FIRST COMBINED OBSERVATIONS IN THE GERMAN-ARGENTINEAN SOLAR OBSERVATORY AT EL LEONCITO

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Abstract

The SOHO era revealed that mass ejections from the Sun include not only hot coronal plasma but also cold prominence material. The role of solar activity (flares or filament eruptions) is not yet well understood. Furthermore, if the cold material pushes the hot one or if the hot one drags the cold one is still an unresolved question. Thus, crucial information about the onset of a coronal mass ejection (both in space and time) can be obtained by combining coronagraphic observations of the emission line corona and H_α images of the sun disk at a high cadence as well as insight about the relation between prominences and coronal mass ejections can be provided.

In the recently inaugurated German-Argentinean Solar-Observatory at El Leoncito (31°48^m S, 69°19^{m}W), San Juan, Argentina, an H_α telescope (HASTA) and a mirror coronagraph (MICA) daily image the solar disk and the inner solar corona. MICA is essentially similar in design to the LASCO-C1 instrument on board SOHO. Since its installation in August, 1997 it has been imaging the inner corona with high temporal and spatial resolution in two spectral ranges: the well known green (~1.8 MK) and red (~1.0 MK) coronal lines at 5303Å and 6374Å respectively. Its field-of-view ranges from 1.05 to 2.0 solar radii above the sun center. Thus, it is ideally suited to observe the hot material and reveal the fast processes that occur in the coronal plasma.

HASTA started operations on May 1998. It is a 110 mm refractor with a focal length of 165 cm, a tunable (+-1Å) Lyot-Filter (central wavelength: 6563Å) with a bandwidth of 0.3Å and a 1280x1024 CCD array. In patrol mode the camera takes images every 30 sec. In high-speed mode full frames can be taken every 2 sec and partial frame images every 0.3 sec. Several explosive events have already been observed (particularly eruptive prominences).

In this work, we present recent combined observations as taken by both telescopes in order to show the capabilities of the instruments. Particular emphasis is put on future applications.

MICA: Mirror Coronagraph for Argentina

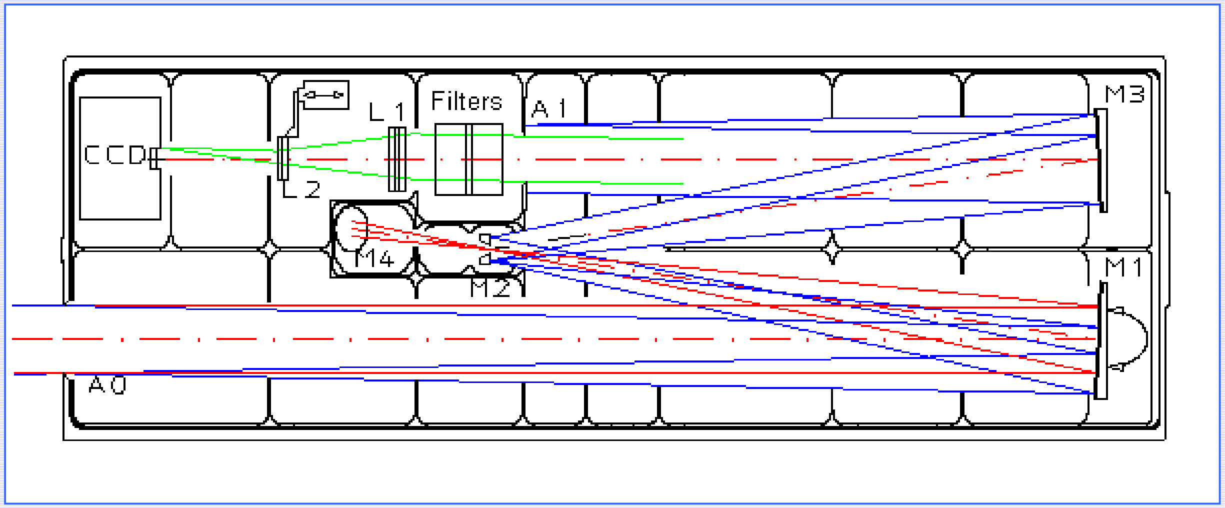


Figure 1: Optical layout

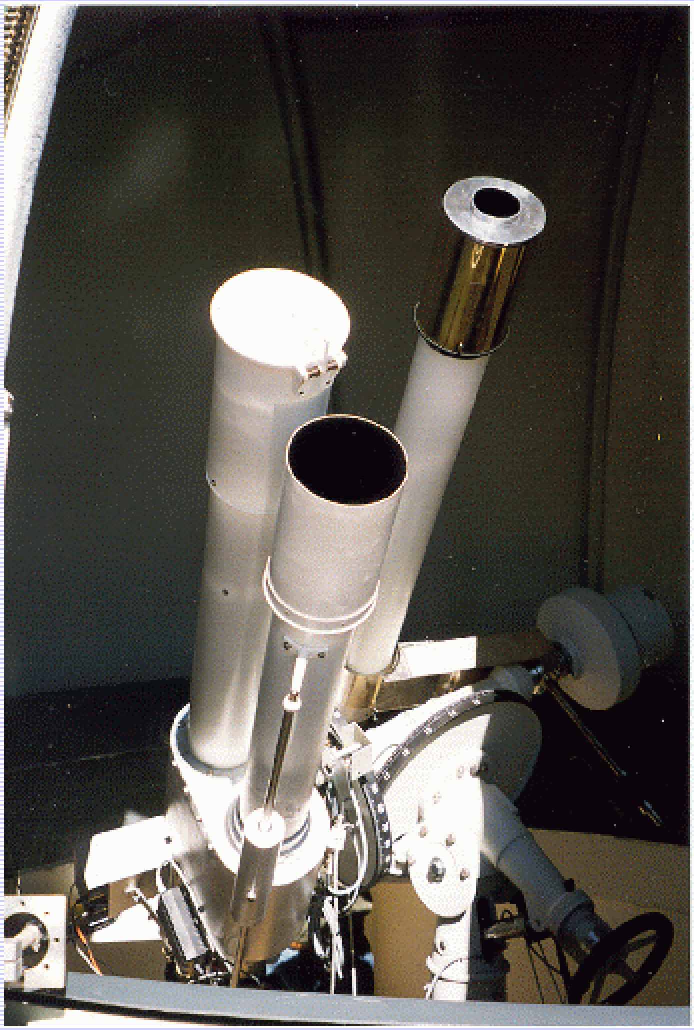
Elem.	Type	Aperture (in mm)	Curvature (in mm)	Remarks
A0	Circ. Aperture	59	-	Entrance
M1	Off-axis Parabola	90	FL = 750	Primary Mirror
M2	Convex Sphere	ID=7 OD=20	R = 2422	Occultor
M3	Off-axis Parabola	90	FL = 750	
S	Shutter	40	-	Mechanical
A1	Annular Aperture	ID=38.4	-	Lyot Stop
TL	Telelens		-	
CCD	Camera	16 μ/pxl	-	1280x1024 pxl (~3.8 arcsec/pxl)

Filter	Aperture (in mm)	Wavelength	FWHM
Fe XIV (On line)	40 (1)	λ5303 Å	Δλ= 0.9 Å
FeXIV (Off line)	40 (1)	λ5260 Å	Δλ= 9.0 Å
Fe X (On line)	40 (1)	λ6374 Å	Δλ= 0.9 Å
Fe X (Off line)	40 (1)	λ6340 Å	Δλ= 9.0 Å
H alpha	40 (1)	λ6563 Å	Δλ= 3.0 Å

... more information about MICA in Stenborg et al. (1999) and http://star.mpae.gwdg.de/mica/mica_home.htm

HASTA: H-Alpha Solar Telescope for Argentina

Location	El Leoncito, San Juan, Argentina. • Longitude 69.3 S • Latitude 31.8 S • Altitude 2370 m
Objective	Observation of solar flares, plages and eruptive prominences in H_{α}.
Telescope	• Diameter = 10 cm • Focus = 170 cm
Filter	• Tunable Lyot-Filter • Central wavelength 6563 Å • Bandwidth 0.3 Å • Tuning range ~ 1 Å
Camera	• CCD, Super VGA, 1280 x 1024 pixels • Pixel size 6.7 x 6.7 µm
Resolution	1.5 arc sec
Operational modes	• Patrol image every 2-3 min • High time resolution image every 3 sec
Integration time	50 - 100 msec



... You can find more information about HASTA in another poster in this meeting as well as in:

http://www.mpe.mpg.de/www_plas/HASTA/hasta_home.html

Some Comments on Image Processing

The unprocessed direct images from MICA show practically no coronal signal. They are affected by the strong radial gradient of the instrumental straylight and the scattered light in the terrestrial atmosphere. Furthermore, the images taken at line center (on-line images) have also an additional contribution from the continuum (or 'white') corona which is due to Thomson scattering of the photospheric light by electrons in the corona. In order to remove the aforementioned contributions from the on-line images and reveal the coronal structures it is then necessary to subtract a nearby continuum image (off-line images) from the on-line ones, taken at a wavelength sufficiently far from line center, i.e., at 5260 Å for the green line, to avoid contamination by emission in the line itself. Both on- and off-line images are bias-corrected and flat-fielded before subtraction. Since the flat-fields are also used for calibration purposes, after 14 images flat-fields for both images are taken. In order to reduce the effects of the sky variability (and also the effects of solar rotation on the structures along the line of sight) it is necessary to obtain the reference continuum images very close in time to the respective on-line images. For the observations presented here, the time difference between the on- and off-line images used is not longer than 3 minutes. A detailed description of the calibration procedure will be presented in a dedicated paper. The MICA images presented were made up of the average of the treated images taken in a time lapse of 10 minutes in order to increase the signal to noise ratio.

As for MICA, the data taken with the HASTA telescope are recorded in ‘fits’ format. They were recorded as full-disk images, the exposure time being 100 msec. For morphology studies like the presented in this poster, the images only need to be centered and corrected for limb darkening. Furthermore, they have been scaled to the spatial resolution of MICA images (3.8 arc sec pixel^{-1}).

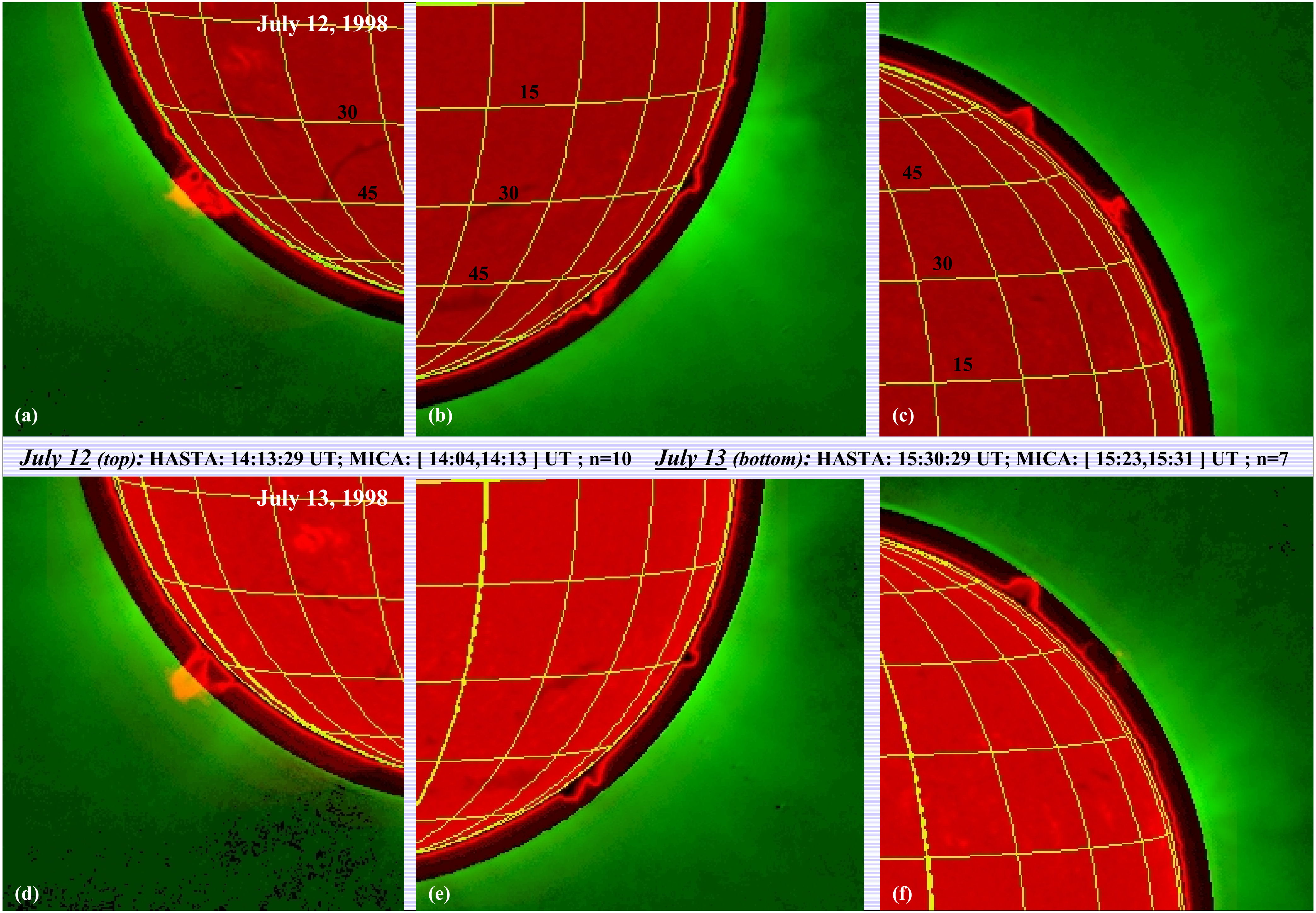
Figure Captions

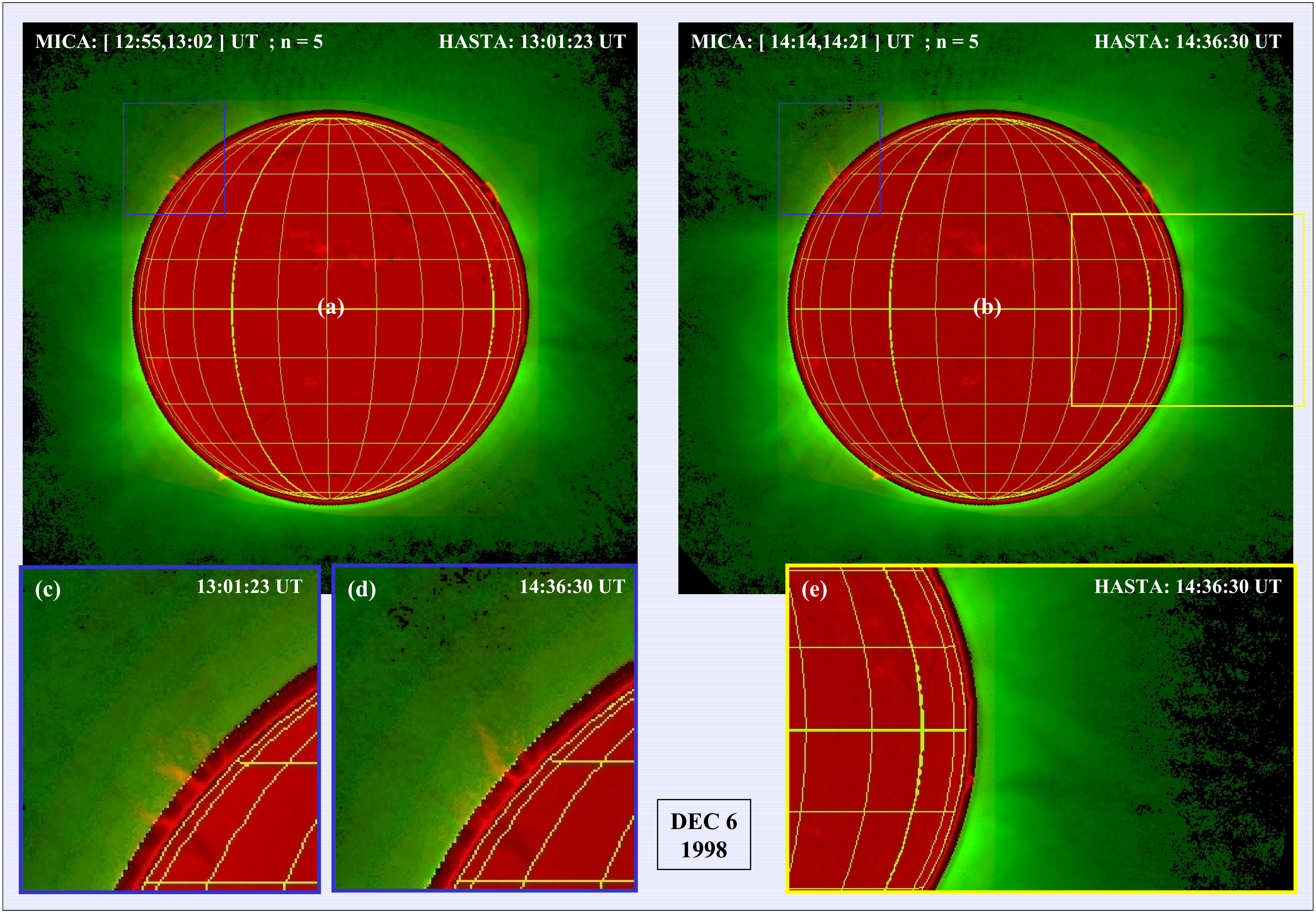
Figure 2: Composite images of MICA green line emission (5303Å) and HASTA H_α (6563Å) images taken on July 12 at ~14:13 UT (top) and July 13, 1998 at ~15:30 UT (bottom). Panels *a)* and *d)* show the south-eastern limb, *b)* and *e)* the south-western limb, and *c)* and *f)* the north-western limb. 'n' indicates the number of images used in making the 10 minutes MICA average image

Figure 3: Embedded images showing the temporal evolution of the MICA and HASTA observations in the green line emission and H_α respectively on November 9, 1998. Note the prominence eruption seen at ~25°S apparent latitude and the corresponding enhancement in the Fe XIV emission line. The green line loop starts growing some 30 minutes before any movement could be recorded with HASTA.

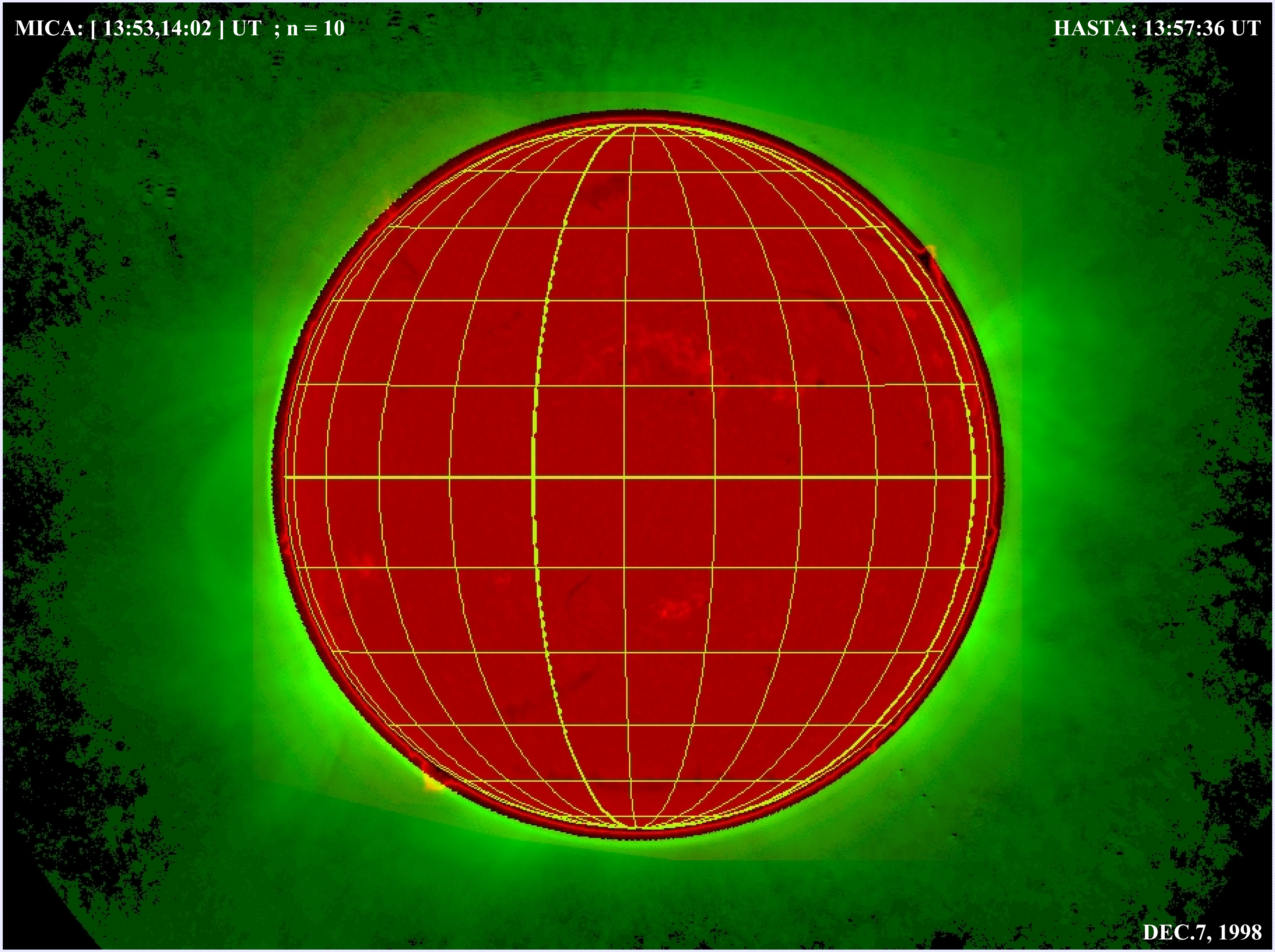
Figure 4: Embedded H-alpha and MICA images taken approximately 1.5 hours apart on December 6, 1998. The observed coronal large-scale pattern remains without any remarkable change. On the shorter scale, the dark region above the prominence in the NE limb (panels *c* and *d*) seems to follow the evolution of the prominence. Panel *e)* shows a zoom view of the western limb. The footpoints of the dark 'loop' observed in green line appear to be anchored in the chromosphere, where the enhancement in H_α is seen.

Figure 5: Embedded image as seen by MICA (Fe XIV line emission) and HASTA (H_α) on December 7, 1998. As in previous figures, note the lack of hot material in zones above filaments and prominences.


July 12, 1998
30
45
15
30
45
45
30
15
(a)
(b)
(c)
July 12 (top): HASTA: 14:13:29 UT; MICA: [14:04,14:13] UT ; n=10
July 13 (bottom): HASTA: 15:30:29 UT; MICA: [15:23,15:31] UT ; n=7
July 13, 1998
(d)
(e)
(f)



MICA: [12:55,13:02] UT ; n = 5
HASTA: 13:01:23 UT
(a)
MICA: [14:14,14:21] UT ; n = 5
HASTA: 14:36:30 UT
(b)
(c)
13:01:23 UT
(d)
14:36:30 UT
(e)
HASTA: 14:36:30 UT
DEC 6
1998


MICA: [13:53,14:02] UT ; n = 10
HASTA: 13:57:36 UT
DEC.7, 1998

Discussion and Future Prospects

The three examples shown in the present paper are just one sample of one year of continuous and joint operation, and good examples of the contributions the two instruments can provide. MICA images are shown in green color table, whilst HASTA images in red color table.

Examination of identifiable features in the presented images show a clear correspondence between the coronal pattern and the respective H_α features close to the limb. Evolution in morphology of hot and cool structures can be very well tracked with both instruments. Furthermore, depletion of hot material can be seen in most cases above prominences or filaments. The relationship of these dark voids above prominences with the three-part structure of coronal mass ejections (CME) seen in white light will be the topic of future investigation. Green line events can be correlated with H_α events almost simultaneously, this fact allowing addressing questions such as whether the release of chromospheric material produces (or is cause of) green line transients. Also the relationship of green line transients to CME can be traced back to the sun with the help of the almost simultaneous observations of both ground-based instruments and the two LASCO coronagraphs (C2 and C3) onboard SOHO spacecraft (Brueckner et al., 1995). Therefore, both instruments (MICA and HASTA) can provide for instance, useful observations for the understanding of the role of the prominence in triggering or driving the CME, question which has not been settled yet. In addition, the initial acceleration close to the Sun seems to play an important role in the propagation of coronal mass ejections in the outer corona (Srivastava et al., 1999). In this context, the fact that MICA can observe inner corona as compared to LASCO-C1 with higher time resolution jointly with HASTA allows us to address this question in an effective way.

Conclusions

Our intent is to provide MICA and HASTA data to the scientific community as soon as possible. The scientists are welcome and encouraged to participate in the analysis of these data in collaboration with the institutions involved. Our goal, which we expect to achieve in near future, is to have access to summary data in almost real time once the Internet connection to the site becomes available. For the time being, concerning coronal data, daily processed 10 minutes green line average images are published in MICA home page as soon as they are received and processed (***http://star.mpae.gwdg.de/mica/mica_home.htm***). Data request can be made by e-mail to stenborg@linmpi.mpg.de. Concerning H-alpha data, you can consult the data available upon request in HASTA home page: ***http://www.mpe.mpg.de/www_plas/HASTA/datareq.html***.

Acknowledgments

This study is based on data obtained in the framework of the German-Argentinean HASTA/MICA Project at OAFA (El Leoncito, San Juan, Argentina), in a collaborative effort by IAFE, OAFA, MPAe and MPE.

References:

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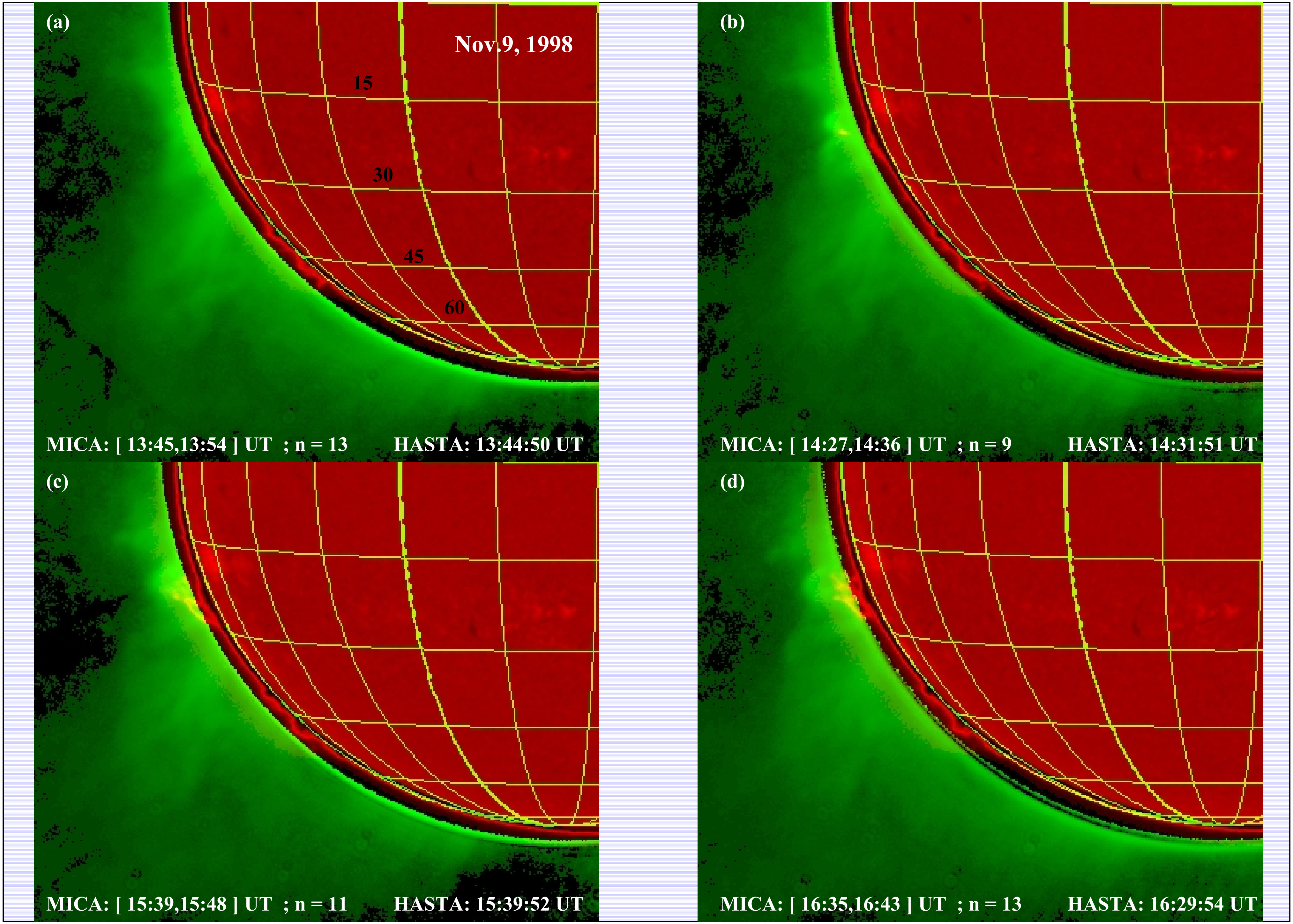
* Srivastava, N., et al., 1999, Solar Wind 9, AIP CP **471**, eds. S. R. Habbal, R. Esser, J. V. Hollweg and P. A. Isenberg, pp. 115-118, New York.


(a)
Nov.9, 1998
15
30
45
60
MICA: [13:45,13:54] UT ; n = 13
HASTA: 13:44:50 UT
(b)
MICA: [14:27,14:36] UT ; n = 9
HASTA: 14:31:51 UT
(c)
MICA: [15:39,15:48] UT ; n = 11
HASTA: 15:39:52 UT
(d)
MICA: [16:35,16:43] UT ; n = 13
HASTA: 16:29:54 UT