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New ICCD guiding camera for the spectrograph UAGS of the telescope Zeiss-1000

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Abstract. Test results of a new ICCD digital TV guide worked out for the spectrograph UAGS of the optical telescope Zeiss-1000 are presented. A system "IT + accumulating CCD camera" with automatic control of accumulation on a CCD is implemented. Observations with the UAGS spectrograph with the described system have shown a considerable gain in the throughput as compared to the ICCD guide operating in the standard television mode. This allows the new TV guiding camera to be considered as a prototype for further upgrading of the operating television channels for the optical telescopes of SAO — the 6 m telescope BTA and Zeiss-1000.

Key words: instrumentation: spectrographs – instrumentation: TV guides

1. Introduction

The television systems have come to be extensively adopted in astronomy since the 1970s. First of all, this is connected with the building of big optical telescopes for observations of much fainter objects and the necessity for automatization of observations when the observer is away from the telescope and can see the object under investigation on the monitor. The TV image detectors took the basic place in the pointing and autoguiding systems of optical telescopes (Jelley, 1980). Historically, the telescope TV guiding systems are made on the principle of local configuration, that is, during observations they operate with only one channel (Robinson and Osborne 1987; Rambold and Stilburn 1988). The matter is that the wide range of luminosities of objects under study call for the use of TV guides of high sensitivity and a wide dynamical range. For this reason, they are made for specific observational facilities and are part of an observing tool, that is, they are unique and not produced in quantities. The costs of TV guides are as high as tens of thousands of $ US (McGregor et al. 2000).

More than twenty dozen TV guides have been made for several spectrophotometric complexes which are employed at the SAO telescopes. The first TV cameras had the I-SIT (Intensifier – Silicon Intensified Target) configuration and were constructed on the basis of vidicon image tubes (SIT vidicons), in particular, supersilicons with an addition brightness amplifier at the input. Over the past time ICCD (Intensifier Charge Coupled Device) have been constructed, which are CCD TV guides with an additional brightness amplifier at the input (Komarov et al. 2002a).

The main reason for the change to CCD detectors in the new TV guides was the construction complexity, large overall dimensions and weight of vidicon devices. As to the stability of the TV raster, resolution and simplicity of construction the ICCD TV guides compare favourably with I-SIT systems that may be called the first generation of the BTA TV guides. Several ICCD systems with optical carry-over (Komarov et al. 2002b) operating under the standard TV conditions (625 lines, 25 frames/s) have been involved in the BTA observations since 1997.

The overall dimensions of the standard slit TV guide of the spectrograph UAGS of the telescope Zeiss-1000 did not permit the use of the new CCD detector for spectrum recording in observations. To solve the problem, a new TV camera was worked out allowing the overall dimensions of the TV guide to be considerably diminished.

Herein is presented the new generation ICCD television system. Its main difference from the previous ones is the ability of the camera to accumulate an image on the CCD with a long exposure of more than 40 ms with a standard television scan. The accumulation time on the CCD can automatically be increased up to 0.66 s with the CCD being illuminated to a minimum.

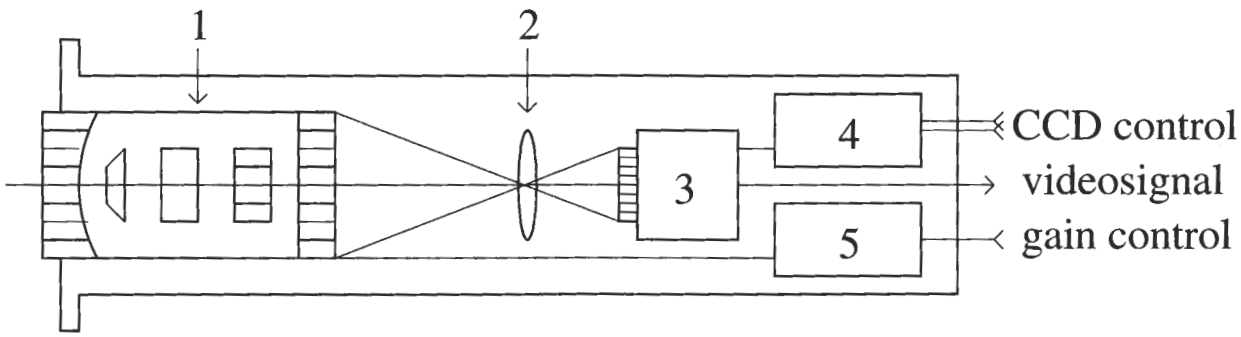

Figure 1: *The schematic view of accumulating ICCD camera: 1 – brightness intensifier of IT with MCP; 2 – carry-over optics 1:4; 3 – CCD camera 1/3″; 4 – control unit of the CCD parameters; 5 – high voltage source of the brightness amplifier.*

Table 1: *Technical characteristics of the CCD camera ("ACTIVISION security systems", 2002)*

PARAMETERS	VALUES
Sensitive element	1/3″ SONY ICX-255 (EX-View HAD)
Number of working elements of the CCD	500(H)×582(V)
Size of pixel, μm	9.8 × 6.3
Scanning	interlaced
Video signal standard	625 lines/25 frames/s
Output video signal	to 10V (including synchrosignal)
Resolution	420 TVL
Minimum illumination on the object, lux (with an objective F/1.2)	0.0003
Adjustment of amplification and accumulation	automatic
Gamma correction	0.45 (on) or 1 (off)
Accumulation on the CCD	2/3,...1/10000 s
Back illumination compensation	is on
Temperature range	$-30°C \div +40°C$
Relative humidity	0 %–90 % (without condensate)

2. Description and parameters of the TV guiding camera

As the basis of the design there was chosen the standard configuration of the latest BTA TV guides: Image tube + carry-over optics + CCD camera (see Fig. 1).

The TV guide is additionally equipped with a built-in high-voltage source and an electronic control board of the CCD camera components, which gives a standard output television signal.

The TV guide is, mainly, a detector that converts input optical image to a video signal at the output.

To register photon events at the input of the television tube or CCD, an additional brightness intensifier (IT) is installed, which provides transformation of primary photoelectrons to photon scintillations with amplitudes sufficient for their reliable detection by the television system at the output luminophore of the IT. A second generation IT with microchannel plates (MCP) of the series EP-10 is employed as an amplifier of the received image brightness (see Fig. 1 (1)). The high amplification in these ITs is achieved through the application of the MCP ensuring a high amplification factor of the flux of primary photoelectrons — up to $5 \cdot 10^4$ (Beguchev et al. 1999).

The image is sent from the IT (1) to the CCD camera (3) through the optical carry-over (2). The optical linear reduction is 1:4; a fast objective Biotar CarlZeiss (f=25 mm, F/1.4) is used.

The CCD matrix SONY ICX-255 incorporated in this camera was developed for sensitive television systems with a resolution of 420 TVL (television lines).

The CCD was made by the EX-View HAD technology and its sensitivity is therefore by 200 % as high in the visible part of the spectrum as the analogous

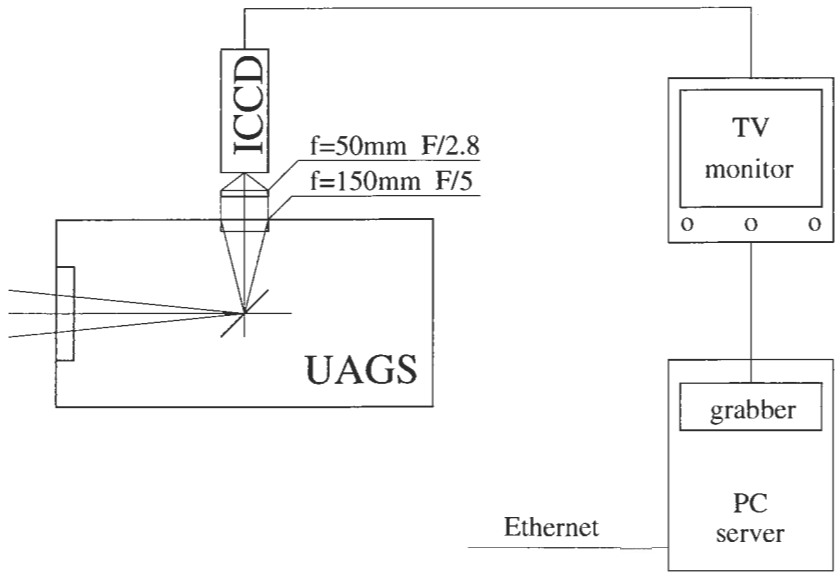

Figure 2: *Block diagram of the TV guide under the conditions of the test observations.*

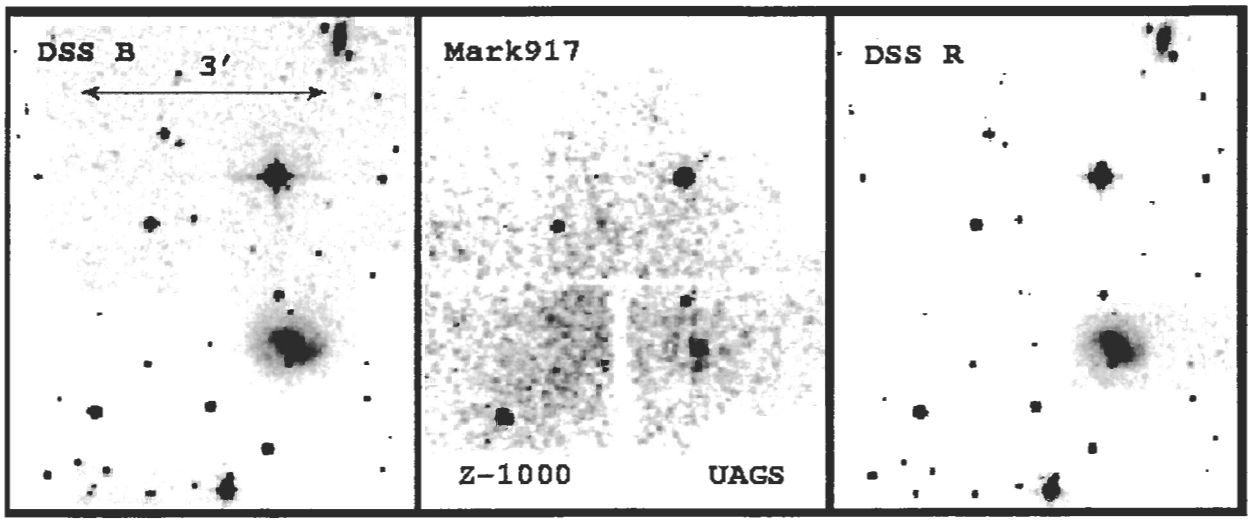

Figure 3: *Vicinity of Mark 917: left panel – DSS-2 image of the field in the B band; middle one – video image of the field obtained with the new TV guiding camera; right panel – DSS-2 image of the field in the R band. East is left and north is down.*

CCD standard ("SONY", 2000).

The CCD camera has automatic control of accumulation time up to 2/3 of a second, 8-bit digital-analog and analog-digital converters (DAC and ADC) and also internal memory – random access memory (RAM) for one frame, which makes it possible to observe the image accumulation during the next exposure with standard video-control devices ("ACTIVISION security system", 2001).

The main technical parameters of the TV guide components are presented in Table 1.

3. Test of the television camera incorporated in the slit TV guide of the spectrograph UAGS of Zeiss-1000

Several TV guides for different observing devices are used on the telescope. A layout of integration of all TV guides in a unified system with digitization of video signals in the Zeiss-1000 server by the example of the digital videonet of BTA (Komarov et al. 2002c) has been worked out lately. The distinguishing feature of testing the new TV guide was the conduction of observations with the reduction of images from the output of the TV guide in a computer in

Table 2: *Stellar magnitudes of objects in the field of study*

Object No.	B*	V**	R*
1	12.6	11.25	10.9
2	15.2	14.26	14.0
3	14.9	13.51	13.2
4(var)	10.9	9.2	
5	17.0		16.1
6	17.8		16.1
7	17.3		16.6
8	17.5***		16.85***

Notes:
from the data of the catalogs
* – USNO-A2.0;
(`http://www.nofs.navy.mil/data/fchpix/`);
** – Zeiss-1000 catalog of standard fields;
*** – USNO-B1.0 (Monet et al. 2003).

which the digitization of the TV signal was implemented. A video grabber VS–56 made by the company "Videoscan" (Moscow) was used as the video controller built in the server. The block diagram of the television system is given in Fig. 2.

4. Observational conditions and results obtained

The weather conditions on the night of the test observations were relatively good, the seeing was about 2″.

The observations were carried out sequentially: using the standard TV guide, then the new ICCD with the accumulation on the CCD. The field of standards in the vicinity of the galaxy Mark 917 (Fig. 3) was observed. The obtained video images from the two TV guides were digitized with the grabber VS–56 in the Zeiss-1000 server. The resulting images are shown in Figs. 4 and 5. The stellar magnitudes of the field objects under study (see Figs. 4, 5) are presented in Table 2.

5. Conclusions

A new TV slit guide for the UAGS spectrograph of the telescope Zeiss-1000 has been designed and made. It differs from the previous TV guides by the following features:

- high sensitivity CCD camera;
- automatized selection of the exposure depending on the CCD matrix illumination;
- wide range of exposures: from 1/10000 s to 2/3 s.

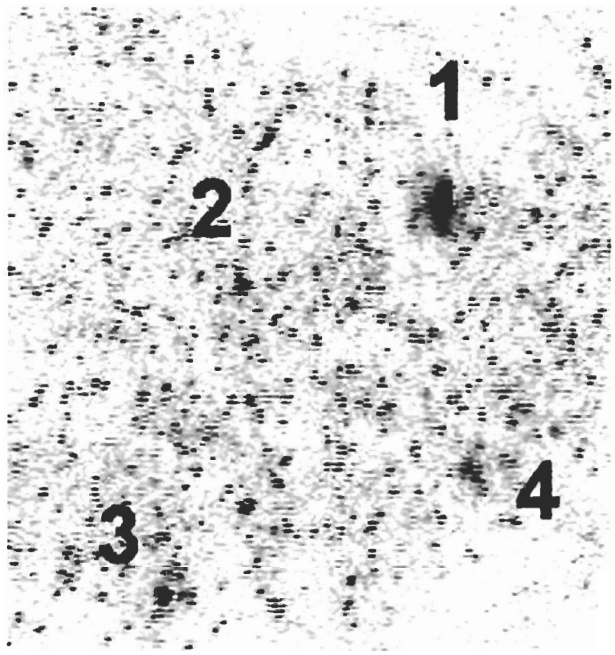

Figure 4: *Digitized image of the field in the vicinity of the galaxy Mark 917 obtained with the standard ICCD TV guide of the spectrograph UAGS (acquisition on the CCD is 0.04 s).*

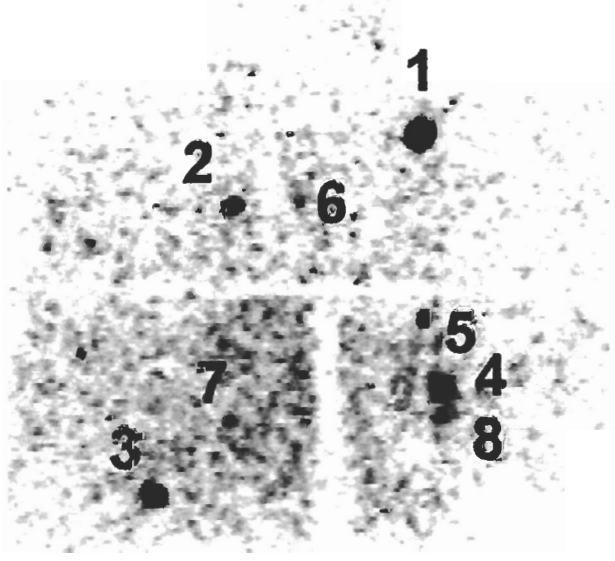

Figure 5: *Digitized image of the field in the vicinity of the galaxy Mark 917 obtained in the observations with the new slit TV guide of the spectrograph UAGS (acquisition on the CCD is 0.65 s).*

A comparative analysis of the results of the reduction of the stellar field around the galaxy Mark 917 has shown that under middling seeing (about 2″) the throughput with the new TV guide has increased by about 2^m in the visible range of the spectrum.

The contemplated replacement of the optics which transfers the sky image from the UAGS spectrograph slit to the TV guide input (f=50 mm, F/2.8, see Fig. 2) by the optics with a higher aperture ratio (f=50 mm, F/1.8) will help to increase the throughput of the TV guide by 0.3–0.5 stellar magnitudes.

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