Recent Observations of the solar corona with a new ground-based coronagraph in Argentina (MICA)

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Abstract

As part of the new German-Argentinian Solar-Observatory in El Leoncito, San Juan, Argentina, a new ground-based solar telescope (Mirror Coronagraph for Argentina, MICA) began to operate in August 1997. MICA is an advanced mirror coronagraph, its design being an almost exact copy of the LASCO-C1 instrument. Since its installation, it has been imaging the inner solar corona (1.05 to 2.0 solar radii) in two spectral ranges, corresponding to the emission lines of the Fe XIV and Fe X ions. The instrument can image the corona as fast as every minute. Thus, it is ideally suited to study the fast processes in the inner corona. In this way it is a good complement for the LASCO-C1 instrument.

After a brief review of the characteristics of the instrument, we present some recent observations. We show the structure and temporal evolution of the inner corona and compare the observations with those obtained by LASCO.

Introduction

In the first LASCO meeting, held in 1988 at Max Planck Institut für Aeronomie (MPAe) the need for complementary ground observations was recommended as highly desirable. For the time being regular observations of the solar corona in different wavelengths are performed from several high-altitude stations around the globe (for a review see Niot and Noëns, 1996).

MICA is a ground-based solar telescope installed in El Leoncito, Argentina, as part of a bilateral science program between Argentina and Germany. The participating institutions are: Instituto de Astronomía y Física del Espacio (IAFE) and Observatorio Astronómico "Félix Aguilar" (OAFA), San Juan University, on the Argentinian side and MPAe on the German side.

MICA is an advanced mirror coronagraph which complements the existing and planned solar telescopes in El Leoncito, especially HASTA (H Alpha Telescope for Argentina, Max Planck für Extraterrestrische Physik).

Since August 1997, MICA daily observes the inner solar corona above the limb (from 1.05 to 2.0 solar radii from the center of the sun) in various spectral ranges. The main feature of the instrument is its high temporal resolution, which enables to record transient phenomena in order to study the processes that occur in coronal transients and the conditions that trigger them, as well as the spatial structure and temporal evolution of the inner corona on both fine and large scale.

The global change of the Earth's atmosphere due to pollution is certainly one of the major issues mankind should be concerned about. Pollution by dust particles, chemicals, and humidity change the atmosphere's transparency for both the incoming solar spectrum and the re-radiated energy. The relative roles of man-made pollution (e.g. agriculture, chemical industry, cars) and natural pollution (e.g. from volcanoes, meteorite impacts, forest fires) are still far from understood. Careful monitoring of the status of our atmosphere all around the globe is essential for progress in environmental research. In this context MICA will produce an important contribution as well. The instrumentation allows an extremely sensitive and accurate determination of the sky transparency and the scattered light levels. Amount and spectral distribution of the sunlight scattered in the sky above the observatory are sensitive indicators of amount and type of atmospheric pollution. Therefore, MICA also measures the sky brightness in the visible range of the solar spectrum. These data are being generated on a routine basis, every day since August 1997. Close collaboration with atmospheric scientists of the various disciplines is intended in order to achieve a global understanding.

The Site

MICA is installed in the Prof. Ulrico Sesco Observing Station of OAFA at El Leoncito, San Juan, Argentina, 50 km eastwards from the Argentinean “Cordillera de los Andes”.

- Longitude: 69.30 W
- Latitude: 31.80 S
- Altitude: 2400 m

Panoramic view of the Prof. Ulrico Sesco Observatory, with the Andes chain in background (6000 m high in average).

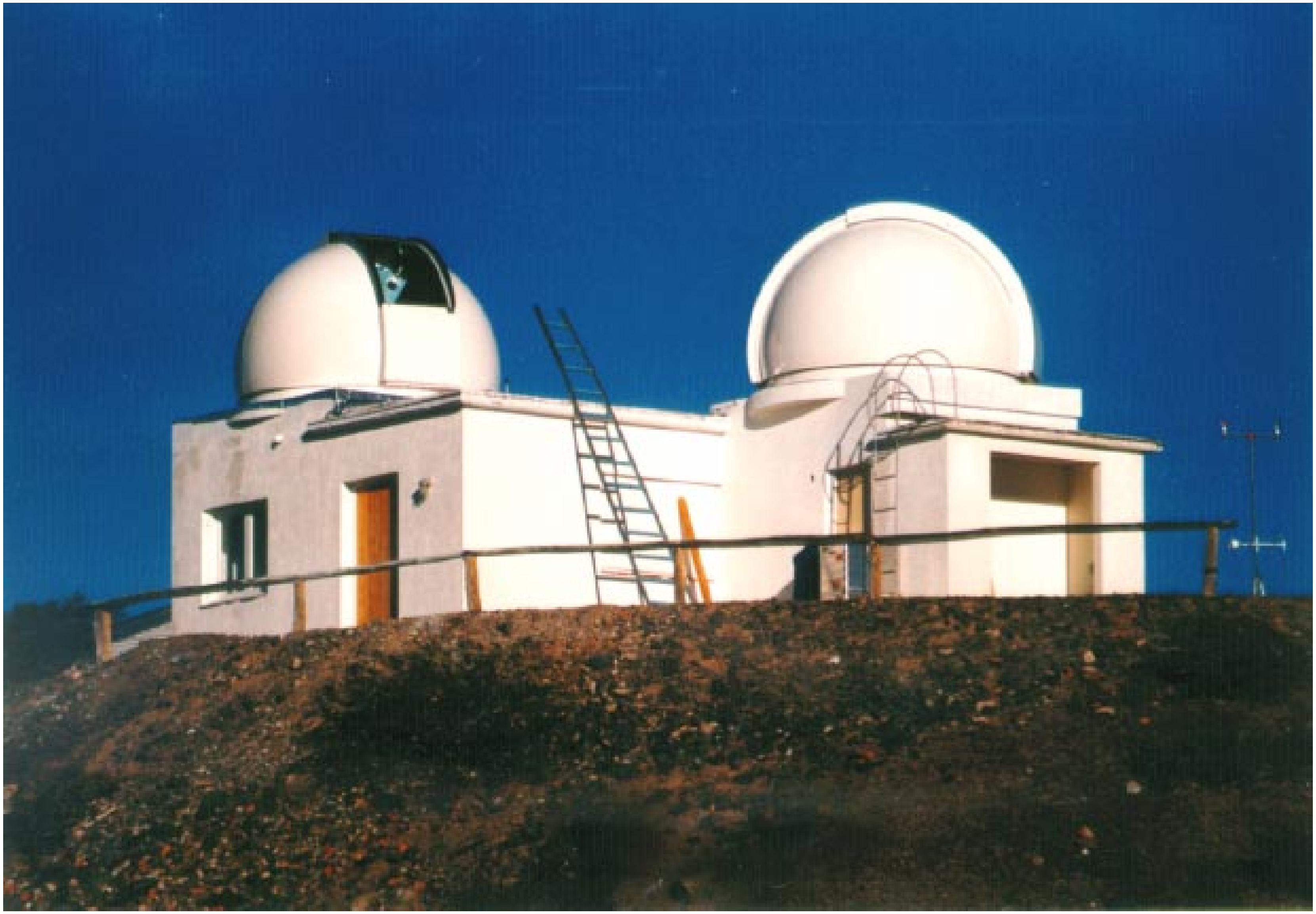
This site offers major advantages for coronagraphic solar observations:

- extremely low air humidity,
- desert climate, i.e. no significant vegetation nearby; no colonization and other human activities causing dust, pollution, insects or other disturbances nearby,
- usually fairly quiet winds for large fractions of most days
- no civil or military airline traffic.

MICA and HASTA building.

Under the open dome, MICA observing the corona…


El Leoncito
BOLIVIA
PARAGUAY
BRAZIL
URUGUAY
CHILE
PACIFIC
OCEAN
ATLANTIC
OCEAN
FORMOSA
CHACO
SANTA FE
CORRIENTES
ENTRE RIOS
CORDOBA
SAN LUIS
MENDOZA
LA PAMPA
BUENOS AIRES
NEUQUEN
RIO NEGRO
CHUBUT
SANTA CRUZ
TIERRA DEL FUEGO
ISLAS MALVINAS
Santiago
Valparaiso
Concepción
Puerto Montt
Montevideo
Buenos Aires
La Plata
Mar del Plata
Bahía Blanca
Viedma
Rawson
Puerto Deseado
Comodoro Rivadavia
San Carlos de Bariloche
Asunción
Stanley
Argentina
International boundary
Provincia boundary
National capital
Provincia capital
Railroad
Road
300 Kilometers
300 Miles
Base 504608 (546795) 6-81



MICA (left) and HASTA (right) building.

Schematic layout of MICA

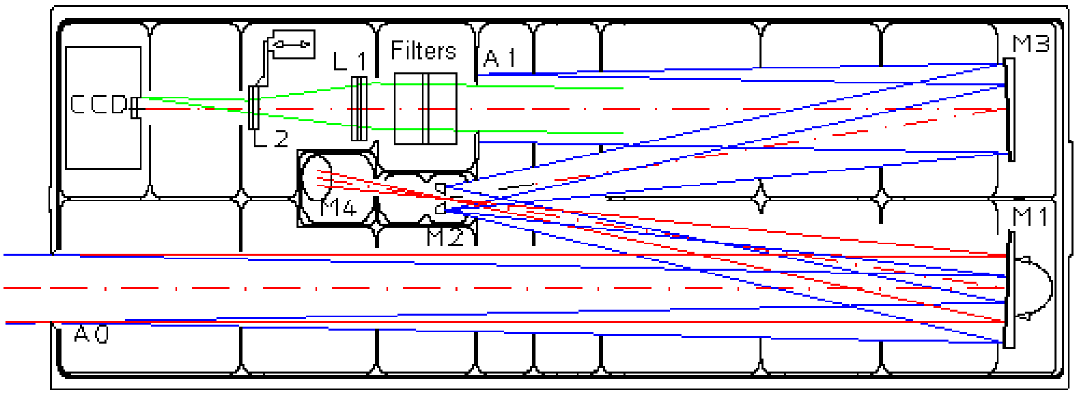


Figure 1: *Optical layout of MICA*

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 pxls

Table 1a:

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

Table 1b: *Filters*

Auxiliary Instruments

- Sky Tester

  It measures the brightness of the sky around the sun disk (aureola). Very sensitive to the clouds.

- Sun Tester

  It measures the intensity of the sun disc.

Measurements of the aforementioned intensities are made every 5 seconds in average. These values are then used <u>by the control software of the telescope</u> (in conjunction with the wind speed as obtained by a weather station) to automatically decide whether the conditions are good for coronal observations.

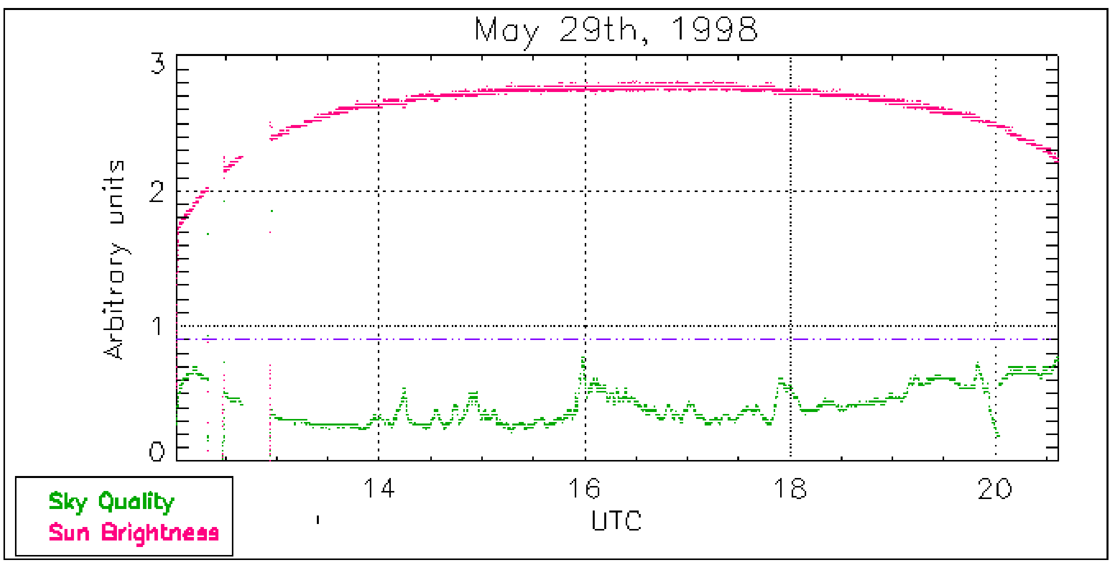


Figure 2: *Example of intensities recorded by sky and sun tester. The dashed line correspond to the threshol for the sky intensity.*

Comparison with Lasco-C1

The MICA system is almost identical to the LASCO-C1. However, there are a few differences (LASCO features in parentheses):

- MICA uses a set of narrow-band interference inserted alternately using a specifically designed mechanism (Fabry-Perot interferometer).

- MICA’s field-of-view reachs out to 2.0 solar radii (3.0).

- The inner edge of the field of view is 1.05 solar radii (1.1).

- A pixel in the MICA system subtends 3.7 arc-sec (5.6 arc-sec). Thus, the maximum possible spatial resolution is around 8 arc-sec (~12 arcsec).

- The whole telescope is enclosed in a lightweight thermal canister which maintains thermal stabilization of MICA during operations at all seasons in El Leoncito.

- Two of the newly developed sky and sun “testers” are mounted close to MICA in order to register the sky and solar disk brightness continuously. Their signals are used for the automatic operation of the telescope.

MICA and the driver electronics are protected by a small cupola of 3 m diameter with a removable roof. The control electronics, computers and screens are located at a common control center used also by SPECHA. <u>During operations, the presence of an observer right at the MICA site is usually not required.</u>

Conclusions

❖ MICA has been in operation since August 1997. Several test and calibration sequences were run during the first months. In particular:

- Adjustment of the working temperature of the filters
- Development of algorithms for the automatic control of the instrument, specially for:

✓ Automatic determination of the right exposure time (due to changes in the sky brightness),

✓ Detection and analysis of external factors (sky and solar disk brightness, wind, etc) in order to automatically decide whether the weather conditions allow starting (stopping, continuing) the observation program.

❖ Recent observations made by MICA have shown a very detailed view of transient phenomena in both temporal and spatial scale. We are able to detect the coronal emission corresponding to the Fe XIV and Fe X ions (green and red coronal lines) out to 1.6 solar radii, using tools of image treatment and background correction.

✓ In particular, some recent observations at nearly the same time of the inner solar corona in two spectral ranges (i.e. λ5303 Å and λ6374 Å) have been presented.

✓ For comparison purposes one observation has been shown as observed by MICA and LASCO-C1 instruments.

❖ We conclude:

➢ *the instrument is very well suited to study the processes that occur in coronal transients and the conditions that trigger them, as well as the spatial structure and temporal evolution of the inner corona on both fine and large scale. This is possible due to the reduced stray light level of the instrument and the good atmospheric conditions of the selected site.*

❖ Future Plans:

✓ To continue exploiting the high temporal resolution of MICA in order to study fast processes in the inner solar corona,

✓ To take advantage of the high sensitivity of the instrument to the incoming radiation in order to study the temporal evolution of the atmosphere's transparency.