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FROM THE EARLY UNIVERSE TO EXOPLANETS AND BLACK HOLES
300 years Russian Academy of Sciences

Universal viewing camera for SAO RAS BTA

V. Komarov, I. Shaldyrvan, V. Komarova, and M. Fokin

Special Astrophysical Observatory of the Russian Academy of Sciences,
Nizhny Arkhyz, 369167 Russia

Abstract. The development, creation, and implementation of highly sensitive observing systems both for the observing complexes and round-the-clock monitoring of sky transparency and cloudiness, are carried out at the Special Astrophysical Observatory of the Russian Academy of Sciences (SAO RAS). The latest development is the universal viewing camera presented in this work, mounted on the outside of the 6-meter telescope (BTA) prime focus cage (CPF) and monitoring a 4° field. This system looks at the sky area where an object under study in BTA observations is located, i.e., the CPF viewing camera is always directed to the same sky field at which the BTA is pointed. And the images are obtained in real time, regardless of the BTA observing program and the complexes in one of the three foci involved.

Keywords: telescopes: optical; methods: observational

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1 Introduction

Guiding, viewing, and monitoring cameras while being auxiliary are not the least elements to support observations in visible light. The range of their application at the SAO RAS optical telescopes is broad: from the slit and field-of-view guidance tools to atmosphere control systems and security cameras, and their usage has more than twenty years of history with technical solutions corresponding to the up-to-date state of technologies.

The modern mass-production CMOS photodetectors, which we start applying in our development, are not only highly sensitive, competing with the CCD cameras in our use, but also quite small.

Our experience with CMOS cameras has allowed us to develop a new compact universal sky monitoring system for the BTA.

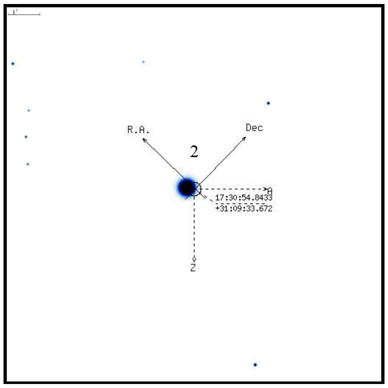
2 New generation BTA viewing systems

In recent years, we have been developing CCD and CMOS viewing systems for the BTA and other optical telescopes of SAO RAS along with the systems for round-the-clock sky monitoring (Komarov & Semenko 2018).

For a long time, CMOS sensors could hardly by compared with CCDs in terms of photosensitivity and image quality, and their application was limited primarily to video surveillance systems. Since 2008, the progress in the performance of CMOS matrices has stepped far forward, and at the moment the technologies used in the production of CMOS sensors allow them to compete with CCDs. The technologies applied in the production of CMOS matrices in the last decade have made possible developing rather cheap IP viewing systems for SAO RAS that have characteristics acceptable for the night-time work. Thus, it should be concluded that CMOS sensors can be effectively used in the low-light conditions. In our case it takes place in the operation of such devices as the viewing systems in the optical paths of astronomical instruments (in the situations where a small percentage of the light studied is transmitted to the viewing system) and in the all-sky cameras for monitoring the night sky as well as atmospheric conditions in order to respond to weather changes in time (Shaldyrvan et al. 2023).

3 Universal BTA Sky Monitoring System

The latest development is a universal CPF sky monitoring system with a 4° field of view. It is mounted on the outside of the BTA CPF and pointed to the same sky area where an object under study is located, i.e., the CPF viewing camera always



No.	Star	RA (2000)	Dec (2000)	B	V
1	HD 159118	17 31 42.534	+30 19 04.24	7.97	6.93
2	HD 158974	17 30 55.373	+31 09 29.30	6.60	5.63
3	HD 158225	17 26 45.963	+31 13 09.30	7.58	7.13
4	HD 157513	17 22 29.307	+30 31 41.52	8.47	8.42
5	HD 157329	17 21 14.712	+31 15 24.86	7.45	6.90
6	HD 156224	17 15 13.500	+30 18 04.62	8.82	7.82
7	HD 156651	17 17 26.491	+31 31 06.16	6.94	7.06
8	W Her	17 20 39.567	+32 28 03.88	6.01	5.39
9	HD 157225	17 20 45.465	+32 40 27.83	7.03	7.01

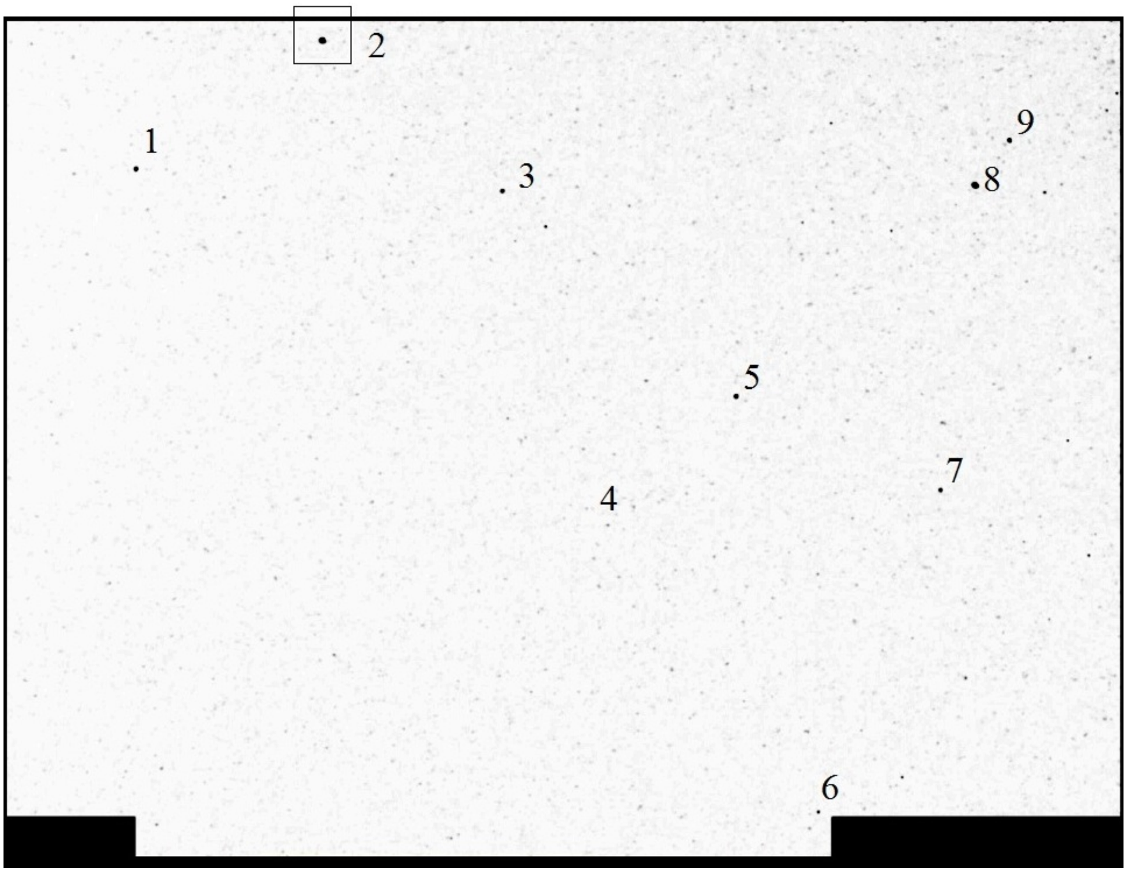


Fig. 1. Top left: a $10' \times 10'$ USNO-A2 Catalogue image simulation centered at the location RA(2000) = $17^{\rm h}30^{\rm m}54\overset{\rm s}{.}843$, Dec(2000) = $+31^\circ09'33\overset{''}{.}67$ in the BTA observations (see the BTA TCS online page on https://www.sao.ru/tb/tcs/ → TV → BTA guide). Top right: the list of the stars marked. Bottom: a view of the sky area taken by the CPF monitoring system simultaneously with the BTA targeting at HD 158974 (No. 2 in a box of nearly $10' \times 10'$); the center (RA, Dec) is $260\overset{\circ}{.}744$, $30\overset{\circ}{.}691$; total exposure time 12×80 ms, b/w mode. The images are given in inverted colors.

follows the BTA in its pointing and tracking. The images are obtained in real time, regardless of the observing complexes in use, i.e., for any of the BTA three foci.

The main characteristics of the CPF camera are as follows: image sensor Sony IMX335; diagonal size 6.52 mm; pixel size 2.0×2.0 µm; maximal resolution 5 Mpixels (2592×1944 pixels); FOV $4\overset{\circ}{.}23 \times 3\overset{\circ}{.}18$; pixel scale $5\overset{''}{.}88$/pixel.

An example of the images obtained using the CPF sky monitoring system is shown in Fig. 1. According to preliminary estimates, reliable identification can be carried out for stars of up to 10–12 apparent magnitude, depending on the photometric conditions.

4 Conclusion

The technologies used in the production of CMOS matrices in the last decade have made it possible to create inexpensive IP cameras with characteristics acceptable for the night work. The new universal BTA viewing camera mounted on the outside of the primary focus cage is aimed at the same sky area as the BTA. The 4° field of view of the new monitoring system provides taking images of the objects that are being observed with the BTA at the moment. The images obtained in real time are outputted to remote access for further processing and identification of the objects in the field of view, they are also available as raw data in the format of a streaming video signal in the SAO RAS local network. The universal BTA monitoring system is structurally similar to the Polaris monitoring system (Shaldyrvan et al. 2024), which allows one to estimate the quality of astronomical visibility (seeing) changing due to the atmospheric conditions. Therefore, an additional feature of the universal monitoring system is providing possibility to control the seeing by the stars in the BTA field of view. And it can be done directly in the same field at which the BTA is pointed, independently of the observing equipment in one of the three BTA foci and in real-time mode.

References

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