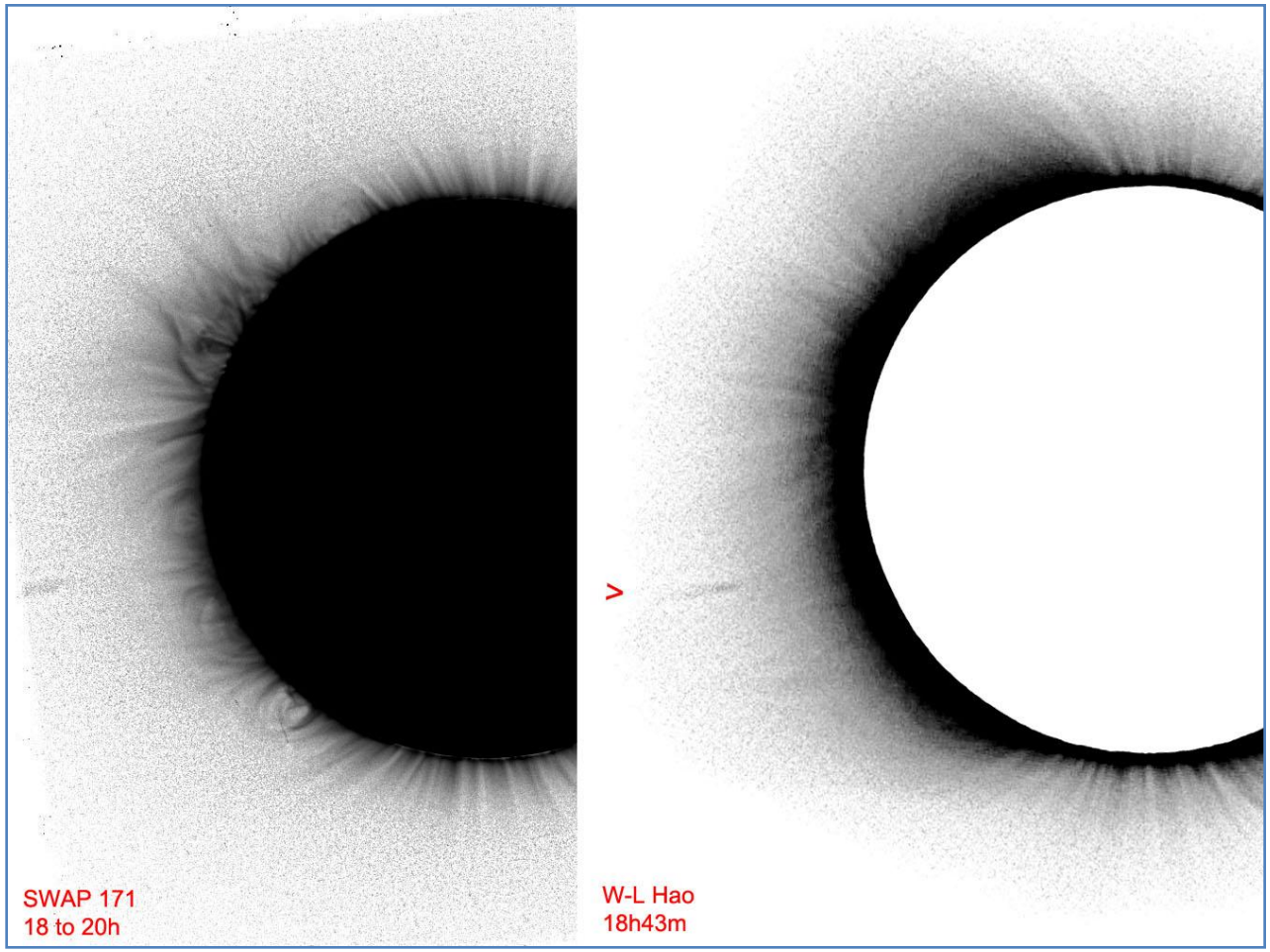
ANALYSIS OF THE JULY 11, 2010 CORONAL PLASMOID IN W-L (TOTAL ECLIPSE) AND WITH THE SWAP (PROBA-2 MISSION)

by

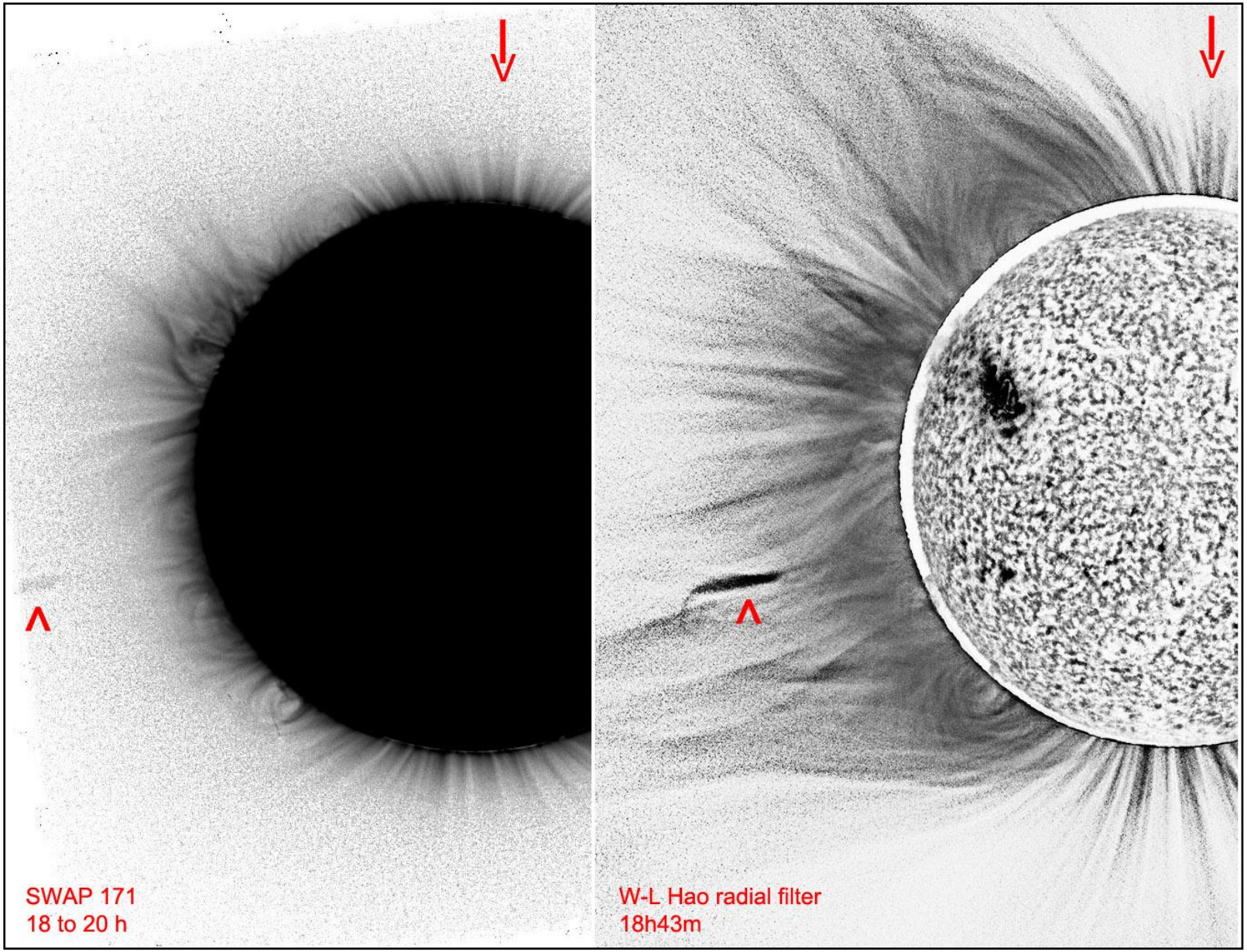
Serge Koutchmy, Cyril Bazin, David Berghmans, Anik De Groof, Miloslav Drückmuller, Alex Engel, Boris Filippov, Leon Golub, Jon Linker, Zoran Mikic , Jean Mouette, Christian Nitschelm, Philippe Lamy, Dan Seaton, Vladimir Slemzin and Ehsan Tavabi

ApJ paper submitted Aug. 2011

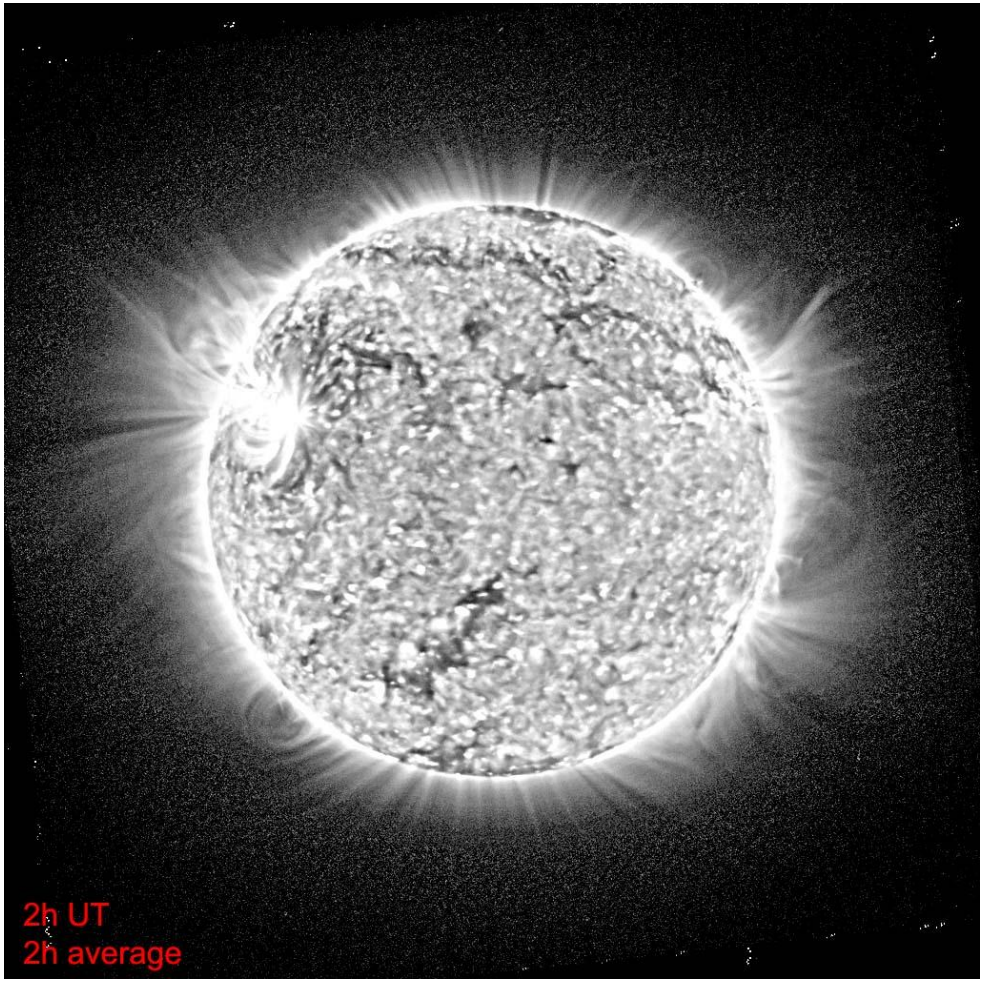
A **new** dynamical phenomenon at the E limb was observed:
blobs and/or plasmoid formation as a remnent of a CME propagating along a streamer;
Origin: a break-out model at small scale is proposed because no direct link with surface phenomena can be found.



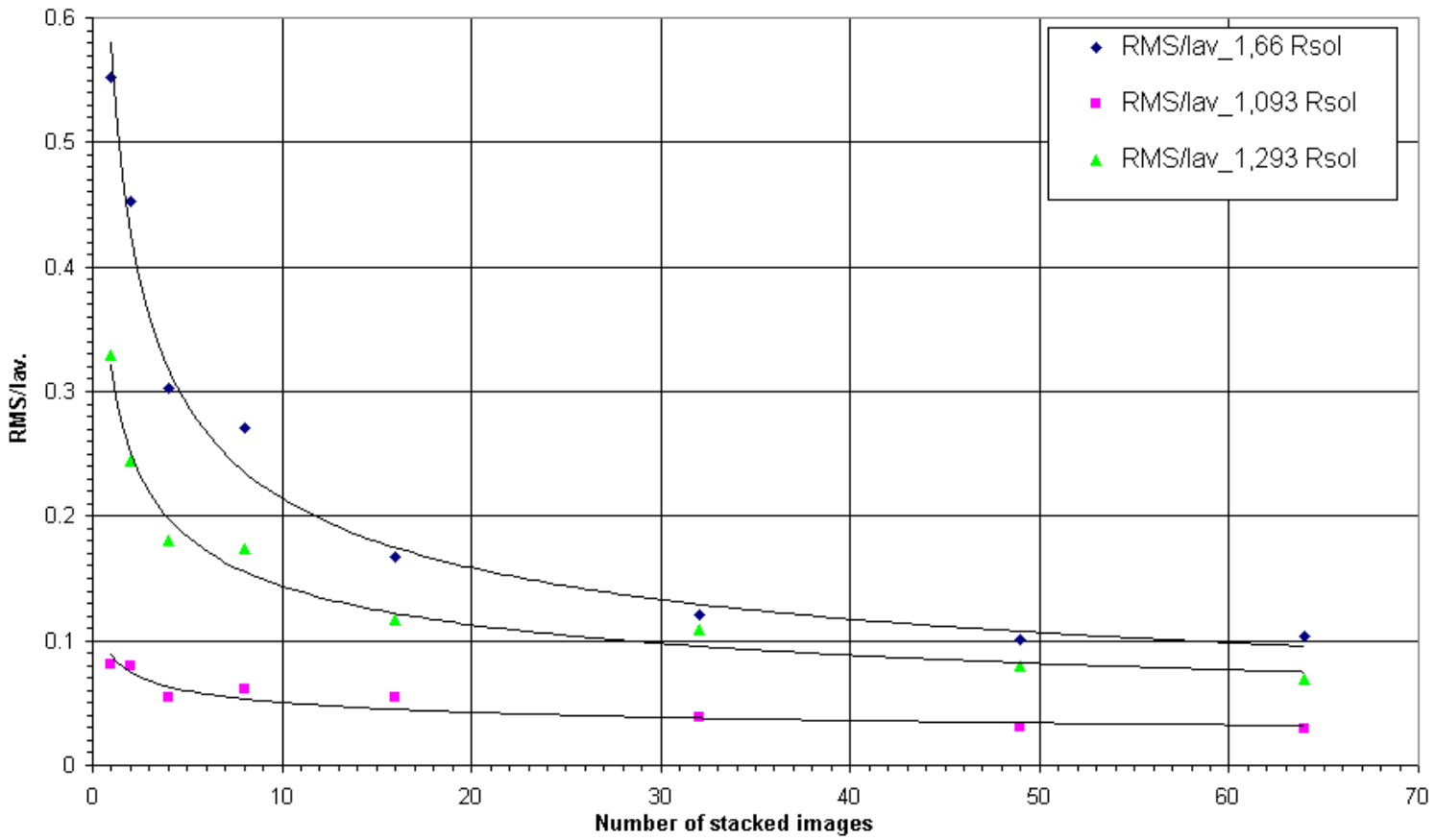
SWAP and simultaneous WL eclipse images of the intermediate corona at E



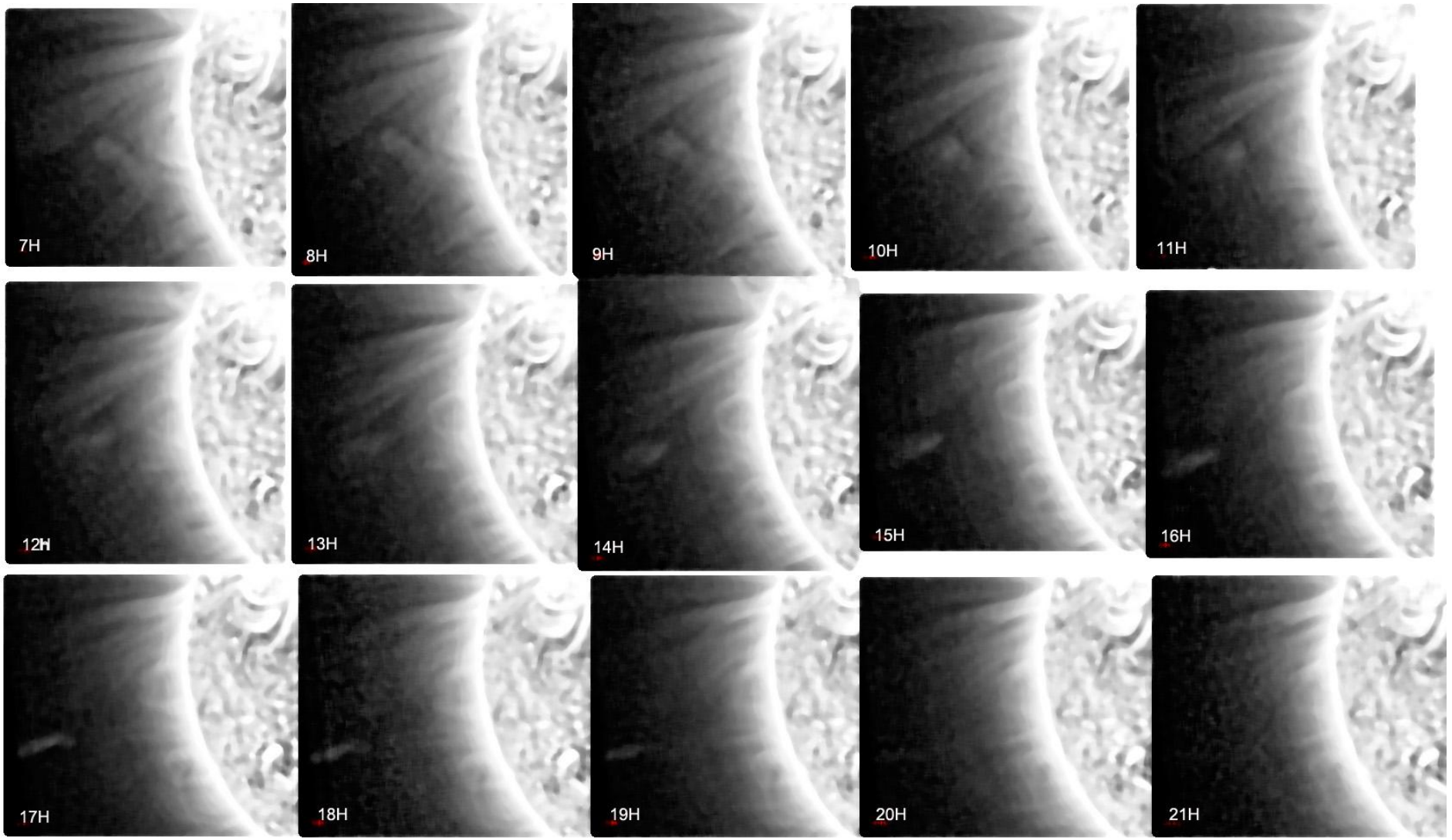
Movie made using a set of 2h-averaged SWAP images (summed images **to improve the S/N ratio** in the outer corona) taken every hour from 2h to 24h

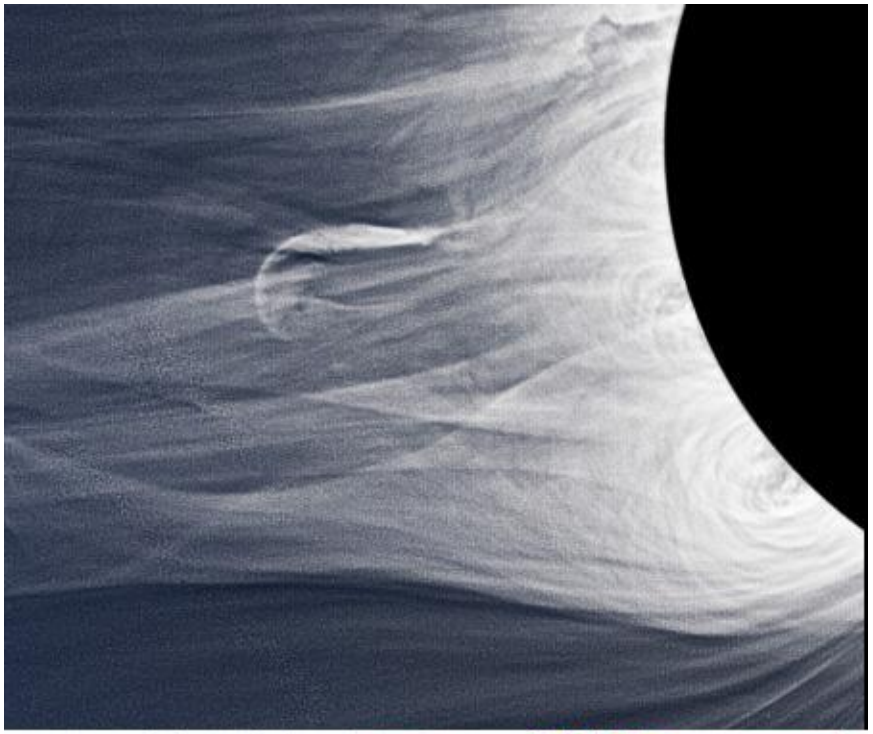


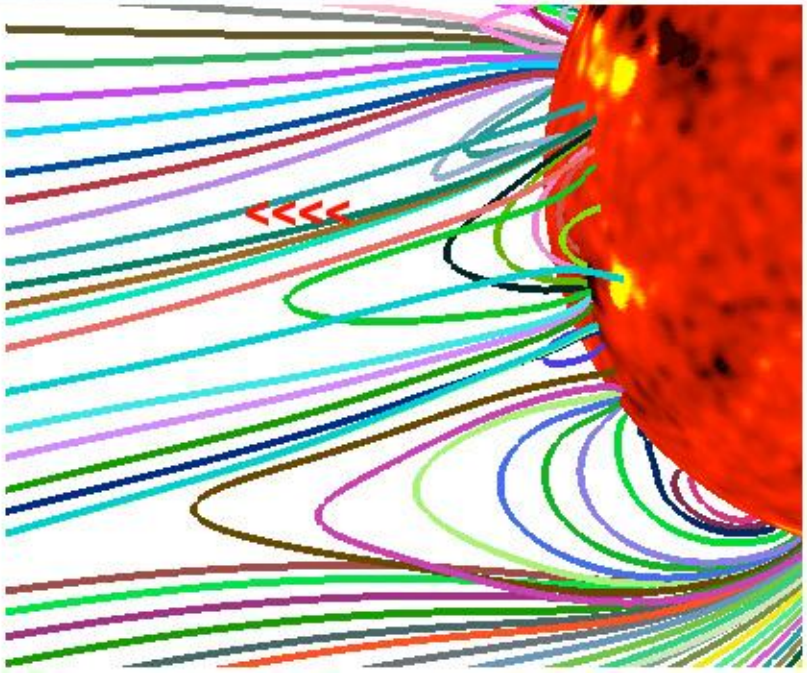
See the Quicktime movie made of processed images (unsharp masking)


RMS/lav. vs Nbr of stacked images at 3 heights
RMS/lav_1,66 Rsol
RMS/lav_1,093 Rsol
RMS/lav_1,293 Rsol
RMS/lav.
Number of stacked images
0
0.1
0.2
0.3
0.4
0.5
0.6
0
10
20
30
40
50
60
70

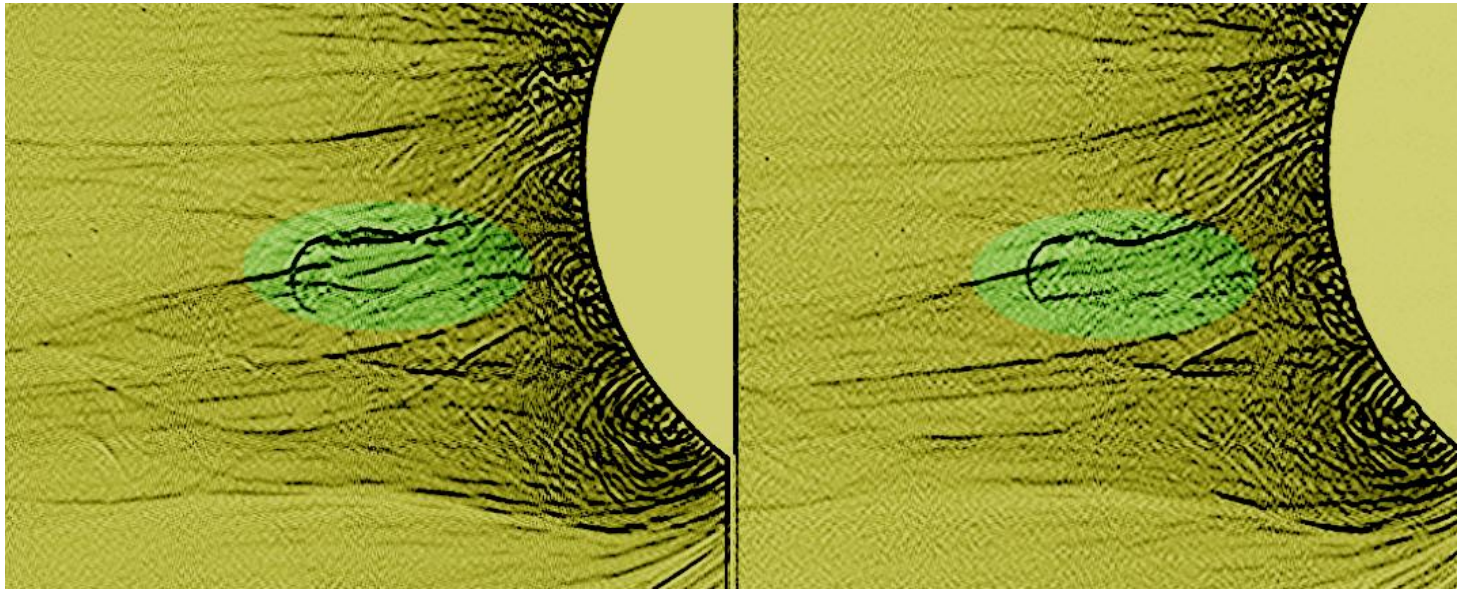
Mosaic of selected summed images from SWAP





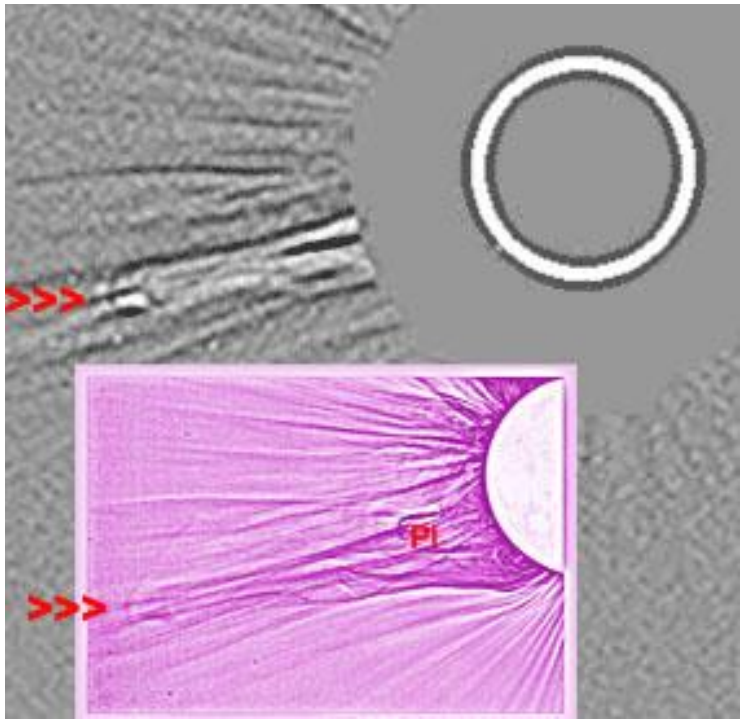


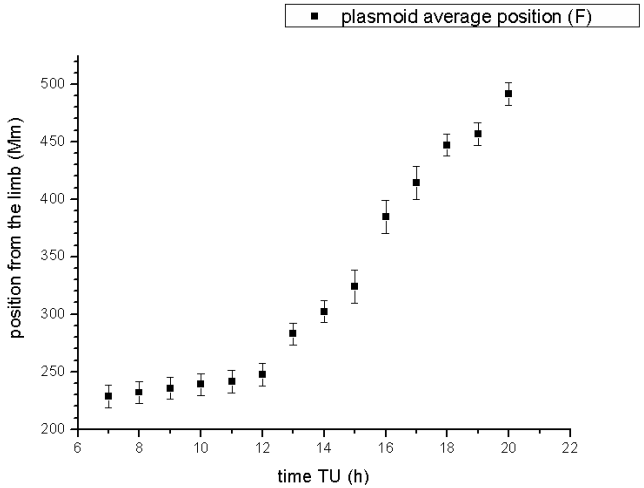
In W-L, the plasmoid is formed and propagates inside a rather open field region, from the calculated coronal magnetic fields using a full set of MHD equations (fff) and the surface fields measured well before the eclipse.

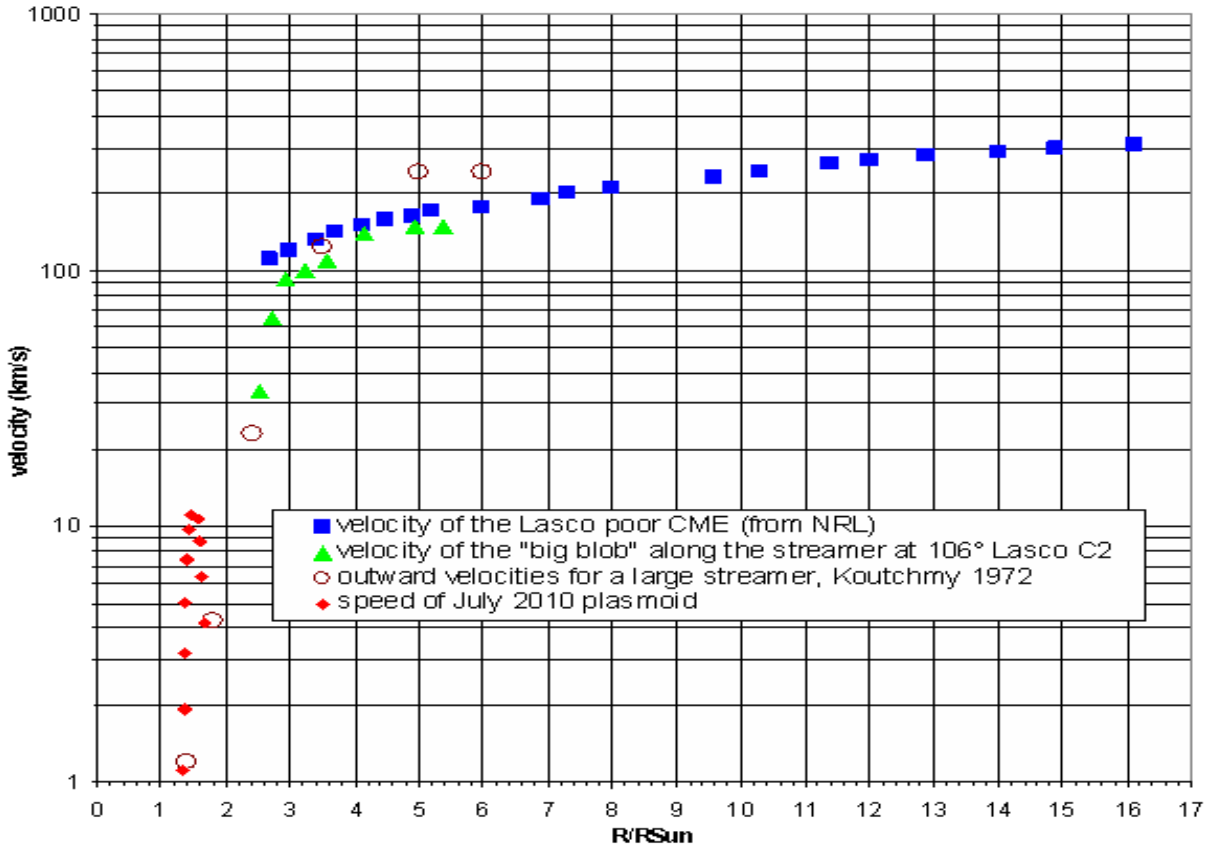


From processed W-L images taken at 18h46 and 20h10 UT, showing the intermediate corona around the plasmoid event.

Before the plasmoid event, a weak CME was observed over the same region, showing blobs and detached structures like plasmoids but in the more outer region (Lasco C2–SOHO W-L observations)




plasmoid average position (F)
position from the limb (Mm)
time TU (h)


velocity (km/s)
R/RSun
velocity of the Lasco poor CME (from NRL)
velocity of the "big blob" along the streamer at 106° Lasco C2
outward velocities for a large streamer, Koutchmy 1972
speed of July 2010 plasmoid

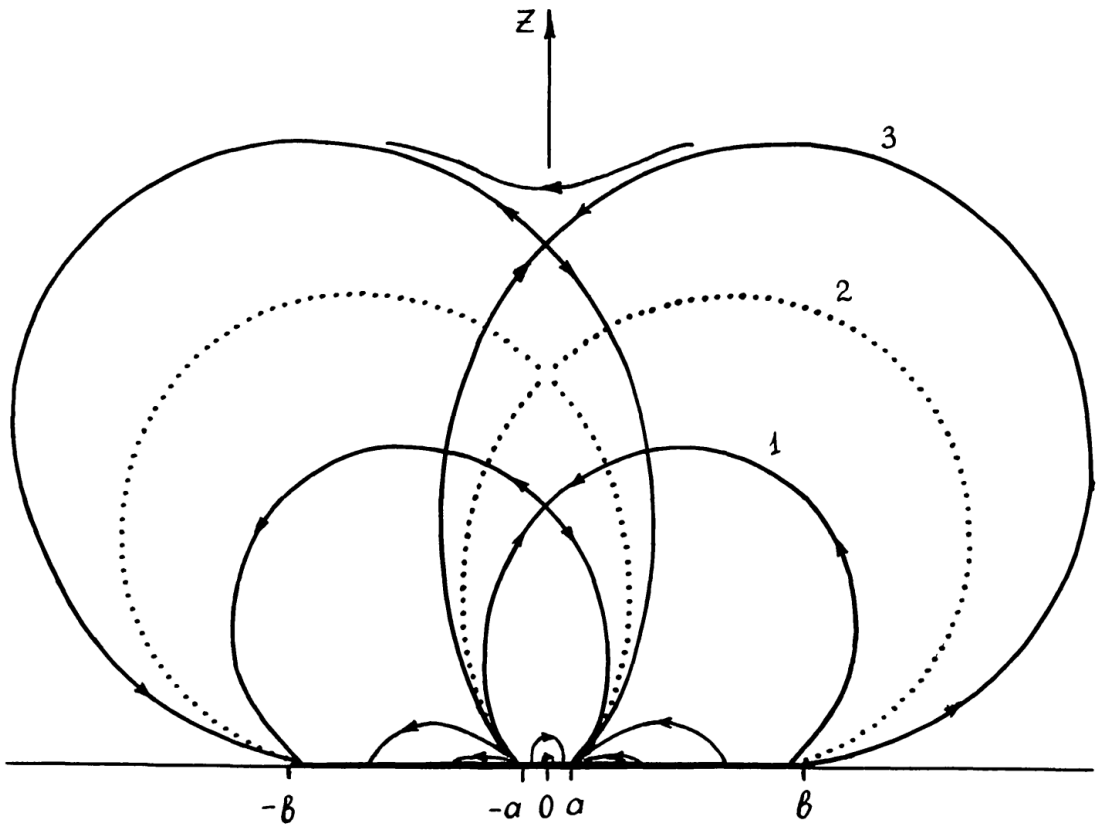


Fig. 7. The picture of magnetic field lines (for $a_1 = 0$ and $H = 100$) at the successive times when (1) $a = 0.0940$; (2) $a = 0.0944$; and (3) $a = 0.0949$.

The « breakout » model for coronal ejections by Syrovatskii, 1982
Producing a V shaped detached plasmoid…
Also: the breakout model for CMEs proposed by S. Antochios 1998

CONCLUSIONS

- Original photometric results were deduced from the comparison SWAP summed images/W-L eclipse data;
- A quantitative analysis of SWAP images was performed suggesting the radiative resonance of the FeIX line is significant in the intermediate corona;
- A new type of dynamical event was discovered, possibly resulting from the breakout of a magnetic structure related or not to a newly emerging magnetic region (Syrovatskii 1982; Antiochios 1998), with important consequences for explaining the low speed solar wind flux from active regions and streamers.

C- Jets and linear W-L Ray

FORMATION OF A WHITE-LIGHT JET WITHIN A QUADRUPOLAR MAGNETIC CONFIGURATION

by

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Paper in print in SP (2011)

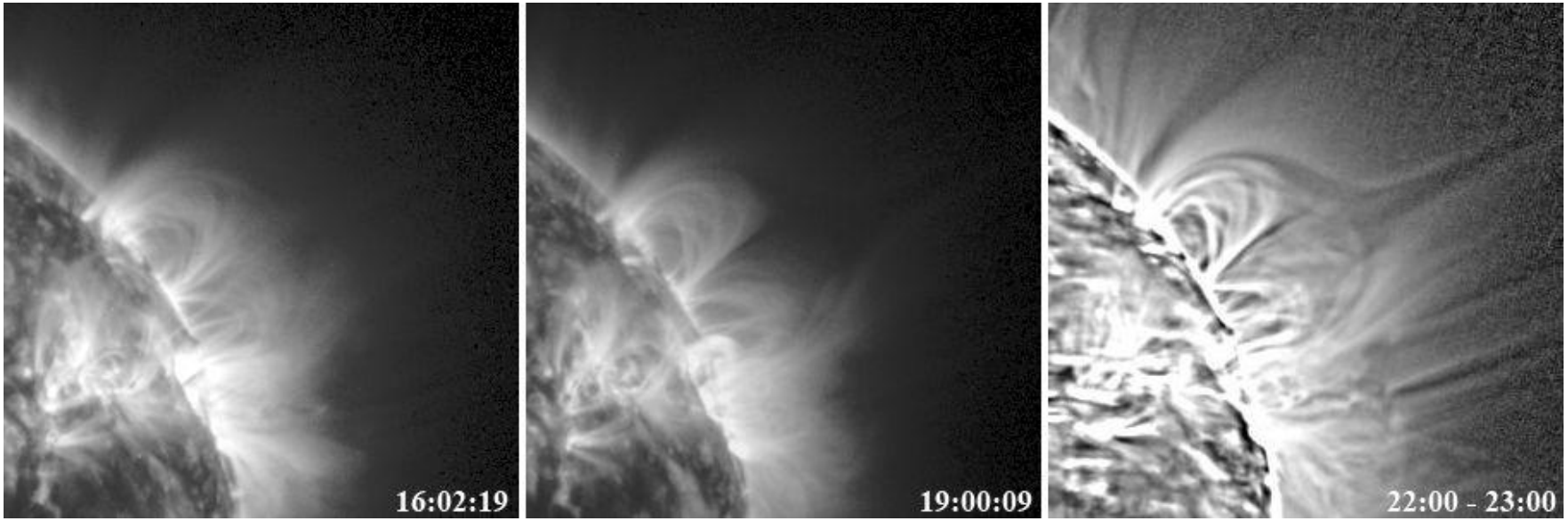
We analyze multi-wavelength and multi-viewpoint observations of a large-scale event viewed on 7 April 2011 originating from an active region complex.

The activity leads to **a white-light jet** (**linear collimated plasma flows** often noticed in W-L eclipse pictures) being formed in the outer corona.

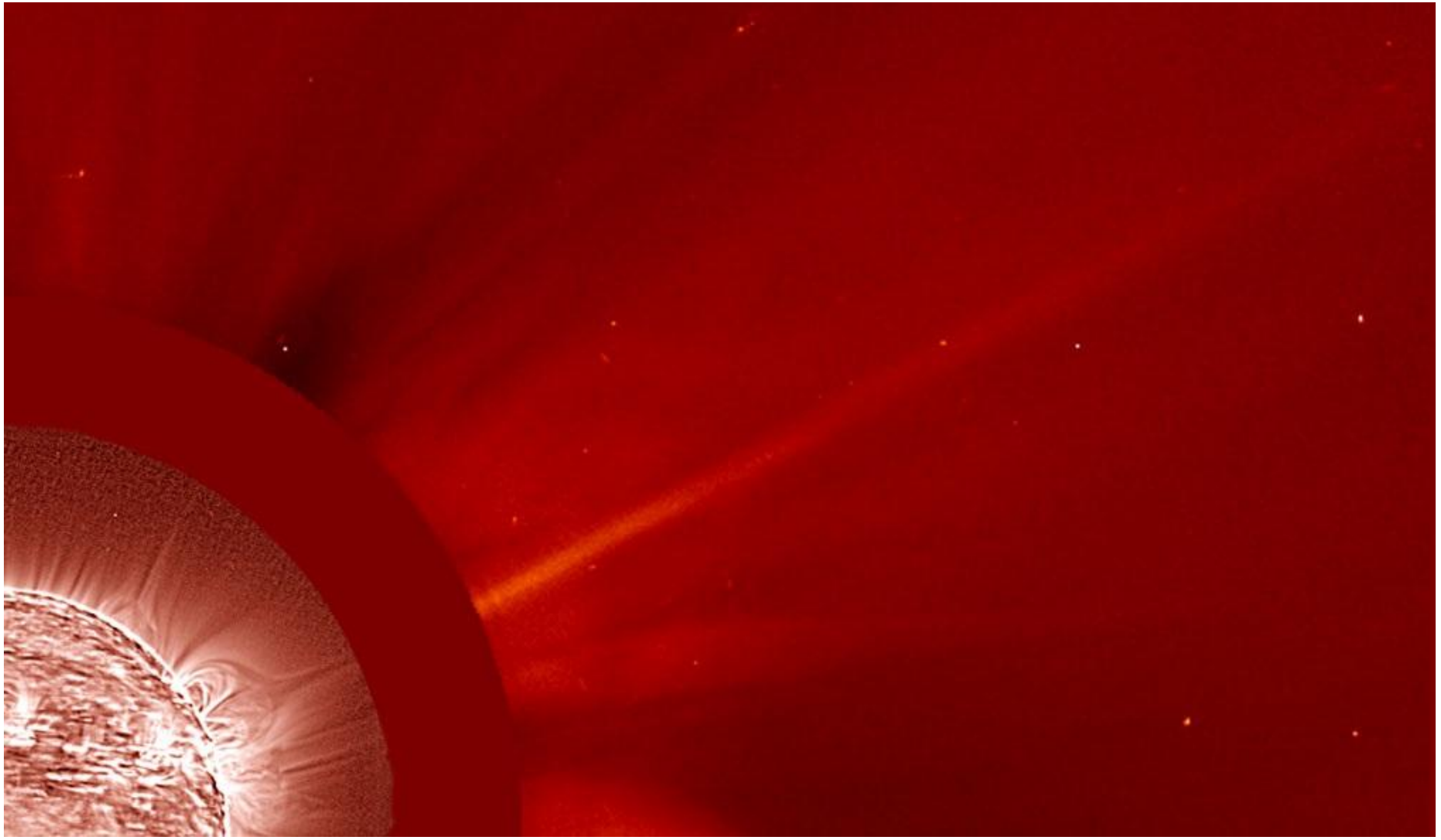
The topology and evolution of the coronal structures were imaged i/at high resolution using the *Atmospheric Imaging Assembly* (AIA) onboard the *Solar Dynamics Observatory* (SDO), ii/ with the STEREO spacecrafts and different points of views

Larger field-of-view images of the corona were obtained using the SWAP onboard PROBA2 microsatellite, providing evidence for the connectivity of the coronal structures with outer coronal features that were imaged with the (LASCO) C2 on SOHO.

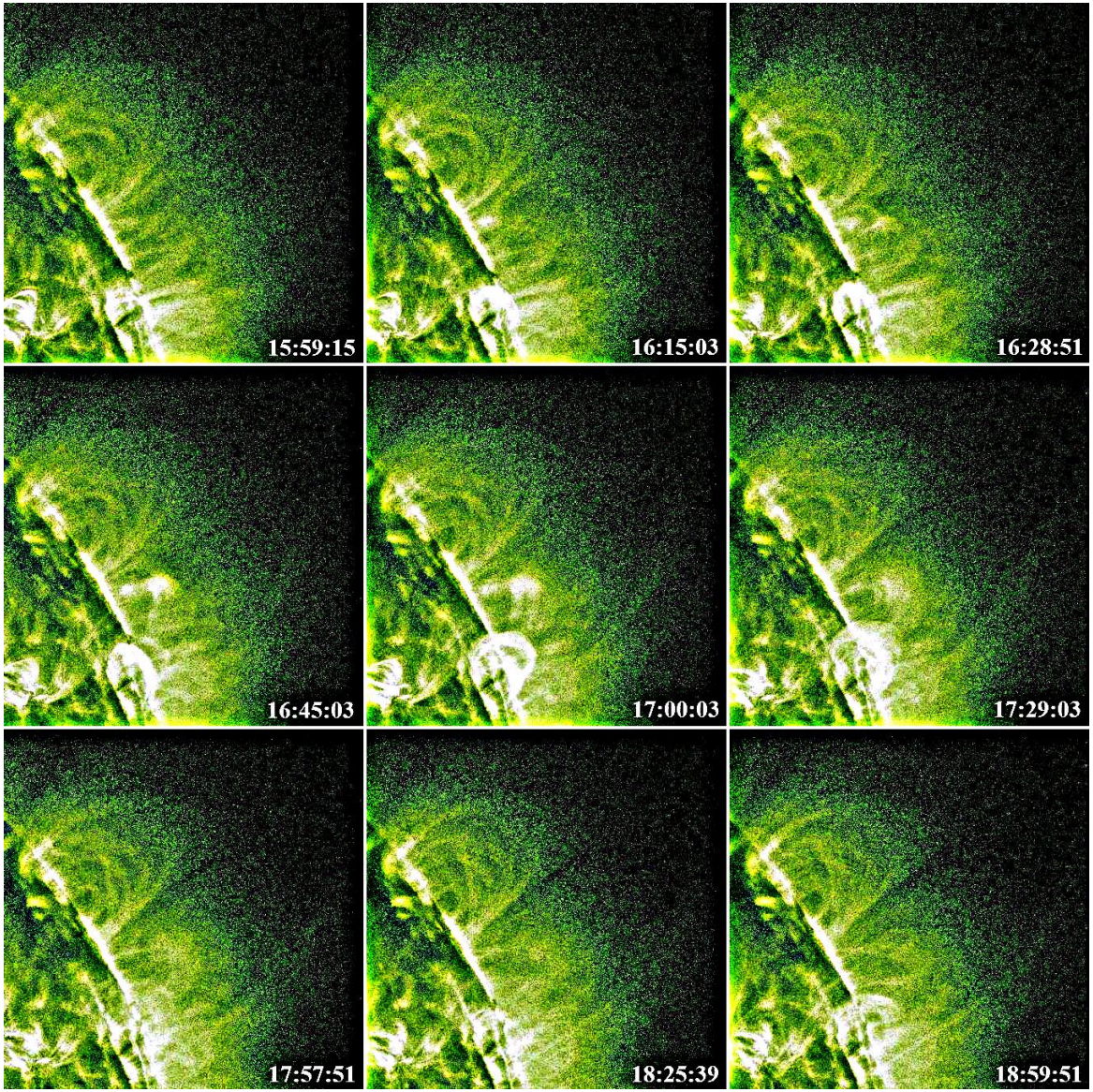
The data-sets reveal an Eiffel-tower type jet configuration extending into a narrow jet in the outer corona.



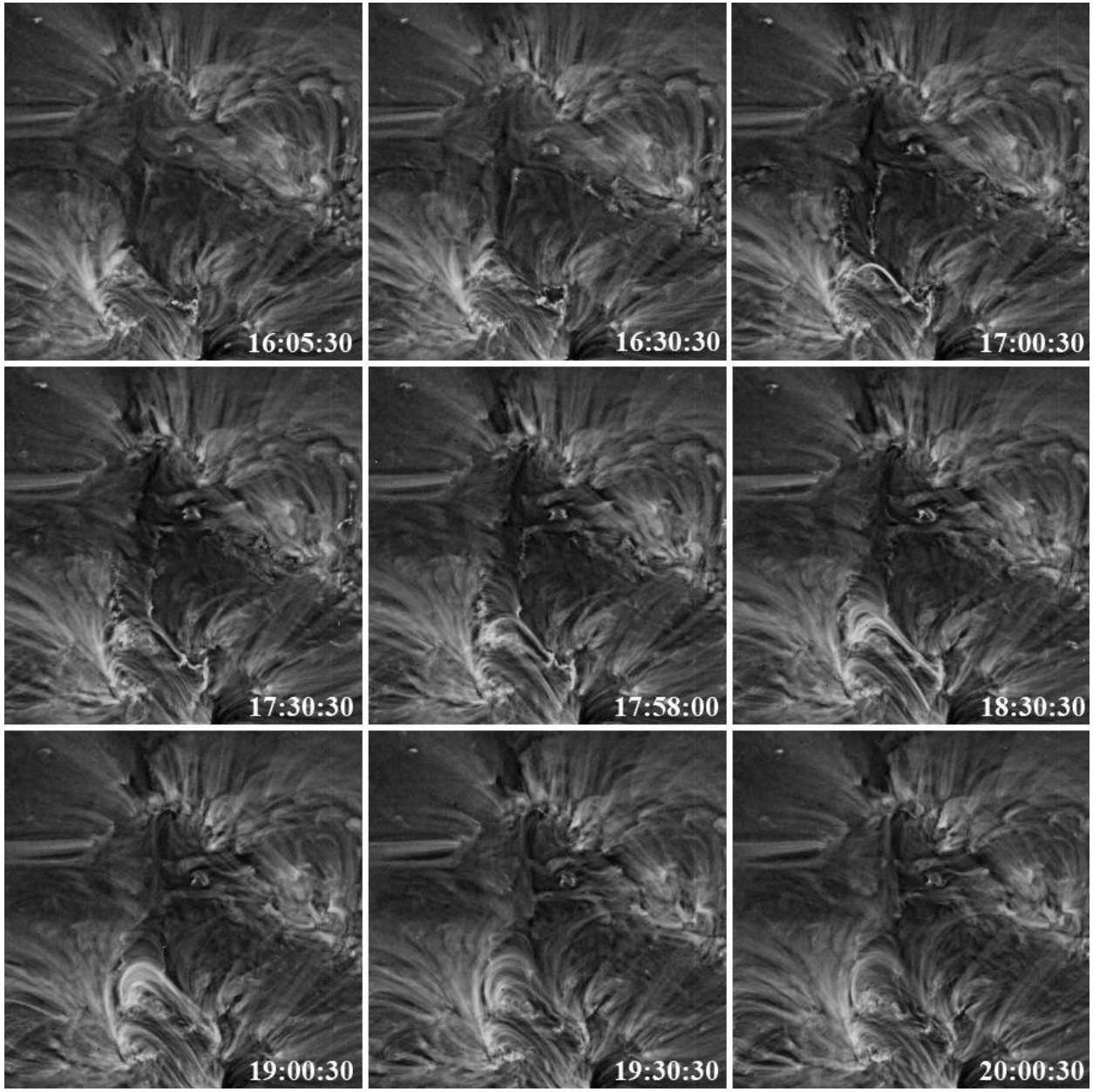
SWAP 171 Å images showing the development of the hyperbolic cavity to large distance from the limb. The right-hand image is obtained by summing 200 images taken from 22 UT to 23 UT and applying the unsharp mask filter after. (Courtesy of the PROBA2/SWAP team)



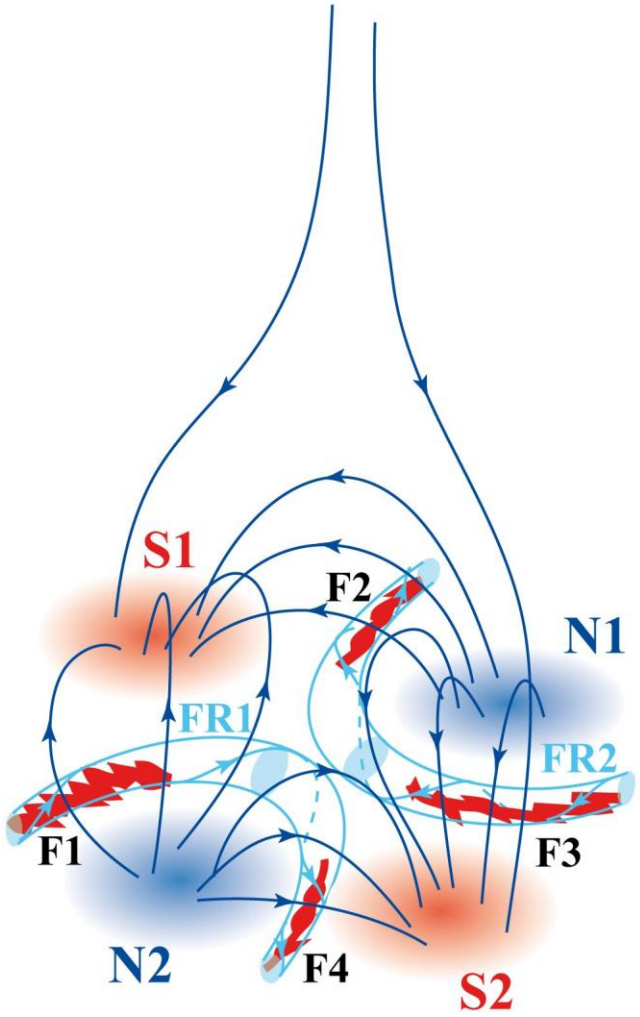
Composite image of the white-light SOHO/LASCO C2 image on 7 April 2011 at 22:00 UT and SWAP 171 Å image (inside)



April 7, 2011 AIA 94 Å images showing the raising of a bright loop system below the hyperbolic cavity. (Courtesy of NASA/SDO and the AIA science team).

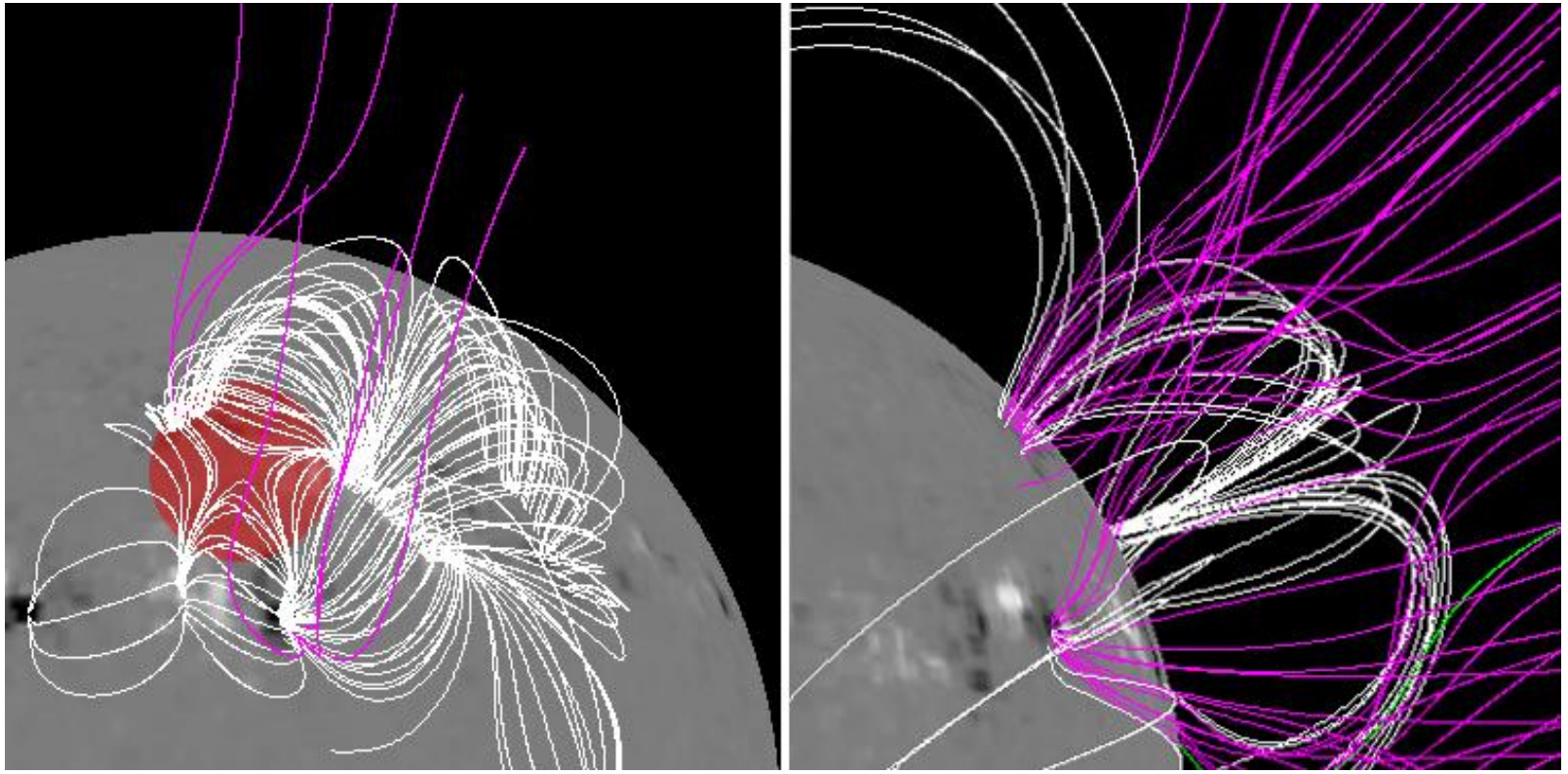


STEREO B SECCHI EUVI 195 Å images of the jet source region on 7 April 2011. An unsharp mask filter was applied to make individual coronal loops more visible. (Courtesy of STEREO/SECCHI Consortium).



Schema of the magnetic configuration of the active complex before the event

The scenario: we think that the dark volume in the corona descends from a coronal cavity of a flux rope that moved up higher in the corona but still failed to erupt. The quadrupolar magnetic configuration corresponds to a saddle-like shape of the dark volume and provides a possibility for the plasma to escape along the open field lines into the outer corona, forming the white-light jet.



Potential magnetic field lines of the region of interest on 4 April 2011 (left) and 7 April 2011 (right) calculated using a PFSS model. Pink lines show open field lines emanating from a negative polarity. Red circle in the left panel shows the central part of the photospheric quadrupole. (Code courtesy of Lockheed Martin Solar and Astrophysics Lab)

THANK YOU FOR YOUR ATTENTION...

and long life to the SWAP!

From Masson et al 2011, paper in press