Reconstruction of the HSFA telescopes

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Abstract. At present, two large horizontal solar telescopes with spectrographs, located at the Ondřejov Observatory, are undergoing an important reconstruction. The original designation of these two identical instruments will mostly be preserved. The telescope/spectrograph HSFA1 will continue to be used for the measurement of solar magnetic and velocity fields, while HSFA2 is in the process of rebuilding to a multichannel spectrograph equipped with CCD cameras. The reconstruction of the electronic control systems is the most important item. The up-to-date electronic equipment will enable a remote control of all functions of the instruments, will offer a large amount of automated procedures and should resist to disturbances caused by atmospheric electricity. The whole telescope/spectrograph control system is designed to reduce and simplify the observer's work as much as possible.

Key words: instrumentation: spectrographs – telescopes: solar

1. Introduction

About 20 years ago, two large solar telescopes with spectrographs were put in operation in the Observatory Ondřejov, belonging to the Astronomical Institute of the Academy of Sciences of the Czech Republic (Ambrož et al. 1980). According to the German name ”HorizontalSonnenForschungsAnlage” (Horizontal device for solar research), the telescopes are known under the abbreviations HSFA1 and HSFA2. Both identical instruments were supplied by the company Carl Zeiss, Jena. The control electronics was made by the Hungarian producer Vilati.

The telescope/spectrograph HSFA1 (Fig. 1) is equipped with a Potsdam-type stokesmeter and it is utilized for measurements of magnetic and velocity fields in the solar photosphere. HSFA2 has been used for spectroscopic observations with one camera, where the registration of the selected spectral region was done by means of a photographic emulsion. Due to maintenance problems and an obsolescence of the control systems (the company Vilati disappeared) a thorough reconstruction and modernization of both instruments started in the year 2000. The designation of HSFA1 for the measurements of magnetic and velocity fields will be preserved, while HSFA2 will be rebuilt to a multichannel spectrograph with a simultaneous registration of five spectral regions by means of CCD cameras.

Fig. 1. Instrument HSFA1 used for measurements of magnetic and velocity fields on the Sun.

2. Principles of reconstruction

Simplicity of operation: All functions connected with the activation of the systems after turning on the instrument, with the setup, calibration, observations in various optimized regimes, and with the shutdown before turning off, have to be performed by control computers themselves. The observer does not need to know technical details about the functioning of the device and he is helped by simple and clear user menus.

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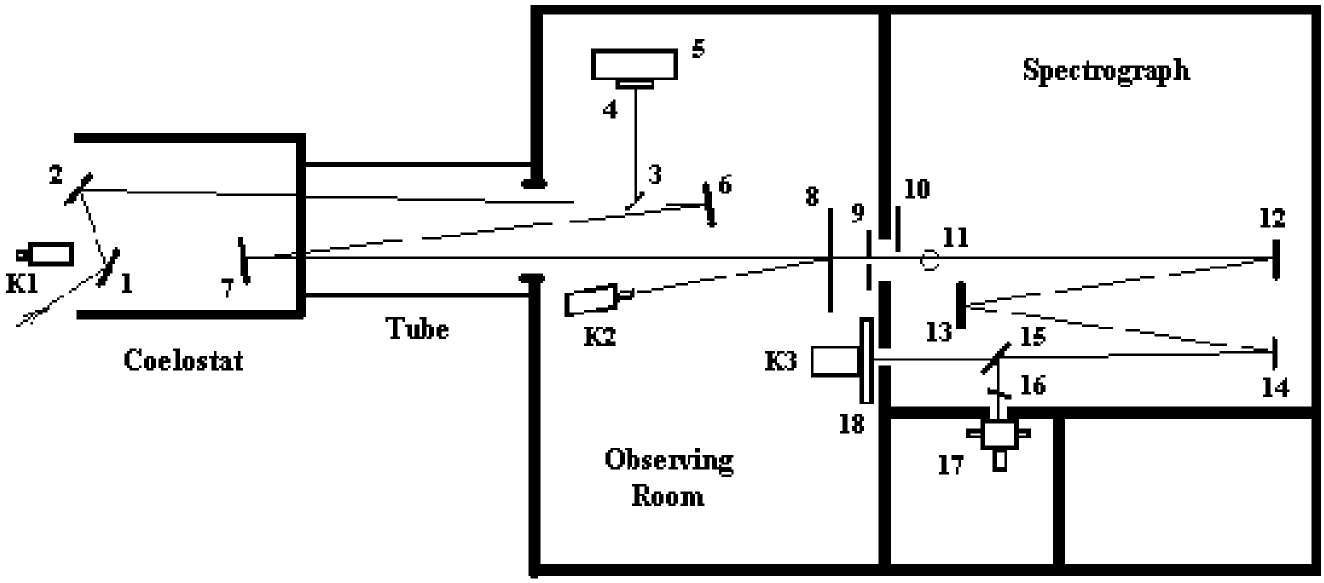

Fig. 2. A sketch of the arrangement of HSFA1 including the magnetograph. See text below for explanations.

Resistance against atmospheric electricity: Since many faults of the original instruments were caused by the atmospheric electricity, a special attention was paid to the design of control systems to minimize the consequences of lightnings and discharges.

A modern conception of controlling: Industrial computers, connected each other in a network and linked to the main computer as well, are used to control different functional nodes of the device. Many of the necessary routines are programmed already at the level of the industrial computers.

Robotic control of the instrument: A remote control of the whole device, including the opening and closing of the telescope, will be among the options available to the observer. Otherwise, the instrument is possible to control directly from the observing room or from a remote room.

The arrangement of the telescope/spectrograph HSFA1, together with the magnetograph, is shown in Fig. 2. The principal elements of the instrument are as follows:

The telescope:

1: coelostat main mirror (plane, $D = 600$ mm)
2: coelostat auxiliary mirror (plane, $D = 600$ mm)
3: guiding telescope with a prism ($F_{\rm eff} = 2.3$ m)
4: sensor of the guiding system
5: moving table of the coordinate system with the guiding sensor
6: telescope primary mirror ($F = 35$ m, $D = 500$ mm)
7: telescope secondary mirror (plane, $D = 370$ mm)
8: screen with the centering sensor for the calibration of the coordinate system

The spectrograph:

9: spectrograph entrance slit (max. height 100 mm)
10: shutter (exposure 0.1 s – ∞)
11: carousel with filters and electro-optical modulator
12: collimator mirror ($F = 10$ m, $D = 230$ mm)
13: diffraction grating (plane, replica, Bausch & Lomb, 154×206 mm, 632 lines/mm, blaze angle 51°)
14: camera mirror ($F = 10$ m, $D = 370$ mm)
15: diagonal mirror of the magnetograph
16: line-shift compensator of the magnetograph
17: block of exit slits and photomultipliers of the magnetograph
18: holder for photographic cassette, eyepiece, or a CCD camera (K3)

CCD cameras:

K1: colour CCD camera for cloud monitoring
K2: b/w CCD slit-jaw camera
K3: b/w CCD camera for spectra

Photographs of principal nodes of HSFA1 are shown in Figs. 3–6.

3. A brief description of the reconstructed instrument

The Jensch-type coelostat has the polar axis laid on hydraulic bearings. The coelostat can be controlled either directly or by means of motions of the coordinate table with the guiding sensor. In the second case, the automatic guiding system keeps the position of the solar disk on the sensor with the accuracy of 1 arcsec. The construction of the coordinate table enables a scanning of an arbitrary rectangular region on the solar disk and in its near surroundings (including a scanning of a region inclined by a given angle with respect to the axis of solar rotation). The observer can select between five different heliographic coordinate systems that can be used either to set a pre-selected object on the spectrograph slit or, on the other hand, to measure the position of an object located on the slit. The measured positions can be stored as pre-selections in different coordinate systems. It makes easy a repeated pointing of the telescope to a given position. The

Fig. 3. Front wall of the spectrograph with a screen in the telescope focal plane (the full solar disk can be projected) and with the entrance slit in the center of the screen. The old control panel of the magnetograph is seen on the left.

Fig. 4. The main and auxiliary mirrors of the Jensch-type coelostat with the control panel. The secondary mirror of the telescope with a focussing system is located on a top of a column in the center of the picture.

software enables to use the optimum regime of the telescope control according to the selected mode of observation (for example, a compensation of Carrington rotation during long-period measurements).

The telescope is focussed by means of its secondary mirror. The image of the Sun at the entrance slit of the spectrograph has a diameter of about 320 mm. The whole solar disk is visible, it is not vignetted, what greatly helps the observer

Several auxiliary devices located in front of the entrance slit of the spectrograph will be available: Image scanner, im-

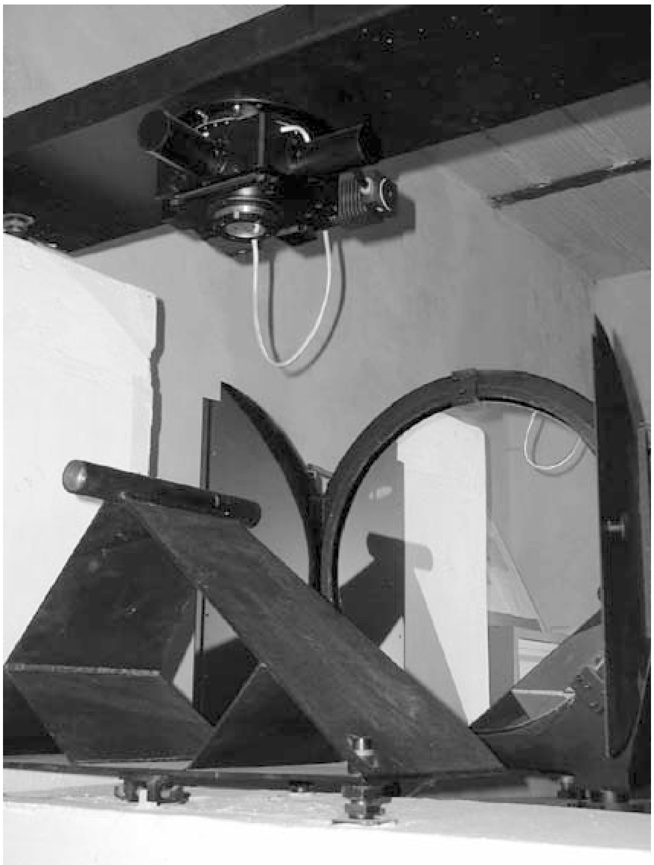

Fig. 5. Guiding telescope, table of the coordinate system with the guiding sensor, and the primary mirror (objective) of the telescope.

age rotator, and the Bowen compensator of polarization. To utilize the high positional accuracy of these devices, a special mode of guiding will be used. A correlation tracker will not be utilized in the HSFA telescopes. In atmospheric conditions of the Ondřejov Observatory (a small Fried parameter) and with a relatively large telescope aperture the image is degraded mostly by blurring and the image motion is small.

The dispersion of the Czerny-Turner-type spectrograph is of about 50 mm/nm in the 5th order in the region of the frequently used line Fe I 525.35 nm. The blaze angle of the grating is 51°. On the basis of theoretical considerations and practical experience with the spectrograph setup, a method for high-precision setting of spectral lines was developed. This method will mostly be applied during magnetographic observations to enable to the observer fast changes of measured lines.

In addition to these basic features, the control software includes many other functions that meet the practical needs of the observer and that simplify the operation of the instrument. Since the design of the system is flexible enough, it will be possible to extend and update the software as well as the hardware of both telescopes/spectrographs according to future requirements.

The communication with the instrument and the complete control of it is realized by means of the main computer's monitor. Multiple user menus are displayed there, according to required actions (two examples are shown in Figs. 7 and 8).

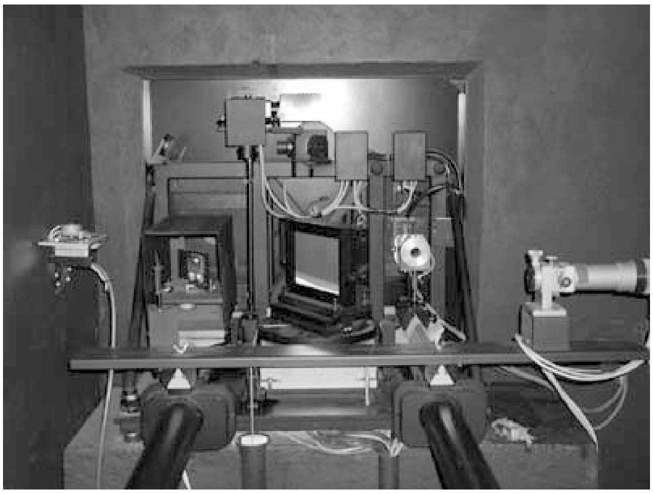

Fig. 6. The main node of the spectrograph. From left to right: Line-shift compensator, diagonal mirror, diffraction grating, electro-optical modulator of the magnetograph, and a photomultiplier for measurements of spectral continuum.

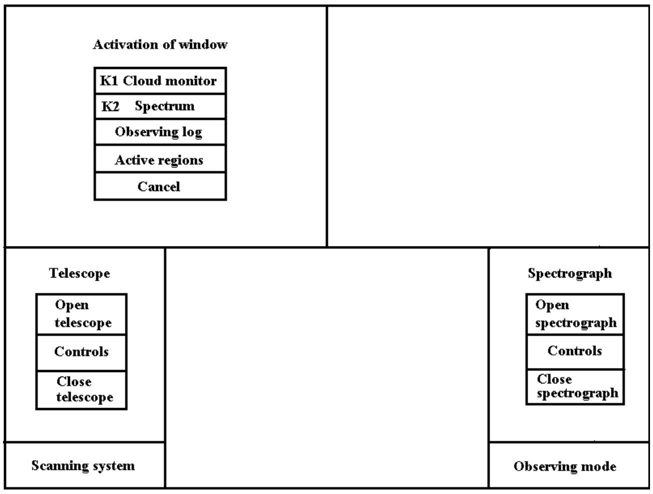

Fig. 7. The Main Control Menu of HSFA on the monitor. The screen is divided in five panels. Two small panels on the sides in the lower part are used to control the telescope and the spectrograph. Different submenus can be subsequently open there. Three large panels, after activation (see options in the upper left panel), can display various types of information, including images.

This method enables, among others, an easy remote control of all functions of the whole device.

4. Reconstruction of the HSFA2 spectrograph to a multichannel version

Since one of our main aims is the spectral diagnostics of flares, we decided to reconstruct the Czerny-Turner spectrograph to a multichannel one in order to detect several spectral regions simultaneously. Fig. 9 shows an optical scheme with 3 cameras, but we plan to have up to 5 cameras placed from the 3rd to 6th order. The linear dispersion of 1000 pixels per nm provides an optimum spectral resolution. CCD cameras working with a cadence of 12 frames per second will be used to register spectra and Hα slit-jaw filtergrams of solar flares and related phenomena. Currently we use the CCD camera Vosskuehler 1300LN with the grabber MATRIX Vision PCimage-SDIG. We also prepare a device to measure the linear polarization in Balmer-series lines originating in solar flares.

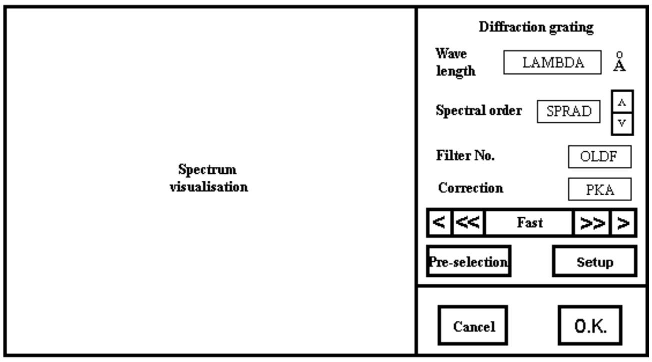

Fig. 8. Example of a control menu: Diffraction grating. Values of operational variables are displayed at positions marked by thin frames. Bold frames outline control buttons.

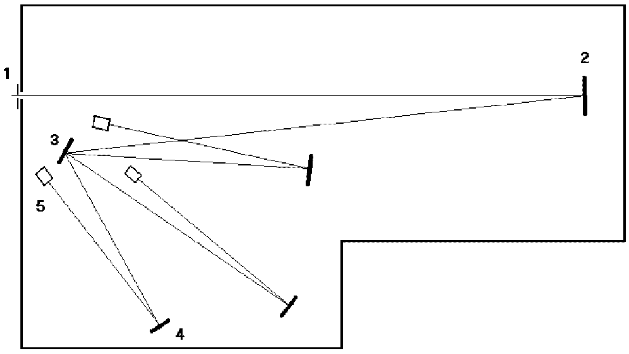

Fig. 9. Optical scheme of the multichannel spectrograph in the reconstructed HSFA2. Legend: 1 - entrance slit, 2 - collimator, 3 - grating, 4 - one of the camera mirrors ($2000/200$ mm), 5 - CCD camera.

The scheme of requirements and tasks for the reconstruction and modernization of the instruments HSFA1 and HSFA2 was elaborated in the Solar Department of the Astronomical Institute, Ondřejov. The reconstruction of the controlling electronics is performed by the company SPACE DEVICES s.r.o., Prague.

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References

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