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Synoptic observations with the Coimbra spectroheliograph

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Abstract. Spectroheliograms in the Astronomical Observatory of the Coimbra University (Portugal) have been photographed in the spectral line of Ca II K continuously since 1926 and, since 1989, spectroheliograms in Hα have been photographed as well. Since 2007, all the spectroheliograms have been recorded using a CCD camera. Until July 2010, about 34 000 observations in total were acquired in the spectral bands Ca II K3, Ca II K1, Hα, red continuum, and Hα Dopplergrams (since 2009), covering a period of 85 years (Ca II K3 line). We describe the characteristics of the photographic and digital spectroheliograms, the statistics of the observations, and the utilization of Coimbra spectroheliograms by the solar community.

Key words: Sun: activity – Sun: chromosphere

1. Introduction

The construction of the spectroheliograph at the Astronomical Observatory of the Coimbra University was initiated by Prof. da Costa Lobo in collaboration with the Paris-Meudon Observatory in 1907. The instrument was designed as a twin of the spectroheliograph in Meudon and saw its first light on April 4, 1925 (Mouradian & Garcia, 2007). Regular observations of the full solar disc in the spectral line Ca II K started in January 1926. In the years 1967–1969 the instrument was moved from the old location in the city to the newly built observatory in Santa Clara, the suburb of Coimbra.

In the period 1988–1992, the spectroheliograph was substantially reconstructed (Bualé *et al.*, 2007). It was equipped with a new objective lens ($D = 25\,\mathrm{cm}$, $f = 4\,\mathrm{m}$) and a new optical branch with diffraction grating that serves for the Ca II K and also for Hα observations.

Photographic plates and cut films were replaced by a CCD camera in 2007 (Klvaňa *et al.*, 2007). This change made it possible to add observations in the red continuum near Hα and, after an upgrade of the data-processing software in 2009, to obtain Hα Dopplergrams (Garcia *et al.*, 2010).

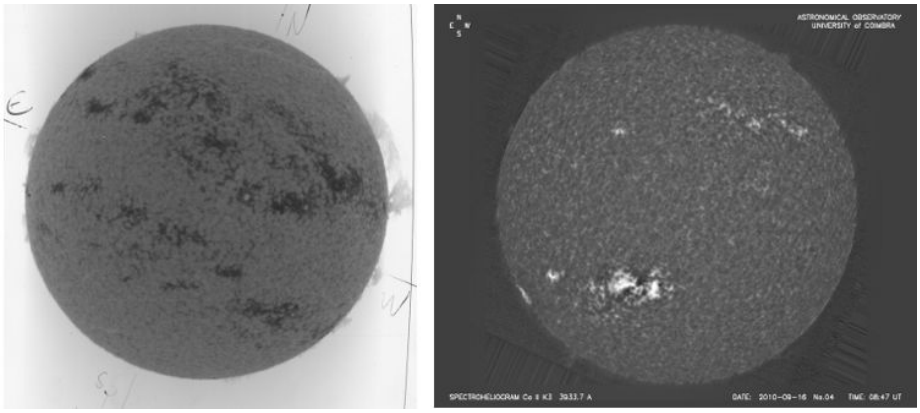

Figure 1. Examples of Coimbra spectroheliograms in Ca II K3. Left – photographic (May 13, 1979); right – digital (September 16, 2010).

2. Characteristics of spectroheliograms

The photographic spectroheliograms obtained in the years 1926–2007 were acquired in the wavelengths 393.37 nm (Ca II K3), 393.23 nm (Ca II K1), and 655.87 nm (Hα). The plate size is 13×18 cm with a plate scale $22''$/mm, so that the solar disc diameter is 87 mm. The spectral bandwidths are 0.015 nm for Ca II K and 0.026 nm for Hα. There is no photographic calibration of the spectroheliograms.

All photographic spectroheliograms were scanned and are available in digital form on the web page `http://tangerine.mat.uc.pt/novo/observatorio/site/index.html`. The scanned spectroheliograms are stored in the form of 8-bit JPEG images with resolution 12 pixels/mm (*i.e.*, $1\farcs8$/mm).

Since 2007, all spectroheliograms have been acquired in the digital form with a 12-bit CCD camera. The observing wavelengths are 393.37 nm (Ca II K3), 393.23 nm (Ca II K1), 655.87 nm (Hα), and 656.28 nm (red continuum), while the bandwidths are 0.016 nm for Ca II K and 0.025 nm for Hα and continuum. An image is usually 1000×1000 pixels large with a plate scale $2\farcs2$/pixel, so that the diameter of the solar disc is approximately 880 pixels. The velocity resolution in the Dopplergrams is 0.57 km s^{-1} in the range ± 15 km s^{-1}. The basic format of the stored data is 16-bit FITS. In addition to it, a series of six 8-bit JPEG images with different transfer tables (Klvaňa *et al.*, 2007) is provided for a quick preview. Examples of spectroheliograms are shown in Fig. 1.

3. Statistics of observations

For the purpose of synoptic observations, one spectroheliogram per day is acquired in each wavelength if the weather permits. The number of observing days

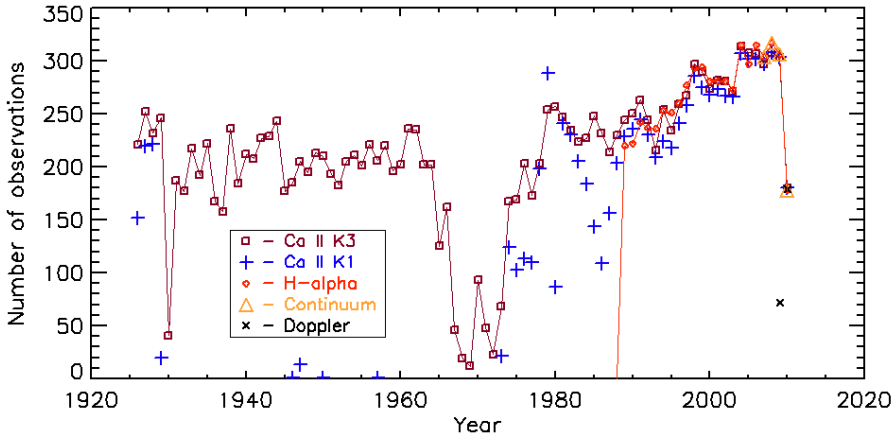

Figure 2. Yearly numbers of observations from January 1, 1926 to July 31, 2010. The number of Ca II K3 observations per year roughly coincides with the number of observing days per year.

fluctuated around 200 per year in the period 1926–1964. It started to increase after moving the instrument to the new site and, since 1998, it has been reaching about 300 days per year. The yearly numbers of observations are shown in Fig. 2.

The spectroheliograms in Ca II K3 currently cover the period of 85 years corresponding to 8 solar cycles. The Hα spectroheliograms have been observed for 22 years, since 1989. The red-continuum observations have been acquired since 2007 and the Dopplergrams since September 2009. Total numbers of spectroheliograms in all wavelengths obtained in the period from January 1, 1926 to July 31, 2010 are summarized in Tab. 1.

Table 1. Total numbers of observations from January 1, 1926 to July 31, 2010.

Wavelength	Ca II K3	Ca II K1	Hα	Continuum	Dopplergram	All
Observations	17770	8871	5933	1105	251	33931

4. Utilization of observations

The Coimbra spectroheliograms are suitable for measurements of the positions, areas, morphology, and long-term evolution of

– sunspots;
– Ca II K and Hα plages;

– prominences and filaments;
– chromospheric network, fibrils, and spicules;
– Doppler velocity structures in Hα.

The daily parameters of solar activity measured on spectroheliograms were published in "Annais do Observatório Astronómico da Universidade de Coimbra" (da Costa Lobo & dos Reis, 1929–1943). Since 1980, copies of selected spectroheliograms have been provided to complement missing observations of the spectroheliograph in Meudon and included into the French BASS 2000 solar survey archive `http://bass2000.obspm.fr/home.php`. After the beginning of the data acquisition with the CCD camera in 2007, all the digital spectroheliograms have been included into the BASS 2000 database.

Finally, let us point out several examples of a recent utilization of the Coimbra spectroheliograms. Spatial distribution of active regions and Ca II K emission features derived from the spectroheliograms, compared with the distribution of solar magnetic and velocity fields, was extensively used to study the evolution of individual active regions and the regularities of spatial distribution of active regions during solar cycles (*e.g.*, Bumba & Garcia, 1994; Bumba *et al.*, 1998, 2000). The association of He II ultraviolet emission with spicules observed in Hα was studied by Andretta *et al.* (2000) and statistics of the north-south asymmetry in the distribution of Ca II K plages were done by Dorotovič *et al.* (2007).

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References

Andretta, V., Jordan, S.D., Brosius, J.W., Davila, J.M., Thomas, R.J., Behring, W.E., Thompson, W.T., Garcia, A.: 2000, *Astrophys. J.* **535**, 438

Bualé, I., Mouradian, Z., Schmieder, B.: 2007, in *Proc. The Physics of Chromospheric Plasmas*, eds.: P. Heinzel, I. Dorotovič and R. Rutten, ASP Conf. Series, **368**, 15

Bumba, V., Garcia, A.: 1994, *Sol. Phys.* **155**, 257

Bumba, V., Garcia, A., Jordan, S.: 1998, *Astron. Astrophys.* **329**, 1138

Bumba, V., Garcia, A., Klvaňa, M.: 2000, *Sol. Phys.* **197**, 175

da Costa Lobo, F.M., dos Reis, M., 1929–1943, *Annais do Observatório Astronómico da Universidade de Coimbra*, Vol. I–XVI

Dorotovič I., Journoud, P., Rybák J., Sýkora J.: 2007, in *Proc. The Physics of Chromospheric Plasmas*, eds.: P. Heinzel, I. Dorotovič and R. Rutten, ASP Conf. Series, **368**, 527

Garcia, A., Klvaňa, M., Sobotka, M.: 2010, *Cent. Eur. Astrophys. Bull.* **34**, 47

Klvaňa, M., Garcia, A., Bumba, V.: 2007, in *Proc. The Physics of Chromospheric Plasmas*, eds.: P. Heinzel, I. Dorotovič and R. Rutten, ASP Conf. Series, **368**, 549

Mouradian, Z., Garcia, A.: 2007, in *Proc. The Physics of Chromospheric Plasmas*, eds.: P. Heinzel, I. Dorotovič and R. Rutten, ASP Conf. Series, **368**, 3