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THE NEW HIGH-SPEED Hα IMAGING SYSTEM AT KANZELHÖHE SOLAR OBSERVATORY

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Abstract. The Kanzelhöhe Solar Observatory upgraded its digital full disk Hα telescope system. Increased image acquisition rate up to 1 image per 2 sec and the ability to tune the Hα filter for optional images in the line wings boost its capabilities. Script controlled operation modes allow to run observation programs which can depend on the actual Solar activity. In order to handle the huge number of images automatic image selection tools were developed to keep high temporal resolution during increased Solar activity but have standard archives for other periods.

Key words: Solar instrumentation - Hα observations - image acquisition

1. Introduction

The Solar physics division of the Institute of Geophysics, Astrophysics and Meteorology University of Graz, Austria studies the dynamics of the Solar atmosphere and Solar activity. Science objectives of recent projects are statistical properties of Solar activity features, pre-flare mechanisms and heating processes as well as propagation of disturbances in the Solar atmosphere (wave phenomena) and Solar drivers of space weather like CMEs. Observations in Hα can be quoted as *the* standard tool for all these studies, accomplished by radio and X-ray observations supplied by collaborating teams or satellites.

Kanzelhöhe Solar Observatory has a long tradition in observing the Sun in Hα, so requests from satellite groups and international collaborations like Max Millenium were made to support their work with full disk Hα observations with high temporal resolution and to adapt the instrumentation to state-of-the-art. Kanzelhöhe Solar Observatory is one of three base stations of the Global Hα Network (Steinegger et al., 2000).

2. Instrumentation

The Solar surveillance program at Kanzelhöhe Solar Observatory contains multi-spectral full disk observations. The so-called Patrol Instrument is a 4 telescope system on a common mounting for white-light, Na-D and Hα observations.

A digital image acquisition system for Hα was introduced in 1997 and is operated since 2000 on a regular schedule and was described in Otruba (1999). The high resolution camera for the Global Hα Network was implemented in 2000. Recent improvements comprise frame selection, automatic exposure time control, increased image acquisition rate and a Hα filter tuning unit to observe optional in the line wings of the Hα spectral line. The upgrade from the 8-bit camera to a 10-bit camera is in progress. The schematic design of the Hα telescope is shown in Figure 1.

The Solar disk is imaged by a d/f=100/2000 lens. A 10 nm bandpass filter prevents the system from thermal stress. A step motor controlled by a PC-based filter tuning unit rotates the polarizers of the 0.7 Å Lyot filter to shift its pass-band. A software daemon listens to the filter moving commands from the master image acquisition software and drives the step motor accordingly. It can be extracted from all other slave image acquisition systems to know the actual filter position. A beam-splitter cube splits the light and lenses adapt the image size and focus the Solar images to the CCD cameras.

The high-speed CCD camera, a Pulnix TM-1010, delivers up to 15 frames/sec which are grabbed by the PC-based instrument controller. The software uses a simple frame selection method based on the standard deviation of the pixel counts in a subimage. Transfer time to the local HDD for the succeeding frame is the limiting parameter for the image acquisition rate of 1 image per 2 sec. Exposure time is automatically adjusted according to the sky transparency to exploit the dynamic range. The software features also a script controlled mode to run observing sequences with adjustable acquisition rate, frame number and filter position. Therefore we use this camera system as the master image acquisition instrument.

The low-speed CCD camera of the Global Hα Network, an Apogee KX4,

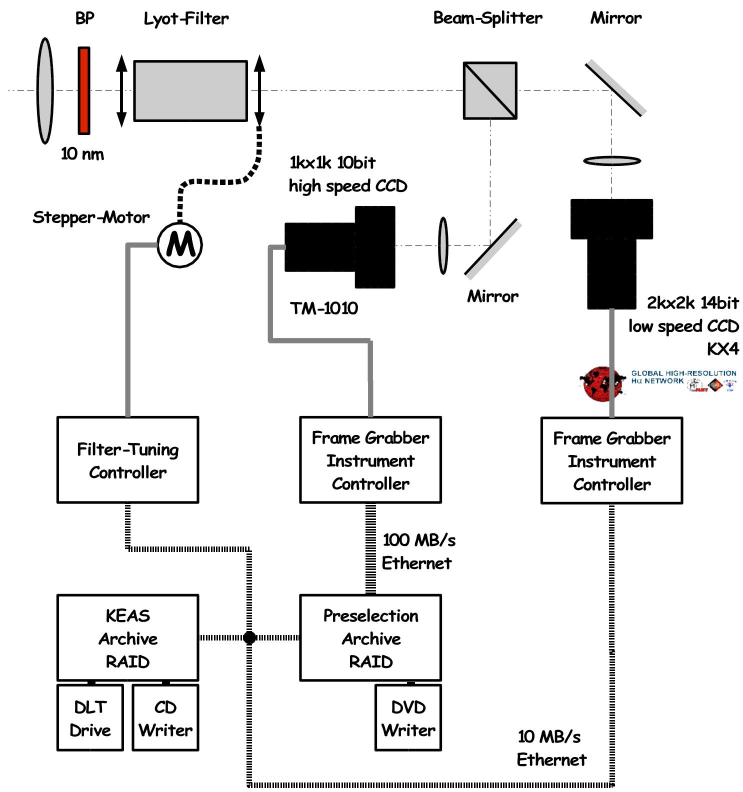

Figure 1: Schematic Layout of the Hα telescope at Kanzelhöhe. The flexible shaft from the stepping motor rotates both outer polarizers of the Lyot filter coupled by a gear. Each frame grabber/instrument controller as well as the filter tuning controller and the archives are based on standard PCs. The PC for the high-speed CCD cam is operated under Windows, all others use Linux which is much more flexible for remote operation. The preselect archives have 240 GB RAID capacity, the main KEAS archives server more than 1.1 TB. See text for a complete system description.

has a very high resolution of 2kx2k and 14-bit but the disadvantage of a very slow read-out of 5 sec per frame which is the limiting parameter and restricts the frame selection mode. The software driving this camera will be adapted to listen also to the filter tuning daemon as a slave system and to note the actual filter position in the image files, but the image acquisition is time controlled and there is no scripting capability.

All image acquisition systems buffer their data locally for at least one day and can be operated stand-alone except the filter tuning mode to achieve some redundancy in case of system faults. After passing a local primary quality check, the data are transferred to the archives system via ethernet. Due to the huge amount of images per day of the high-speed system (up 14 000 images) this check is performed on an extra pre-select archives system which is connected to the image acquisition system by a fast-ethernet link. The communication between filter tuning controller and image acquisition systems uses the existing ethernet links for the data transfer.

3. Filter Characteristics

The Hα filter used at Kanzelhöhe Solar Observatory is a ZEISS Lyot filter built in 1960 with FWHM = 0.7 Å which is precisely temperature controlled. A limited shift of the pass-band is possible by rotating the outer polarizers. However, tuning the filter off-Hα line center rises transmission at unwanted wavelengths due to side lobes in the filter transmission curve. Therefore the shift is restricted from approx. -0.35 to $+0.45$ Å and certain polarizer positions cannot be used. The transmission at ± 1.7 Å results from the domination of such a side lobe.

4. Operation Modes

In order to study the fast temporal evolution of explosive phenomena and underlying rapid changes in the Solar chromosphere, highest possible image acquisition rates and optimum image quality by application of frame selection methods are desirable. Limiting parameters are the max frame rate of the CCD camera and frame grabber, frame selection processing and data transfer to a HDD and the HDD capacity itself or the transfer rate to archives media. One extra concern is also material fatigue of components by mechanical movements, e. g. rotation of polarizers or mechanical shutters.

4.1. Low-speed CCD camera

With respect to the scientific goals of the Global Hα Network this camera is currently operated with an acquisition rate of 1 image per min regardless to the actual Solar activity. Read-out time and lifetime of the mechanical shutter do not permit much higher acquisition rates. All images which pass the automatic quality check are archived.

4.2. High-speed CCD camera

Absence of a mechanical camera shutter and a frame rate up to 15 frames per sec yields a limitation of the acquisition rate by the transfer of the data to the local HDD and the time needed to poll the filter tuning daemon.

If one abandons the option to tune the filter in a High-speed Mode the max acquisition rate of 1 image per 2 sec is achieved, otherwise in the more flexible Script Mode a max rate of 1 image per 5 sec is the top. It is a customary cyclic operation mode with selectable filter positions by processing a configuration file of the master image acquisition system. The configuration file is a simple text file which may be altered by external resources, e.g. Solar activity parameters, so that the observation program can react to the actual Solar activity. Currently we process the GOES X-ray data, which are published in almost real-time, to control the contents of the configuration file and therefore the observation program.

As a standard we run the Script Mode with the rate mentioned above. During quiet times we observe only in line center to prevent the mechanical components of the Lyot filter i.e. the polarizers to be damaged by material fatigue. When the Solar activity rises the filter is tuned to the blue and red line wing of the Hα line once per minute and we replace single images of the time series by off-line-center images (-0.3 Å, +0.4 Å and +1.7 Å which looks like a continuum image). From these periods we archive all images to achieve the full temporal resolution for higher Solar activity.

After finishing observations in the evening, all images are transferred to the intermediate archives system which stores the data for at least one week. An automatic image selection system based on GOES X-ray levels and Solar activity reports, but with human supervision, selects data to be archived and to be dismissed. For quiet periods we select one good image per minute from the time series by applying the optimal window method (Giammanco, 2000). During higher Solar activity we keep all images to achieve the full temporal resolution of rapid changing phenomena and we prepare archives according to running projects or on request. A standard time series of one image per minute is archived on our main archives server for all periods.

5. Example of an Observation

For demonstration of the capabilities of the upgraded instrument we show an observation of an Imp 1 F flare from Sept. 17, 2002. The event was observed during the whole flaring phase from 6:20 UT to 10:00 UT in the line center with a resolution of 1 image per 5 sec. Processing GOES data, the observations in the lings wings with a rate of 1 image per min (in each wing) were automatically started at 6:40 UT. Figure 2 shows the active region close to flare max in the line wings and line center.

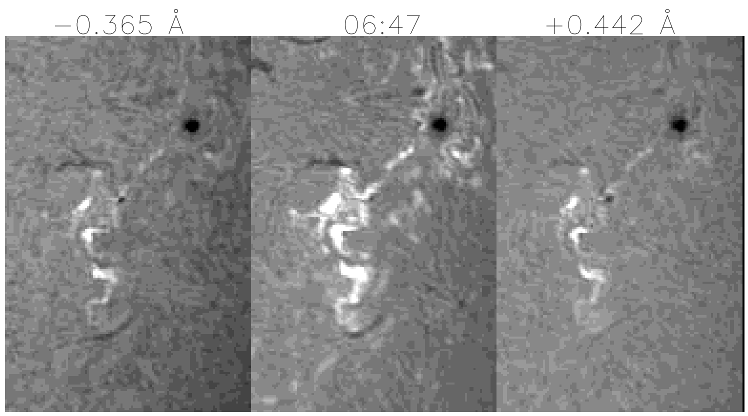

Figure 2: Imp 1 F flare from Sept. 17, 2002 at 6:47 UT observed with the high-speed 1kx1k 8-bit CCD cam in Script Mode. Left observation in the blue line wing, right in the red, center in Hα line center. The images are cropped from the full disk images. Actual observations published in almost real-time can be found under *http://www.kso.ac.at*

References

Giammanco, C.: 2000, *Astron. Astrophys. Suppl. Ser.* **147**, 1.

Otruba, W.: 1999, in B. Schmieder, A. Hofmann and J. Staude (eds.) Third Advances in Solar Physics Euroconference: Magnetic Fields and Oscillations *ASP Conf. Ser.* **184:**, 314.

Steinegger, M., Hanslmeier, A., Otruba, W., Freislich, H., Denker, C., Goode, P. R., Marquette, W. M., Varied, J., Wang, H., Luo, G., Chen, D., Zhang, Q.: 2000, *Hvar Obs. Bull.* **24**, 179.

NOVI SUSTAV ZA BRZO SNIMANJE SUNCA U LINIJI Hα NA SOLARNOM OPSERVATORIJU KANZELHÖHE

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Izlaganje sa znanstvenog skupa

Sažetak. Na Solarnom opservatoriju Kanzelhöhe poboljšan je digitalni sustav za snimanje cijelog diska Sunca u vodikovoj liniji Hα. Omogućeno je snimanje Sunca jednom u dvije sekunde kao i podešavanje Hα filtra za opažanja i u krilima linije. Ovisno o trenutnoj aktivnosti Sunca mogu se odabrati posebni programi opažanja. Da bi se ovladalo velikim brojem opažačkih podataka, razvijena je automatska metoda arhiviranja snimamka: s visokim vremenskim razlučivanjem tijekom pojačane aktivnosti i standardnom sekvencijom za razdoblja niske aktivnosti Sunca.

Ključne riječi: Solarni instrumenti - Hα opažanja - prikupljanje snimaka