THE PIC DU MIDI SOLAR SURVEY

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Abstract.

We carry a long term survey of the solar activity with our coronagraphic system at Pic du Midi de Bigorre in the French Pyrenees (CLIMSO). It is a set of two solar telescopes and two coronagraphs, taking one frame per minute for each of the four channels : Solar disk in H- α (656.28 nm), prominences in H- α , disk in Ca II (393.3 nm), prominences in He I (1083 nm), all year long, weather permitting. Since 2015 we also take images of the FeXIII corona (1074.7 nm) at the rate of one every 10 minutes. These images cover a large field: 1.25 solar diameter, 2k*2K pixels, and are freely downloadable form a database.

The improvements made since 2015 concern an autoguiding system for better centering of the solar disk behind the coronagraphic masks, and a new Fe XIII channel at $\lambda = 1074.7$ nm. In the near future we plan to provide radial velocity maps of the disc and polarimetry maps of the disk and corona. This survey took its present form in 2007 and we plan to maintain image acquisition in the same or better experimental conditions for a long period: one or several solar cycles if possible.

During the partial solar eclipse of March 20, 2015, the CLIMSO instruments and the staff at Pic du Midi operating it have provided several millions internet users with real time images of the Sun and Moon during all the phenomenon.

Keywords: Sun, corona, survey

1 Introduction

Solar astrophysics have a long story at Pic du Midi: coronagraphy was invented there in the 1930's by Bernard Lyot: Lyot (1939, 1945, 1950) Since then, solar observations have been relayed by space probes, but groundbased work keeps its interest for long term surveys. The images from ground based observatories such as Pic du Midi are complimentary to those from space, and may have an advantage in the long run, for example it may turn out easier to finance a long term survey from ground than with space probes.

The survey that we are carrying is in the frame of the "services d'observation" by the Institut National des Sciences de l'Univers (INSU). This survey could not exist without the important contribution of Observateurs Associés (OA) on many aspects : financial support, human resources for data acquisition and software development, and expertise. This association regroups 90 volunteer astronomers, who take turns (one week durations) at Pic du Midi observatory by teams of two: almost every week of the year is covered. There is a detailed story and description of this association on their web site : http://www.climso.fr.

The deal offered to the volunteer astronomers is free accommodation for one week at Pic du Midi in exchange of their work during that week. The lodging fees are paid by funding from Université de Toulouse. Observatoire Midi Pyrenees (OMP) and its staff take in charge all the mechanical and heavy logistic aspects.

2 the present instrument

The four telescopes are grouped on an equatorial mount. Two coronagraphs with 20 cm apertures cover the whole sun with a field from 1.002 to 1.25 solar radius: one dedicated to the H- α prominences and the other to the He-I prominences at $\lambda = 1083.0$ nm. In addition there are two solar telescopes: one 15 cm aperture centered

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on the H- α line, and one 9 cm aperture on the Ca-II line at $\lambda = 393.3$ nm. These four instruments and the associated data base are operational since march 2007. Details on the instrument and its history can be found on http://www.climso.fr , and on http://bass2000.obspm.fr/solar-spect.php as well as in Dettwiller & Noens (2008). A quick view of the most recent images is also available there, although a more complete set of images can be downloaded from the databases (see examples in Fig. 1 and Fig. 2). The data base contains images (nominally one per minute per instrument, weather permitting) and films made from these images. An example of image exploitation can be found in Romeuf et al. (2007). Also available are combined images of prominences and solar disk.



Fig. 1. Left: Detail of the solar chromosphere in H α (λ =6162.8 nm) taken with the CLIMSO-L1 solar telescope at Pic du Midi. The actual image covers the whole solar disc with the same resolution. **Right:** Ssolar prominence in H α (λ =6162.8 nm, taken 2015-09-30 at 07:41:37 U.T. with the CLIMSO-C1 coronagraph at Pic du Midi. Images are taken every minute (weather permitting) and sent to a public database. The occulting disc is adjusted to the solar apparent diameter so that the observable field starts at 1.001 solar radius.

3 the autoguiding system

In summer 2014 we added an autoguiding, to achieve a precise superposition (nominally 1 arc second) of the solar disk image onto the coronagraphic mask, in both coronagraphs. A dedicated telescope is placed along one of the coronagraphs, and uses a Fresnel array as objective, Koechlin et al. (2012) : a 50 μ m thick copper foil punched with several thousand miniature holes of special shapes and positions (adding up to almost half of the total surface) and focussing the solar light by diffraction. The angular resolution (diffraction limited for monochromatic light) is the same as that of a classical lens of same diameter, here 62 mm. The chromatism induced by the diffractive focusing is strongly reduced by a filter in front of the camera. A 1 nm bandpass filter is good enough here, but diffraction limited imaging requires a slightly narrower bandpass. The frames (one par second) are processed on line: the position of the solar disk is computed by correlation with a circle and



Fig. 2. Left: Solar corona seen with the CLIMSO C2 coronagraph during the partial solar eclipse at pic du midi, 2015-04-20. Right: solar corona in Fe XIII seen by coronagraph C2 during a "normal" day and clear sky at pic du midi. The nominal frame rate for the coronal images sent to the data base is one every 10 minutes.

this information is used by the autoguiding system, which sends commands to the equatorial mount to correct the mechanical drifts and low frequencies of atmospheric seeing.

4 The data bases

The Images and films from this survey can be downloaded from: http://bass2000.bagn.obs-mip.fr/base/ sun/index.php and from: http://bass2000.obspm.fr/home.php?lang=fr. We plan to improve the compatibility of the CLIMSO images data base with the Virtual Observatory standards, as well as the interoperability with other databases.

5 Future plans

Our future plans for the instruments are the following:

- 1. improve the image quality by lucky imaging techniques in real time;
- 2. improve the image contrast by wavelength modulation and subtraction of references in the continuum;
- 3. photometric calibration of the images (the solar disc images are already available in W m⁻² sr⁻¹);
- 4. add several channels showing polarimetry data and velocimetry data.

We do not intend to interrupt the survey in its present form, but add new data types : the longer the time base, the better. The evolutions we are implementing intend to meet better the needs of the scientific community: comments are welcome. Also, if you use these images, which are public and freely available, please source them.

6 Conclusion

The scientific goals and long term plans for this survey are decided in coordination with the "programmes nationaux" of the Institut National des Sciences de l'Univers (INSU). This survey provides a wealth of solar images and films, which are easily downloadable and can be used freely for research or education purposes. We intend to maintain data acquisition on the same spectral channels and in the same or better instrumental setups for as long as possible: we improve the image quality (angular resolution, contrast) but we keep a backwards compatibility with the previous data sets. We also implement new spectral channel and soon new data types such as velocimetry and polarimetry. You are welcome to give us a feedback on how the data is used and how it could be improved.

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