



## **Future Robotic observatory on Mountain Vidojevica: site and equipment specification**

N. Martinović\*, M. Jurković, M. Stojanović, O. Vince and  
M. Bogosavljević

*Astronomical Observatory of Belgrade, Volgina 7, 11000 Belgrade, Serbia*

**Abstract.** We present an overview of the instrumentation installed at the new Astronomical Station Vidojevica in Serbia. These instruments currently include the 60-cm telescope, the all sky camera, the seeing monitor and the weather station. We give a brief technical description of the equipment in relation to the future goal of integrating the components into a fully robotic observatory.

**Keywords :** site testing (Astronomical Station Vidojevica) – telescopes (60-cm telescope, Milankovic telescope) – instrumentation: miscellaneous (SBIG AllSky 340, Seeing monitor, weather station)

### **1. Introduction**

For the last several years the Astronomical Observatory of Belgrade (AOB) has worked on a project to install a new observational facility in Serbia. Construction of the new observatory infrastructure began in 2005 at the summit of Mt. Vidojevica (elevation 1155m) in southern part of Serbia. The Astronomical Station Vidojevica (ASV) will be built in two phases. The first phase includes the 60-cm telescope, supporting equipment and infrastructure. This equipment will be used to monitor and quantify in detail the astroclimate conditions of the site.

In the second phase, a 1.5m-class fully robotic telescope will be installed at ASV. The work on this phase was launched in 2010, when AOB received funding through the European Committee FP7-REGPOT project *BELISSIMA* aimed towards the purchase of the 1.5m-class telescope. The Republic of Serbia will finance the supporting infrastructure required for the project. The acronym *BELISSIMA* stands for BELgrade

---

\*email: nmartinovic@aob.rs

Initiative for Space Science, Instrumentation and Modeling in Astrophysics and further information can be found at the website of the project: <http://belissima.aob.rs>. The second phase telescope will be named “Milanković”, after Milutin Milanković, a famous Serbian geophysicist, civil engineer and astronomer who was the director of the AOB from 1948 to 1951.

In this contribution we present a brief technical overview of the 60-cm telescope and the auxiliary monitoring equipment.

## 2. The 60 cm telescope

The 60-cm Cassegrain telescope was installed at ASV in spring of 2011, and it is currently undergoing commissioning tests (Fig. 1). The proposed name for the new telescope is telescope “Nedeljković”, named after Milan Nedeljković, the first director and founder of the Astronomical Observatory of Belgrade. The basic characteristics of the site and telescope are given in Table 1. The 60-cm telescope is on a German equatorial mount. It was purchased from the company “Astro Optik” (now “ASA Astrosysteme”, Austria). The telescope is controlled via the “Autoslew” software which was delivered by the manufacturer. The planned observational usage of the telescope is very diverse - from precise photometric observations of double systems, variable stars, small bodies of the Solar system to Targets of Opportunity (ToO), e.g. SN and GRB follow-up. A large part of the time on the telescope will also be devoted to student training. We expect our first scientific results in the near future.



**Figure 1.** The 60-cm telescope installed at ASV.

**Table 1.** The basic characteristics of the site and telescope.

Altitude	1150 m
Longitude/Latitude	21:33:20.4 / 43:08:24.6
Primary / Secondary mirror	D = 600 mm, f/3 / D = 200 mm
Cassegrain telescope	f/10, F = 6,000 mm
Focal reducer	up to f/5

### 3. Instruments

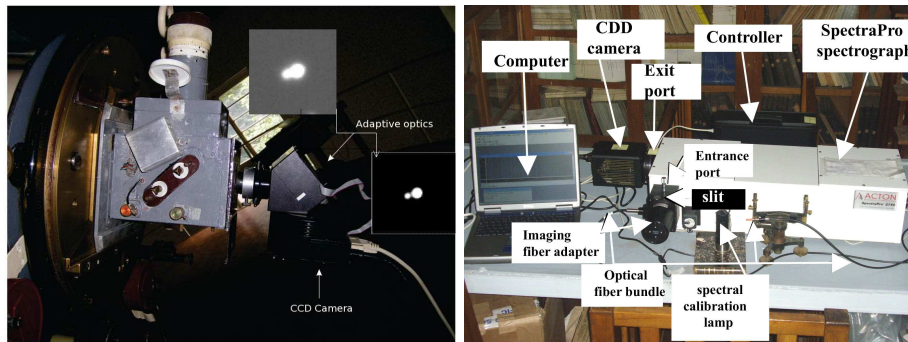
The Astronomical Observatory of Belgrade provided several high sensitivity CCD cameras for different astronomical tasks:

- Apogee U42; back-illuminated, large format (2048 x 2048) chip; 13.5 x 13.5  $\mu\text{m}$  pixel size; QE = 92% @ 600 nm.
- Apogee E47+; back-illuminated, 1024 x 1024) chip; 13 x 13  $\mu\text{m}$  pixel size; QE = 92% @ 600 nm.
- SBIG ST-10ME; Kodak KAF-3200ME detector with peak QE = 85% at 600 nm; 2184 x 1472 array; 6.8 x 6.8  $\mu\text{m}$  pixel size.

SBIG AO-7 Adaptive Optic was purchased in order to improve the image resolution. Primarily, we plan to use it to separate close binary systems which are otherwise unresolvable because of bad seeing. Fig.2 (left)) shows the SBIG AO-7 on SBIG ST-10 CCD camera.

An Optec Intelligent Filter Wheel (IFW) is adapted to the Apogee cameras. The following filters are provided for photometry:

- 2" BESSEL filter set: B, V, R, I, and Clear



**Figure 2.** Left panel shows the adaptive optics system and the right panel demonstrates the Fiber feed spectrograph used along with the telescope.

**Table 2.** Parameters of the fiber feed spectrograph

Aperture ratio	f/9.7
Optical design	Czerny-Turner
Resolution	0.023 nm
Dispersion	1.1 nm/mm $\pm$ 0.1 nm
Slit width / height	10 $\mu$ m to 3 mm / 4-14 mm
Grating size	68 $\times$ 68 mm
Grating mount	triple-grating turret

- 2" Strömgren filter set: v, b, y, and
- 2" H- $\alpha$  and H- $\beta$

The Astronomical Observatory of Belgrade has one portable fiber-feed spectrograph aimed to be used on the 60-cm and the future “Milanković” telescopes. Fig. 2 (right) shows the setup configuration of the spectrograph (Vince & Lalovic 2005). We plan to use the spectrograph to measure low resolution spectra of relatively faint stars and asteroids, medium-resolution spectra of relatively bright stars and studies of the variations in highly broadened spectral line profiles. The spectrograph parameters are given in Table 2.

## 4. Auxiliary equipments

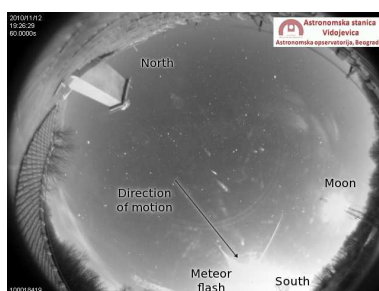
### 4.1 All sky camera

We use the SBIG AllSky-340 all sky camera for monitoring the night sky and measuring night-time cloud coverage. It contains a highly sensitive Kodak KAI-340 chip with 640 $\times$ 480 resolution and 7.4 $\times$ 7.4  $\mu$ m pixel size. The Fujinon 1.4 mm f/1.4 fish-eye lens gives horizon to horizon sky coverage. This camera has 95% sky coverage and good quality images with low noise. It is protected by aluminum enclosure and acrylic dome. The camera detects stars up to 6<sup>th</sup> magnitude in the center of the image. The all sky camera is operational since late 2010, providing continuous observations with a typical 60-second exposure on a moonless clear night. We are currently working on the development of an algorithm for automated measurement of the cloud coverage from all sky images. The data and automated measurements from this instrument will be made available on-line.<sup>1</sup>

We have also been able to derive the World Coordinate System (WCS) solution for the all sky images, which facilitates measurements of bright transient events such as meteors, variable stars, surveying for sudden events (like supernovae, GRB) etc.

<sup>1</sup><http://ftp.sbig.com/pdffiles/Allsky340%20Manual.pdf>

We provide an example of a typical image in Fig. 3. The image shows a meteor, and its fragments, captured on 12<sup>th</sup> of November, 2010, at 19:27 local time, as it passed above Mt. Vidojevica. At the peak brightness, the meteor was brighter than the Moon (also seen near the edge of the frame).



**Figure 3.** Bright meteor captured with the all sky camera mounted along with the telescope.

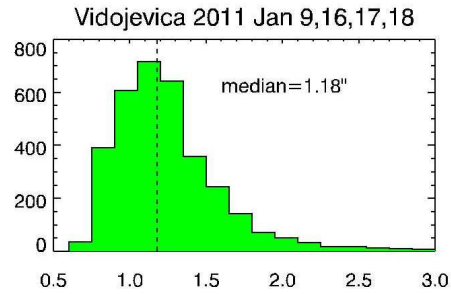
#### 4.2 Seeing monitor

Since November, 2010 the SBIG All Weather Seeing Monitor is used for monitoring observing conditions at the site. It uses an uncooled, shutter-less version of the SBIG ST-402ME camera mated to a 150 mm focal length f/5.3 lens inside the weatherproof box. The lens and the box are permanently pointed to the North Celestial Pole. Field of view of the seeing monitor is wide enough to capture Polaris during the whole night. The software measures Polaris' perturbation by seeing, and automatically calculates the FWHM at the zenith. The readout is fast, so a new measurement of the Polaris' position is obtained every 5 milliseconds. Systematic measurements are underway. Preliminary results from several nights in January of 2011 are presented on Fig. 4. The average seeing is measured to be around 1.2 arc-second.<sup>2</sup>

#### 4.3 Weather station

We use DAVIS Wireless Vantage Pro2 weather station to measure the weather conditions at ASV. It includes two important parts: i) the Integrated Sensor Suite (ISS), which combines rain collector, temperature and humidity sensors, anemometer and solar panel as a sole package (Fig. 5 left), and ii) the console, which wirelessly communicates with the ISS (Fig. 5 right). Temperature and humidity sensors are enclosed in solar-powered, 24-hour fan aspirated radiation shield. This station can transmit weather data wirelessly up to 300 m. At the moment we are in the process of incorporating Vidojevica weather station in the network of meteorological stations in Serbia.

<sup>2</sup>[http://www.davisnet.com/weather/products/wx\\_product\\_docs.asp?pnum=06153](http://www.davisnet.com/weather/products/wx_product_docs.asp?pnum=06153)



**Figure 4.** This figure shows the results for seeing measurements at the site starting from January 2011.

Since it is completely operative, we have started acquiring data and we plan to have on-line access to real time weather reports.<sup>3</sup>



**Figure 5.** The Wheater station ISS is shown in the left panel whereas the right panel shows the console.

## 5. Conclusion

With the all-sky camera, seeing monitor and meteorological station in operation we now have a system of sensors to integrate towards a more automated operation of the 60-cm telescope. In the near future, we plan to implement software which will enable centralized monitoring of all of these systems together with telescope and instrument control (CCD camera, spectrograph). We will test some existing solutions for robotic observatory control (e.g. RTS2 Kubanek et al. (2006)). This experience will be of great value for us when designing the 1.5m telescope and infrastructure for phase two of the development of Astronomical Station Vidojevica.

<sup>3</sup><http://ftp.sbig.com/sbwhtmls/online.htm>

## **Acknowledgments**

This work was supported by the European Commission through project BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and modelling in Astrophysics), FP7-REGPOT-2010-5 grant agreement no. 256772.

## **References**

- Kubanek P., Jelinek M., Vitek S., et al., 2006, in Lewis H., Bridger A., eds, Proceedings of the SPIE, Advanced Software and Control for Astronomy, 6274, 62741
- Vince I., Lalović A., 2005, Serbian Astronomical Journal, 171, 55