Mem. S.A.It. Suppl. Vol. 9, 51

Memorie della
Supplementi

Digitization of the Arcetri Solar Photographic Archive

E. Marchei[1,2], I. Ermolli[1], M. Centrone[1], F. Giorgi[1] and C. Perna[1,2]

[1] INAF Osservatorio Astronomico di Roma, Italy
[2] CVS Centre for Study the Variability of the Sun, Italy

Abstract. The solar tower of the Arcetri Astrophysical Observatory produced synoptic observations of the solar atmosphere from 1925 to 1974. The photographic archive contains about 13000 plates of full-disk Ca II K and H_α spectroheliograms acquired during about 5000 observing days. The program to digitize and distribute the images of this archive started at the Rome Astronomical Observatory by CVS (Centre for Study the Variability of the Sun) on 2004 and is now complete. We hereby summarize the digitization work.

Key words. Sun: historical data – Sun: variability – Sun: magnetism

1. Introduction

There is an increasing interest to digitize the precious information contained in the astronomical plate archives, both for the preservation of their content and for its distribution to all interested researchers in order to achieve their better scientific exploitation.
On 2002 the Italian Ministry of University and Research funded a two years large scale project to start a coordinated effort to digitize the archive of plates of five italian astronomical institutes and of the Specola Vaticana (Barbieri et al. 2003). This program included images and spectra plates exposed at different telescopes, but solar data were not treated, mainly due to the huge quantity of solar plates archived.
Nevertheless, the interest to digitize and distribute the data in the Italian historical solar archives is really wide. In fact, the results obtained by the synoptic observations of the solar disk stored on these archives permit a variety of retrospective analysis of the state of solar magnetism and provide a temporal baseline of several decades for the study of many solar properties. These archives also permit to deepen the knowledge of the role of the Sun on the climate change noticed during the last century.
This paper presents the preliminary study carried out to digitize the plates of the solar archive of the Arcetri Astrophysical Observatory. Details about the digitization work carried out by the CVS (Centre for Study the Variability of the Sun) project at the Rome Astronomical Observatory, with the sponsorship of Regione Lazio, are also summarized.

2. The Arcetri Solar Archive

The Arcetri synoptic solar observations constitute one of the elder solar archive in Europe. The photographic archive contains

Send offprint requests to: I. Ermolli, *e-mail:* ermolli@mporzio.astro.it

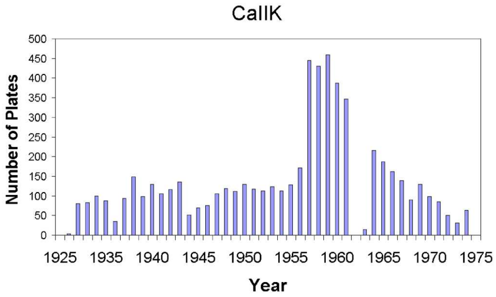

Fig. 1. Number of CaII K spectroheliograms per year.

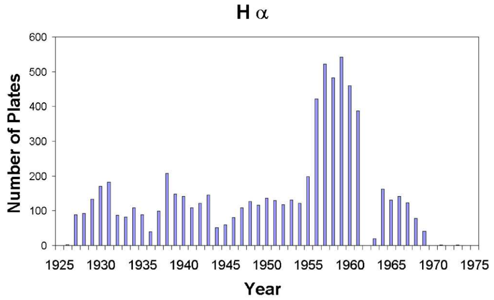

Fig. 2. Number of H_α spectroheliograms per year.

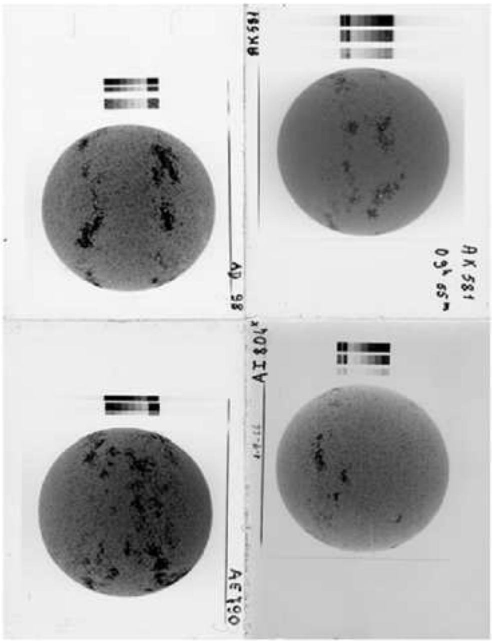

Fig. 3. Example of the images produced by the simultaneous digitization of four plates.

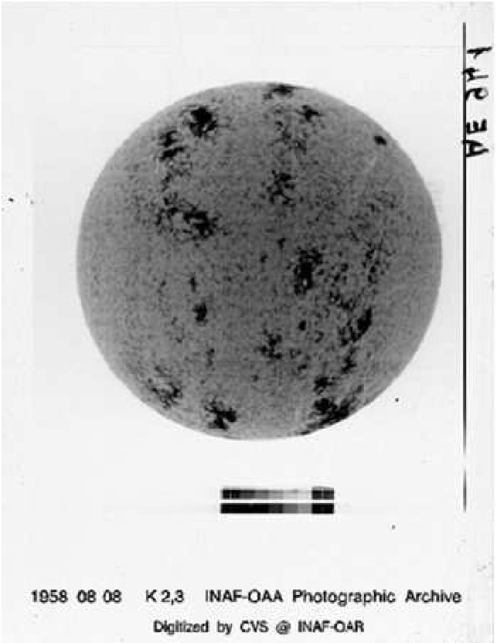

Fig. 4. Example of the digitized images available on line: CaII K Arcetri spectroheliogram taken on 8 August 1958.

12917 plates of full-disk CaII K and H_α spectroheliograms acquired during 5042 observing days at the Arcetri G.B. Donati tower from 1925 to 1974 (Godoli & Righini 1950). The archive contains 5976 Ca II K and 6941 H_α plates respectively. At the time of observations the instrument had a grating of 600 lines/mm and a ruled area of 100 mm × 100 mm, with a dispersion of 0.33 nm/Å at 3934 Å. The size of the solar disk image on the plates changed in time, but, as described in the following, the largest portion of the archive contains a solar disk image on the plate of ≈ 6.5 cm; the spectral window was 0.3Å centered at the CaII K line core. The image scale was about 0.033 mm/arcsec. The instrumentation used to realize the solar archive is not longer available.

The Arcetri solar tower and spectroheliograph showed from the very beginning limitations for the study of the solar surface details (Gasperini et al. 2004; Righini 2003), being the spatial scale of observations degraded by the local seeing on average to about 5 arcsec. Nevertheless, the Arcetri solar archive is unique respect to the other historical series. In fact, more than 65% of the plates in the archive contains the image of a step wedge for the calibration of the non-linear response of the photographic emulsion.

The about 13000 plates of the Arcetri archive are stored in plastic envelops housed in three eight-drawer metal racks at the Arcetri Astrophysical Observatory. A MOU signed between the Arcetri and Rome Observatories allowed the progressive moving of the plates to the Rome Observatory for the digitization work.

3. Preliminary study

Figures 1 and 2 show the number of plates in the Arcetri archive obtained from CaII K and H_α spectroheliograms taken from 1925 to 1974. There is an average of about 100 CaII K and 120 H_α plates per year during the whole period, while the number of plates quadruples from 1956 to 1961.

A preliminary study devoted to define the characteristics of the digitization work was carried out using 80 plates extracted from the archive. The selected plates were acquired in the CaII K radiation between 1931 and 1974; we choose two plates for each available year, one acquired in Winter, the other one in Summer.

The plates stored in the archive have different dimensions and contents. In particular, the ones acquired until 1936 measure 9x18 cm, have two images of the Sun with a diameter of 6.5 cm and do not contain calibration wedges (13% of the whole archive); on the other hand, the later plates measure 9x12 cm, have just one image of the Sun with a diameter of 6.5 cm (87% of the whole archive). 5% of the data is stored on acetate negatives. Calibration wedges were used from 1938 onwards, with just one wedge until 1943 and two or three afterwards.

Three instruments were simultaneously tested to define the digitization work. In particular, we acquired test images of a linear target under different settings using two commercial scanners (Epson Perfection 1200, Epson Expression 1680 pro) and a system endowed with a 1kx1k CCD camera, the latter developed at the Tor Vergata Rome University. To check the instrumentation, we also acquired test images for the whole sample of plates available.

After analyzing the images obtained by working at 600, 1200, 1600 and 2400 dpi, 8 and 16 bit, we concluded that the two scanners work at a maximum resolution of 1200 and 1600 dpi respectively, and make numerical interpolations for higher resolutions. With the Epson 1680 scanner it is possible to digitize four plates at a time in the 9x12 cm format (Fig. 3), three at a time in the 9x18cm format; scanning takes about 5 minutes. On the contrary with the Epson 1200 scanner it is possible to digitize just one plate at a time, the scanning takes about 1 minute. Using the latter instrument there is also need for the realization of a plate adapter. The CCD System shows advantages for both image acquisition speed and homogeneous acquisition. However, the system allows the digitalization of just one plate at a time. An adapter must be made for larger format plates.

The spatial scale and data significance of the solar image produced by the digitization work depend on the characteristics and settings of the instrument used. To define the scanner setting to be used we took into account both the typical seeing of the Arcetri site and the quality of most archive plates. In the best days the seeing during observations was worse than 1 arcsec. The plate quality results affected by lack of homogeneity - typical of the acquisition system (lines, scratches, dragging effects).

We thus decided to perform the whole digitization work by using the 1200 dpi setting. In fact, assuming the angular diameter of the Sun and a 6.5 cm diameter of the solar disk in each plate, a scanner setting of 1200 dpi corresponds to a scale of 0.62 arcsec/dot in the digitized image. Due to the limitations of the typical local seeing, with higher scanner settings (1600, 2400 dpi), no space information content would be added in comparison with the acquired image, whereas lower resolutions (600, 800 dpi), would not allow to resolve some details that could be present occasionally on the solar disk.

The size of the digitized images also varies according to the scanner setting. For example, the size of each image increases from 13 to 46 Mb

assuming 1200 dpi resolution, 8 and 16 bit data significance respectively.
The preliminary analysis of the acquired images suggested that the archive scanning should be performed by using the scanner Epson Expression 1680 Pro, with the setting 1200 dpi and 16 bit significant data. Even though many plates of the available sample seem to be underexposed, the effect of the potential reduced dynamic range of acquisition from 16 to 8 bit certainly would depend on the exposition of individual plates and have to be evaluated with care. We decided that the increase of the information content per pixel obtained acquiring images at 16 bit would not simply produce more digital products for most archive plates.
The instrument and settings so defined allow the scanning of plates in groups of four for most of the archive; each scanning produces a tiff format 8435x11153 pixel image (179 Mb) and takes about 5 minutes.

4. Summary

The digitization of the whole Arcetri solar archive is now complete. The scanning of 12917 plates at 1200 dpi 16bit produced a digital archive of about 500 Gb data (raw images, tiff format). Those data have been stored in DVD and divided following the original Arcetri classification. The digitization lasted about one year.
The full-disk solar images obtained are now available through the CVS portal at the page *http://cvs3.mporzio.astro.it/ cvs/cvs/arcetri.html*. This link accesses the archive containing jpg reduced size images (510x680 pixels respect to the 4210x5576 pixel original size), for a fast display and light on-line storage (Fig. 4). Science quality full-size fits images are available by request at cvs@mporzio.astro.it, but will be soon freely available through the CVS portal.
Procedures for both photographic calibration of the plates and image processing have been also developed during the digitization work. A summary can be found on the CVS webpage, while details are on a few upcoming papers (Ermolli et al. 2005).
The digitized Arcetri images permit a variety of retrospective analyses for the state of the solar magnetism and provide a temporal baseline of about 50 years for the study of many solar global properties.

Acknowledgements. Bruno Caccin incited very often the digitization of the Arcetri solar archive, conscious of its wide scientific interest. We thank Fabio Cavallini and the Arcetri Solar Group for providing the archive, thus allowing the fulfilment of the CVS project, supported by Regione Lazio. We thank Alberto Righini for interesting and helpful discussions.

References

Barbieri, C., Blanco, C. et al., 2003, Mem. Soc. Astron. Ital. Suppl. 3, 351
Ermolli, I., Centrone, M., Giorgi, F., Marchei, E., 2005, Mem. Soc. Astron. Ital., in press
Gasperini, A., Mazzoni, M. and Righini, A., 2004, Giornale di Astronomia, 3, 23
Godoli, G. and Righini, A., 1950, Mem. Soc. Astron. Ital. 21, 4
Righini, A., 2003, Mem. Soc. Astron. Ital. 74, 556