Multi-Wavelength Investigations of Solar Activity
Proceedings IAU Symposium No. 223, 2004
A.V. Stepanov, E.E. Benevolenskaya & A.G. Kosovichev, eds.

DOI: 10.1017/S1743921304007227

The Pulkovo CCD Spectroheliograph - Magnetograph

L.D.Pafinenko

Central (Pulkovo) Astronomical Observatory, Saint-Petersburg, Russia, email: parfinenko@gao.spb.ru

Abstract. The CCD spectroheliograph-magnetograph is a focal plane ancillary instrument for Pulkovo horizontal solar telescope ACU-5. The instrument is placed at an exit port of an isothermal high-resolution diffraction-grating spectrograph. The modified Leighton optical scheme for registration of sunspot magnetic fields is used. The instrument provides obtaining FITS digital video cards of radial velocities, magnetic fields and spectroheliogram in any line of spectral region 3900A - 11000A. The time of obtaining of one video card by the size 91" ×154" is equal 10.24sec. The angular resolution of the instrument is 0".8; spectral resolution is 0.01-0.03A. There is remote access to a solar telescope in real time on the basis of Internet - process engineerings.

The classical spectroheliograph is a solar spectrograph with an exit slit in the spectral plane. The solar image is moved across the entrance slit, and the photographic plate is moved simultaneously along behind the exit slit. There are no real exit slits in Pulkovo CCD - spectroheliograph magnetograph. There are one or two electronic (virtual) slits. The CCD spectroheliograph-magnetograph is a TV analog of Leighton's specroheliograph (Leighton, 1959), specifically designed for the measurement of Doppler shifts of solar spectral lines and Zeeman effect (polarization of Zeeman components in the solar spectrum). Research of sunspot oscillations of radial velocities and magnetic fields were carried out by Pulkovo CCD spectroheliograph-magnetograph from observations made with horizontal solar telescope ACU-5 in Pulkovo observatory. Its main mirror has a diameter of 44cm and the focal length in the primary focus F is 17.5m. Secondary focus F - 64m, special focus F -0.8m. The focus F - 0.8m is applied to obtaining the full sun disk, the focus F= 17m is applied at observation of active region. The sunlight is directed into the telescope by 50cm coelostat and 50cm second flat mirror. The coelostat and second flat mirror are situated 5m above the ground. An isothermal high-resolution diffraction-grating spectrograph (dispersion: 3.7 mm per A in the fourth order) is used for CCD spectroheliograph-magnetograph. The CCD magnetograph detects intensity differences as a function of polarization state in just one or two isolated wavelength domains centered on the wing of spectrum line. Low-frame-rate television system use only one or two sense points (paired samples) from every 312 TV scan line (64 sec) of interlaced field (0.02 sec). Two sense points are placed in the left and right wings symmetric relative to the centre of gravity of the spectral line. Difference of signal is a Doppler shift of solar spectral line. The CCD spectroheliograph-magnetograph described here includes means to measure the circular polarization of spectral line radiation. Wollaston prism is used as beam-splitting techniques. The line scanning of TV camera is oriented precisely along dispersion of a solar spectrum. Immediately preceding the Wollaston prism a mica quarter-wave plate is introduced. A mica quarter-wave plate, Wollaston prism, and broad-band blocking filter admit two alternating states of circularly polarized light of spectral line. This system produces two images of exactly equal size and approximately equal brightness, situated

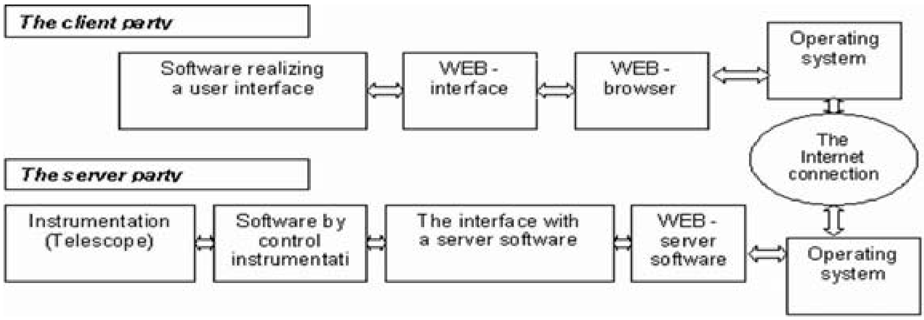

Figure 1.

side by side on the CCD. Appropriate differences of paired samples intensities in two polarization states the same wing of spectral line (FeI 8468.418A, λ^2g=215) are computed in real time to yield longitudinal magnetic flux at each position(312) along the entrance slit. It is one line of digital magnetogram (0.02sec). Computerized scanning (synchronous with optic scanning of the solar image) produces eventual digital raster magnetogram, spectroheliogram or dopplerogram in FITs format. In addition to full-disk images, magnetograms and spectroheliograms can be obtained more rapidly for limited fields of view, typically of active regions and sunspots. A full-disk image requires about 7 minutes (F=3m), while active regions scans 116" $\times$ 154"(F=17m) requires 10.24 sec (312$\times$ 512 pixel, 316.8 Kbt). Scan rate is equal 15"/sec. The TV camera contains achromatic optics to match properly the spatial and spectral scales of spectrograph (F=8m, D=3.7 mm/A) to the small CCD chip. One keeps optical distortions well within practical limit. The actual spatial scale achieved with this system is 0.4 arcsec/pixel. The analog output of the camera is passed through a low-frame-rate television system and is then digitized at 15.625 KHz by a 12-bit analog-digital converter L-Card. It is controlled by vertical and horizontal synchronization signals from composite video input. Horizontal frequency of the low-frame-rate television system is 50Hz. Date acquisition and analysis are controlled by the standard IBM PC. The reduced date are recorded as FITS images (312$\times$ 512 pixel = 316.8Kbt) on a hard disk of PC (the number of real CCD pixels can be not to equal the number of pixels of FITS image). The software, which controls the CCD magnetograph, is compiled from 32-bit C/C++ language (DJGPP) and Borland Turbo Assembler. The observer controls the CCD spectroheliograph-magnetograph from PC keyboard; video monitor indicates the position of electronic slits on the image of solar spectrum. Special Programmatic complex (Figure 1) allows a remote user from any computer, having connection with the Internet, to make acquisition of the image of the Sun with CCD camera of 5- inch telescope - refractor GAO RAN in real time (Bobkov et al, 2002).

Acknowledgements

This work has been done partly under Russian Foundation For Basic Research, grant 04-07-90254.

References

Leighton R.B. 1959 *Astrophys.J.* **130**, 366.

Bobkov E.V., Parfinenko L.D., Sochenov A.S., Sheynin Y.E., & Uljanov I.A. 2002 *Izv.Pulkovo Observatory* **216**, 505.

https://doi.org/10.1017/S1743921304007227 Published online by Cambridge University Press